RECOVERY OF SOOT OBSCURED FINGERMARKS

Teodosia Krumova (21013708)

Word Count: 13,300

APRIL 2, 2024

STAFFORDSHIRE UNIVERSITY

Table of Contents

Abbreviations

BY40- Basic Yellow 40

CFM- Cyanoacrylate fuming

CNA- Cyanoacrylate fumed (used in tables and for names of samples)

CP- capillary piston

DSC5- DSC5 Foster and Freeman imaging system

H_2O- Ultra-pure deionised water

NaOH- Sodium Hydroxide

List of figures

List of tables

List of flowcharts:

Equipment used:

Glass samples- Fisher 1238-3118 1.0- 1.2mm; red PVC tape; aluminium sample-6.5cm x 2.5cm; DSC5 system; Burn Box; Cyanoacrylate fuming system- Mason Vactron fuming chamber; PPE-laboratory coat, gloves, glasses; MediPal Disinfectant wipes; JLar tape

Abstract:

Non-porous surfaces such as aluminium, glass and PVC can be found at arson scenes as these surfaces are often met in commercial and domestic settings. Therefore, these surfaces were experimented on to find out the best soot cleaning method for them. Fingermark evidence can be useful in an arson investigation; however, investigators would often ignore this evidence type due to the idea that it would be destroyed in the fire (Bleay, Bradshaw and Moore, 2006; Deans, 2006). This experiment focussed on discovering the best soot removal method for three non-porous surfaces: glass, aluminium, and PVC. Different cleaning methods were explored, two of which: gel-lift and Sodium Hydroxide 0.5% soak were tested in the preliminary study and showed the least success; therefore, these methods were not used in the main study. The cleaning methods researched in the main study were ultra-pure deionised water (H_2O) soak for 20 minutes, tape-lift, and Mikrosil. Samples were also not cleaned and instead, were exposed to the development methods straight away. The samples were photographed using the DSC5 Foster and Freeman instrument following the cleaning methods and following the development using cyanoacrylate fuming and Basic Yellow 40 dye. Fluorescent light was applied to the samples following the development methods. The experiment aim was to find the best cleaning method for glass, aluminium and PVC. Another aim was to find out whether cyanoacrylate fuming, and Basic Yellow 40 dye was needed to visualise the fingermark. It was found that the best soot removal method for the glass surface was tape-lift. However, this method was found to present the best results if it is developed using cyanoacrylate fuming and Basic Yellow 40 dye. The best soot removal method for the aluminium surface was found to be H_2O soak. Positively, this method does not require any further development methods. The best soot removal method for the PVC surface was found to be Mikrosil which required to be developed using cyanoacrylate fuming and Basic Yellow 40 dye.

1. Introduction

Fingermark evidence in arson scenes of crime is often not looked for by investigators because it is assumed that the fingermarks have been destroyed during the fire or they assume that it is unlikely for an identification to be successfully made (Bleay, Bradshaw and Moore, 2006 and Deans, 2006). There is some guidance on soot removal techniques provided by the Home Office (2022), these methods include acid immersion, brushing the soot off, tape-lifting, silicone rubber casting compound use, liquid latex, absorene, and sodium hydroxide. The purpose of this research is to find the most successful way of removing soot off fingermarks.

Using fire to damage or dismantle property is arson- the Criminal Damage Act 1971 (Criminal Damage Act 1971). Once a fire is found to be intentionally caused and then classed as arson it becomes a duty to the police, more specifically a Fire Investigation Officer, to investigate the crime under the Fire and Rescue Act 2004 Section 45 (Leicestershire Fire and Rescue Service, 2023). There has been over 20, 000 deliberately set fires between April and June of 2023 in England. 700 of which are domestic houses, and over 1,800 were vehicle fires. Whereas, in 2009, deliberately caused fires between April and June were over 41,000 with nearly 1,500 of them being domestic fires and over 5,000 vehicle fires (Home Office, 2024). Arson cost £78 million to the British economy and has an estimated anticipation cost of £11 million (GOV.UK, 2023).

Fingerprint evidence is individual and unique type of impression frequently found at crime scenes (Jackson and Jackson, 2017). The friction ridge impression does not change with aging, even though it could be changed due to scarring of the tissue (Jackson and Jackson, 2017). In 1892 Sir Francis Galton argued that the odds of two people having the same fingerprint is 64 billion to 1, and ever since, two of the same fingerprints have not been found yet (Jackson and Jackson, 2017).

Fingermarks can be used for fire investigations because it shows that the individual was at the location of the crime scene, but a time frame cannot be established, further analysis of the placement of the fingermark could aid the investigation (Ronde et al., 2019). However, the quality of the fingermark can be affected by environmental conditions such as humidity and temperature (Ronde et al., 2019). Fingermarks are deposited due to the different secretions- eccrine and sebaceous. Eccrine glands can be found everywhere around the body (Department U. S. Department of Justice, 2014). They released 99-99.5% water (Freinkel and Woodley, 2001) with the rest being amino acids, sodium chloride and others (Department U. S. Department of Justice, 2014). Some individuals may not be very good fingermark donors due to their ethnicity, for instance, black Africans have more eccrine glands than Europeans (Freinkel and Woodley, 2001). Whereas sebaceous glands are found on the face and hair canal and contain fatty acids (Freinkel and Woodley, 2001).

Soot removal is the process which involves removing sheets of soot from the fingermark, this aids the enhancement and development of the fingermark (Home Office, 2022). Soot obscured fingermarks may be difficult to recover because the fingermark dehydration since the fingermark would have been exposed to heat. The humidity in the fingermark from the eccrine secretions evaporates over time, for example Boseley et al. (2021) argues that there is some dehydration within the first 8 hours of the deposition of the fingermark. This could suggest that the close range of fire may affect the fingermark. Dhall, Sodhi and Kapoor (2013) exposed fingermarks to 100-900 °C for an hour. They argue that fingermarks on glass- 830 °C and aluminium foil- 750 °C caused the surfaces to be destroyed, making the fingermark recovery impossible. Once 900 °C was reached, fingermarks were unable to be developed. Positively, they attempted to represent a real fire scene by sprinkling water on top of the samples. Negatively, this research mainly focuses on the different development methods following exposure to high temperatures, rather than the temperature effect on fingermarks. They discovered that fingermarks exposed to 500 °C on a tin can present good quality fingermarks. Once 600-700 °C was reached, fingermarks on a black ceramic and a metal spoon could not be developed. Negatively, this research has not used a sufficient number of repeats for their results to be representative. They have only used a single fingermark for one surface and one temperature. On the other hand, Colella et. al., (2019) tested the persistence of fingermarks on a light bulb exposed to different temperatures and time. They had over 670 fingermarks and found that 62.7°C did not damage the fingermarks, however, 156.3°C did create damage to the fingermarks. However, their experiment varies between 18 hours of exposure to 1 month of exposure (Colella et al., 2019). It is unlikely that the fingermarks get exposed to heat as long as a month in arson scenes, therefore, this research may not be applicable.

There are a variety of surfaces on which fingermarks can be recovered from arson scenes. For the purposes of this research aluminium, glass and PVC plastic were used because they are commonly found in domestic and commercial settings. Glass and aluminium are often used in fingermark research (Dhall and Kapoor, 2016) and plastic (Fieldhouse and Gwinnett, 2016).

The Home Office (2022) suggests specific cleaning methods depending on the level of soot. For instance, tape-lift and silicone rubber casting are best for medium amounts of soot, acid washing is for heavy soot. They also categorise the soot removal methods having low to high effect on the fingermark quality. Tape-lift and silicone rubber castings have a medium effect on the fingermark, whereas acid wash has a high effect on the fingermark quality. Additionally, they consider the soot type and the level of soot on the surface. For example, types of soot can include dry, sticky and charring soot. The levels of soot on the surface vary from light to heavy.

Tape-lift

Tape-lift is another soot removal method recommended by Bleay, Bradshaw and Moore (2006) and the Home Office (2022), however, they advise that the method is repeated in cases where there is soot still on the surface. The use of brushing the soot off the fingerprint, NaOH wash and tape-lift has shown to be successful (Ahmad et al., 2011). Tape-lift can be more difficult to use on larger surfaces (Clutter et al., 2009). Spawn (2004) discusses different soot cleaning methods; however, the researcher does not undertake their own research. tape-lift as a soot removal method which was found to be successful. Spawn (2004) argues that tape-lift is one of the most suggested method used for soot removal. Spawn (2004) states that if needed it can be repeated multiple times which is predominantly three repats. Bleay, Bradshaw and Moore (2006) and the Home Office (2022) suggest that three repeats are also often needed when tape-lift is used to remove soot. Spawn (2004) refers to a study to which the author does not have access to, where they argue that the scotch tape is better than JLar tape because it does not tear as easily and is more flexible. Negatively, Spawn (2004) acknowledges that the resources used for their research had been restricted, therefore, their review may not be very reliable. This review was also written in 2004, which could be argued as backdated.

Conversely, Ahmad et al. (2011) discovered that the use of mixed methods such as brushing the soot off, followed by Sodium Hydroxide 2% and tape-lift as a successful method. However, this was tested on samples from a petrol bomb, this could suggest that the multi method use is due to the soot being stuck on the sample. Ahmad et al. (2011) states that the tape-lift method was repeated until there was no soot visible or until the fingermark was detectable. However, nowhere is mentioned how many times this method was repeated (Ahmad et al., 2011). Negatively, they only explored 58 fingermarks for the testing of the cleaning methods, they also do not mention how much soot was present on the sample (Ahmad et al., 2011).

Mikrosil

Home Office (2022) explores the silicone rubber casting compound use for soot removal, however, they do not specifically use Mikrosil for this. Bleay, Bradshaw and Moore (2006) have used Mikrosil as a soot removal method. According to them, Mikrosil can be very useful in objects with abnormal shapes (Bleay, Bradshaw and Moore, 2006). The recommendations provided by Bleay, Bradshaw and Moore (2006) which is a part of the Home Office Scientific Development Branch have put together the most useful soot removal methods. The Chief Scientific Adviser leads the research undertaken by the Home Office Scientific Development Branch, they employ researchers and scientists to find the best scientific method for the investigation of all types of evidence (Home Office, 2013). Bleay, Bradshaw and Moore (2006) and the Home Office (2022) state that the use of the silicone rubber casting can be applied more than once to the surface if there is soot still left on the surface. However, it is argued that the tape-lift method, repeated multiple times can be more useful in the soot removal method than the use of a single application of a silicone rubber casting compound (Bleay, Bradshaw and Moore, 2006). However, this could be expected due to the repeated application of tape-lift against a single application of silicone rubber casting compound. Liquid latex may not be as effective as Mikrosil because once multiple layers have been applied, it drips down on glass surfaces, it is expensive and has found to be destructive to surfaces such as a dry wall (Clutter et al., 2009). Clutter et al. (2009) suggests that the use of Mikrosil, followed by tape-lift if there is still soot on the surface or a second coat of Mikrosil instead.

Mikrosil has been used in real-life arson scene in 2005, Metropolitan Police had found the body in a canal of a drug dealer (O'Hagan and Calder, 2020). The same individual had recently been reported for disruption at a flat which was later set on fire. Following the fire a large amount of soot was found at the scene. Mikrosil had been used to lift fingermarks from a wooden door frame, and liquid latex was used for the rest of the crime scene (O'Hagan and Calder, 2020). Blood as well as fingermarks were found at the scene and a conviction was made (O'Hagan and Calder, 2020).

Ultra-pure deionised water (H_2O)

The idea of using water as a soot removal method is due to the expectation of the soot to drift away from the surface and stay in the water, as Home Office (2022) briefly mentions. However, they do not specify the use of water and briefly mention how the use of some acids may aid the soot removal (Home Office, 2022). Water is often used as an additional cleaning method, for example, following Sodium Hydroxide (NaOH) immersion, the samples are rinsed using a water wash (Bleay, Bradshaw and Moore, (2006) and Home Office (2022). Water sprinkles were found effective at cleaning soot from fingermarks from a variety of surfaces, including glass and aluminium (Dhall and Kapoor, 2016). In real-life arson scenes it is likely that high pressure water would be used to extinguish the fire. Bleay, Bradshaw and Moore (2006) acknowledge this, however, they advise that attention is paid to fingermarks which have not been exposed to water. An ultrasonic bath with water has also been found to have some success (Bleay, Bradshaw and Moore, 2006). Ultra-pure deionised water has been used for this experiment because research has found that sea water for example can be destructive to fingermarks (Madkour et al., 2017).

Sodium Hydroxide (NaOH) and gel-lift (Preliminary study)

Home Office (2022) suggest the use of NaOH or an acid wash solution for item which have accumulated soot on them. They suggest the immersion/wash of the item using an acid wash for 30 seconds, however, they do not specify what percentage should be used

(Home Office, 2022). Following this, they suggest the item to be washed with an alkali solution for 15 seconds (Home Office, 2022). Stow and McGurry (2006) found some success in the use of NaOH 1% and 2% soak and wash. However, their research tested the cleaning of fingermarks that have been covered in heavy soot and accelerant oils. They found that the NaOH 2% soak for 10 minutes showed no results, after 20 minutes some of the soot had started to fall off, after 30 minutes the soot had been removed completely but some accelerant oil was still present (Stow and McGurry, 2006). Other studies have also found NaOH 2% soak for 30 minutes and tape-lift on a glass to be successful (Ahmad et al., 2011). The study conducted by Stow and McGurry (2006) does not specify the way the fingermarks were deposited. If not, enough force is applied when depositing the fingermark this could lead to a lack of residue deposited, whereas, if there is excessive force applied this could lead to smudging of the ridge detail (Fieldhouse, 2011). Therefore, results from the scoring system used by Stow and McGurry (2006) could have been affected due to the lack of a fingerprint sampler which aids the equal force applied when deposited fingerprints (Fieldhouse, 2011). Using a scoring system (Stow and McGurry, 2006; Ahmad et al., 2011) can be subjective due to the results being individual for different examiners (Hanna, Chadwick and Moret, 2023).

Other soot removal methods

Liquid latex can be used to clean soot off fingermarks, it is applied by spraying multiple layers onto the surface that needs cleaning and then it is peeled off (Clutter et al., 2009). Liquid latex was unsuccessful with some surfaces because of its high adhesiveness. However, the Home Office (2022) suggest the liquid latex to be applied using a sponge or a brush in multiple layers on the surface if needed. Negatively, if too many layers are applied, the drying process may take long (Home Office, 2022). Gel-lift is advertised as a low-adhesive and being able to lift powdered fingermarks (GELLIFTERS, n.d.), suggesting it would have a better success. Therefore, gel-lift was used in the preliminary study as a replacement of liquid latex.

Developing the fingermarks

Generally, for non-porous surfaces, the Home Office (2022) suggests the fingermarks to be developed using a vacuum metal deposition, fingerprint powders and powder suspension as the most effective methods. Another method that can be used is cyanoacrylate fuming and cyanoacrylate fuming enhancement methods (Home Office, 2022).

Cyanoacrylate fuming (CFM) is a development method used for fingermarks on non-porous surfaces (Home Office, 2022). The polymers attach to the eccrine and sebaceous sweat of the fingermark, creating white noodle lines throughout the ridge detail of the fingermark, the size of the lines can range depending on how old the fingermark is (Ramotowski, 2013). Home Office (2022) argues that the fresher the fingermarks, the easier it becomes to polymerise the fingermark due to the high amounts of eccrine sweat and water. In this experiment the samples are subjected to CFM and then stained using Basic Yellow 40 (Home Office, 2022). However, it is advised that the object should not have been wetted if CFM is used (Bleay, Bradshaw and Moore, (2006) and Home Office (2022). This could make CFM unusable for fingermarks which have been soot obscured due to the chance of it been exposed to water during the fire extinguishment. However, Home Office (2022) explains that if the samples has been exposed to water it may decrease the quality of the cyanoacrylate fume process, rather than it being completely impossible to CFM. They explain that this is due to the salts to which the polymers attach to, present in the fingermarks dissolving in the water (Home Office, 2022). Bleay, Bradshaw and Moore (2006) explain that fingermark exposed to high temperatures only leaves inorganic salts in the fingermarks, which once CFM leads to irregularities in the surface, this is mainly detected when using a Vacuum Metal Deposition instrument. Trapecar (2012) developed fingermarks which have been submerged underwater and CFM the finger-marks, his research showed that CFM was the best development method. Fingermarks were visualised using the DSC5. The DSC5 aids the close-up visualisation through fluorescence imaging of the fingermark ridge (Foster + Freeman, 2022). This instrument aided the fluorescence of the stained fingermarks. Bleay, Bradshaw and Moore (2006) have not explored using CFM and Basic Yellow 40 stain on soot obscured fingermarks. However, the Home Office (2022) suggests the usual development methods used for non-porous surfaces after the fingermark has been cleaned, this could involve CFM.

Grading Systems

The Home Office has their own fingermark grading system that starts from Grade 0 to Grade 4 (Hockey, Dove and Kent, 2021). Figure 1 shows the Home Office grading system. The Home Office fingermark grading system is much less detailed in comparison to Fieldhouse and Gwinnett (2016). The Home Office grading system only looks at the amount of ridge detail that is available for analysis (Figure 1). Whereas Fieldhouse and Gwinnett (2016) grading system has 4 criterions (Figure 2). Criterion 1in this grading system focuses on the quantity of the fingermark available, criterion 2 focuses on the ridge detail, criterion 3 focuses on the ridge detail continuality and lastly, criterion 4 focuses on the contrast between the surface and the fingermark to (Fieldhouse and Gwinnett, 2016). The detail in which the fingermark is examined and graded is much richer than the Home Office grading system. Fieldhouse and Gwinnett (2016) provide a detailed booklet to aid the examiner' interpretation of each criterion and acknowledge that the deposition method of the fingermark may be affected by the deposition method. The Home Office grading system does not mention the contrast between the fingermark and the surface. For example, the fingermark under Grade 4 (Figure 1) could show subjectivity between different examiners due to possible difficulties with the surface contrast.

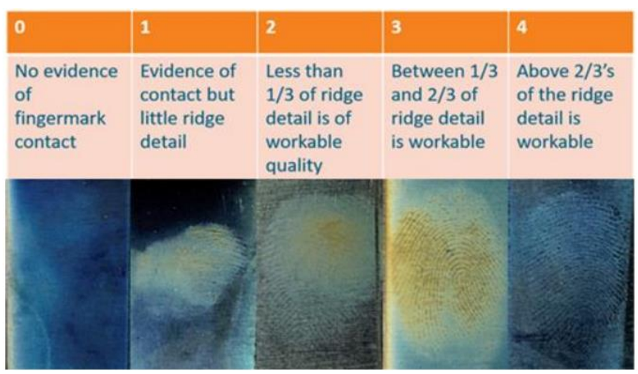


Figure 1: Home Office grading (dstl, 2020)

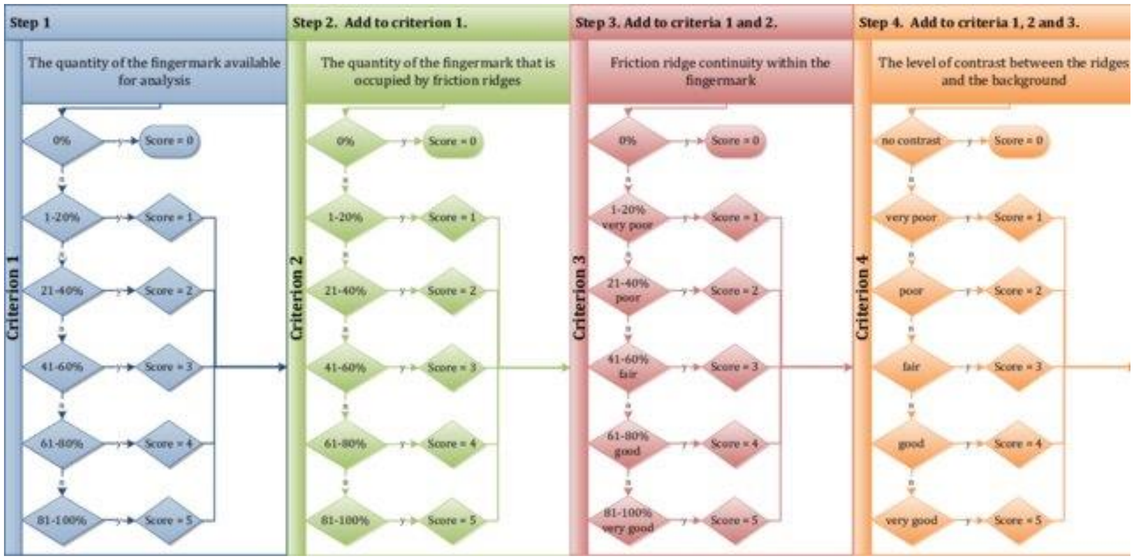


Figure 2: Fingermark Grading System (Fieldhouse and Gwinnett, 2016)

Aim: Establish the best cleaning method depending on the surface type.

Objectives:

1) Develop a sooting method.
2) Apply the different cleaning methods.
3) Develop the fingermarks using cyanoacrylate fuming and BY40.
4) Use the Fingermark Grading System to grade the quality of the fingermarks (Figure 2).
5) Carry out statistical analysis on the data to find the best cleaning method.

1) **Alternative Hypothesis:**

There will be a difference between cleaning methods.

A) **Null hypothesis**:

There will not be a difference between the cleaning methods.

2) **Alternative Hypothesis:**

There will be a difference in the quality of the fingermarks using the cyanoacrylate fuming and BY40 development following cleaning.

A) **Null Hypothesis:**

There will not be a difference in the quality of the fingermarks using the cyanoacrylate fuming and BY40 development following cleaning.

2. Methodology

Main study

Creating the samples:

Full Personal Protective Equipment was worn in the laboratory, samples were always handled with gloves on. The surfaces were cleaned using MediPal Disinfectant wipes and then immediately dried using blue roll. Three fingermarks were placed on three of the same surfaces for the same set of conditions. This was repeated for every cleaning method, time period, and surface type. Control samples were created. The time periods are immediate sooting after fingerprint deposition, 2-, 3- and 7-days sooting after deposition. Samples were cyanoacrylate fumed (CNA) and stain using Basic Yellow 40 (BY40). Samples were graded using the Fingermark Grading System (Fieldhouse and Gwinnett, 2016) after cleaning and again after CNA and BY40 application. The fingerprint donor did not wash their hands at least 1 hour before the deposition (Fieldhouse, 2011a) and before every deposition the fingers were rubbed against the hair, forehead and back of ear.

Samples for the following cleaning methods were created:

- No cleaning.
- Mikrosil cleaning.
- Tape-lift cleaning.
- Ultra-pure deionised water soak.

A total of 432 fingermarks were created and tested for the main study of this experiment.

Sooting the samples:

The samples were stuck on the middle tray using blu tack, inverted over the fire source. The blue tack was placed on the inverted side of the samples, to allow the samples to be pushed onto the middle shelf without damaging the fingerprints and ensuring they are stuck well. Care was taken to not obstruct ventilation holes in the shelf. The samples were stuck in a random order. Five (5) grams of sawdust was measured, and 10 ml of diesel is measured using a pipette in a 10ml capillary piston (CP) tip. The diesel was spread out around the sawdust by slowly pressing the button of the pipette, to saturate the sawdust. Safety doors were engaged before ignition. Photographs were taken of the samples following every process. A long wooden splint was held using long metal clamps. The end of the wooden splint was set alight using a lighter. The smaller safety door of the burn box (Figure 3) was lifted. Using the already lit wooden splint held by the long metal clamps the wooden splint is put through the smaller safety door to set the sawdust alight. After the sawdust was set alight the smaller door was closed. A stopwatch was used to time the burn duration. A controlled soot-release is done by leaving the smaller door open following some period of time. After cooling samples were removed from the burn box and subjected to a cleaning process.

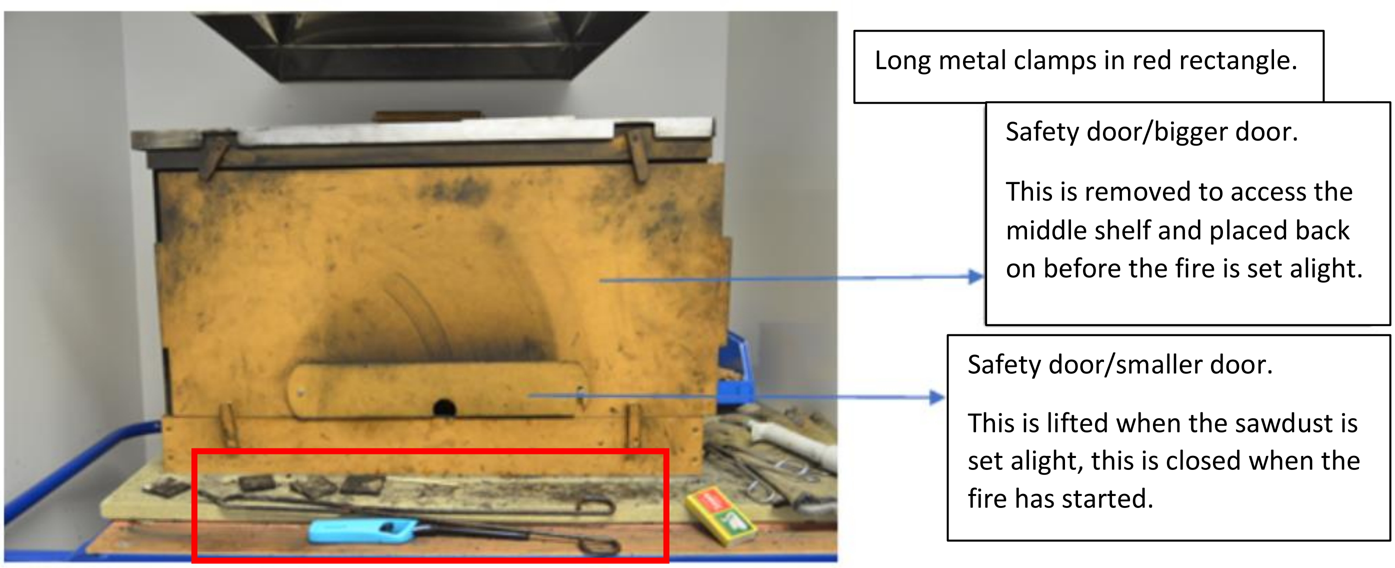


Figure 3: Burn box safety door and smaller safety door

Once the samples were unstuck, they were then placed in a tray according to each of the cleaning methods and were photographed.

Cleaning methods

Ultra-pure deionised water soak cleaning method

Three glass, aluminium and PVC samples were placed flat into a plastic tray and submerged by pouring ultra-pure deionised water into the tray until the samples were covered. Care was taken not to pour the water directly onto the samples. Some of the samples may float, to stop this, tweezers are used to press the sample down under water, taking care not to touch the samples where the marks were deposited. After this a 20-minute timer is set. A piece of tissue is placed in a tray, to place the samples in after the soak. This was left to dry in the fume cupboard. Samples are handled on the side where there was writing to prevent the fingermark from being damaged.

Tape-lift cleaning method

A long piece of fingerprint lifting tape (Jlar tape) was cut out. Please refer to Figure 4 for a visual representation of this method.

Step 1:

Leave the sample on a flat surface. Unroll the tape very quickly, unroll enough tape to cover the sample with an additional 1 cm of tape. Stick 1 cm of the tape to the table and hold the tape upwards away from the sample.

Step 2:

Hold the end on the tape upwards with one hand whilst the other hand is sliding the tape down, across the sample. This removes any bubbles.

Step 3:

Apply pressure to the tape.

Then unstick the tape starting from one corner of it.

Ensure that the tape does not accidentally stick to the sample again during this process.

Figure 4: Tape-lift cleaning method guide

Mikrosil cleaning method

The Mikrosil mixture was created according to the manufacturing instructions, the mixing and setting time was also followed according to the manufacturer instructions. Mikrosil was mixed individually for each sample to ensure that the mixture has not hardened since it dries very quickly. It can be applied onto the surface using a spatula, this is left to dry and then peeled off (Bleay, Bradshaw and Moore, 2006). Once dry after 8 minutes, this is peeled off by starting off with one corner and lifting the hardened paste away from the surface.

No clean method

The No clean samples were not subjected to any cleaning methods. These samples were photographed using the DSC5 Foster and Freeman instrument and graded. They were then cyanoacrylate fumed and BY40 stain. They were then photographed using the DSC5 and graded.

Preliminary study samples

Sodium Hydroxide 0.5%- Samples were placed in a tray and sodium hydroxide solution was poured in the tray to soak the samples in for 20 minutes. The samples were left to dry and then developed.

Gel-lift was placed on top of sooted samples, this was left for a few seconds and peeled off. Samples were developed following this.

Development of samples

Following all the cleaning methods, images of each of the samples were taken using the DSC5 instrument without any filters but just the use of a ring light. This was done with samples after they were cleaned. These were graded. The samples are then cyanoacrylate fumed and BY40 stain The DSC5 instrument is used to photograph the samples again. A specific filter and light were used, this is explained below. The samples were graded following development.

Cyanoacrylate fuming

Following the application of the cleaning methods, the samples were placed in the cyanoacrylate fuming instrument Mason Vactron MVC3000. The samples must be fully dry before they are placed inside the superglue fuming instrument. Manufacturers guidance was followed for Autocycle use. The samples were placed inside the instrument. Approximately three (3) grams of superglue (Home Office, 2022) was added to the cabinet and run on Autocycle.

Basic Yellow 40 (BY40) method

The cyanoacrylate fumed samples are stained using BY40 (Home Office, 2022). The BY40 solution used was made up of 2 grams of basic yellow dye and 1L. of ethanol. Two pairs of gloves were worn, in case the first pair breaks due to the sharp edges of the aluminium samples. The staining method is done inside the fume cupboard. A 1000ml beaker is filled with 500ml BY40 stain. One sample is held between the fingertips of the pointer finger and middle finger and another sample is held between the middle finger and the ring finger. The samples were soaked for 1 minute at a time. Following this, samples were rinsed under a slow stream of tap water. The rinsed samples are left to dry inside the fume cupboard. This process is repeated for all the samples.

DSC5 Foster and Freeman method

The Crime Light protector is plugged in and tightened through the bolts on the instrument. The power button was pressed. Filter OG 530 AG yellow/orange is slid into the Crime Light instrument. 520nm OG590 button is pressed on the Crime Light Instrument. Following this set up, each sample was photographed up-close. The cleaned(/C) samples were visualised without the use of any filters because the samples had not been exposed to any enhancement methods, the DSC5 was only used to photograph the images. Once the samples had been enhanced using cyanoacrylate and BY40, the samples were photographed using the appropriate filter and light.

3. Results and discussion

Preliminary study results and discussion:

Sooting the samples

Initial findings from the preliminary study were that 5 grams of sawdust and 10ml of diesel is a better method to soot create soot, rather than a 10cm x 10cm piece of carpet and 10ml of diesel. The sawdust must be centred above the samples and must be placed in a pile. When the sawdust was spread out with diesel, there was a lack of soot created due to the sawdust burning too rapidly. Regarding the placement of the samples, the holes in the middle shelf must not be covered by the samples, due to the blockage of the airflow. If the holes are blocked, the samples did not soot successfully. It was discovered that the samples directly above the fire source had the most soot on them. Hence why the samples were placed randomly around the middle shelf. If the samples were placed together according to surface or cleaning method, the results would not be fair.

Materials used

It was found that the initial plastic sample used melted because it was too close to the fire source. This is why PVC tape was stuck to a glass slide instead. Initially, white PVC tape was used to replace the molten plastic surface. However, it was found that white PVC did not allow the visualisation of the ridge detail even after the sample was cyanoacrylate fumed and BY40 stain. Dhall, Sodhi and Kapoor (2013) also found difficulties with the contrast between a white ceramic tile and the fingermark. This could be because the white surface reflects the fluorescent light from the DSC5 instrument. Brown and two different red PVC tapes were tested by depositing fingermarks on the surface, developing the fingermarks and seeing which surface allowed the visualisation of the fingermark better. It was concluded that one of the red PVC tapes were of better use as it allowed the visualisation of the fingermark.

Initially, a thin aluminium sheet was used for this experiment. However, difficulties were met with sticking the samples onto the middle shelf. Due to the thin material, there was a risk of damaging the fingermarks when handling them. Hence why this was replaced with a much thicker aluminium sheet.

Removal of NaOH and gel-lift cleaning methods

Stow and McGurry (2006) used 2% NaOH for their research, however, they focused on the heavy soot and accelerant oil removal. This is why, the author decided to use 0.5% NaOH to try and compensate for the lack of heavy soot and accelerant oil presence. Sodium Hydroxide solution 0.5% (NaOH) was used to soak the samples for 20 minutes. The samples were placed in a tray and following this, the NaOH 0.5% was poured on inside the tray. This method was done in the same manner that the H_2O soak was undertaken. Na0H method showed no success therefore it was not used in the main study. NaOH had an overall total average of 7 as a cleaning method, this is the same total average as H_2O. NaOH could be considered as unreliable because of the high SD (SD=8.01; average=11.3) for aluminium surfaces (Table 2). The high SD suggests that the results are spread out and not consistent. This was similar to the results from the PVC sample (SD=5.18; average=3.7) (Table 2). And for the glass surface (SD=0; average=17), suggesting that it can be useful for glass samples (Table 2). However, glass also scored a SD=0.94; average=19.3 in H_2O soak. This could suggest that the cleaning methods have similar properties in cleaning soot from fingermarks. The similarity between the two cleaning methods is that NaOH contain large amounts of H_2O. H_2O is the better cleaning method because it does not stop the potential of dual recovery like NaOH does because it could be destructive to DNA (Bleay, Bradshaw and Moore, 2006).

Gel lift had an overall total average score of 5.5 (Table 1) and 3 (Table 2) which is the lowest scores out of all the cleaning methods, therefore gel-lift had no success in the preliminary study. Gel-lift worked well with the aluminium surface (Table 2), however, it showed poor results in the first preliminary study (Table 1). This shows inconsistency in gel-lift. However, the inconsistency could be due to the different amounts of soot on the surface.

Negatively, there were only three fingermarks tested for each surface and cleaning method for the preliminary study. This shows that the results may not be reliable enough due to the lack of repeats. To achieve better results, it could be needed to repeat the method or/and apply more than one cleaning method.

Table 1: SD and averages of the preliminary results

GLASS	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning averages**	**NaOH average**
	8.7 SD: 2.05	9.3 SD: 0.94	0 SD: 0	12.7 SD: 4.02	17 SD: 0	12.7 SD: 2.05
ALUMINIUM	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning averages**	**NaOH average**
	5 SD: 0	5	18.3 SD: 1.24	0 SD: 0	0 SD: 0	10.3 SD: 2.49

		SD: 2.35				
PLASTIC	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning averages**	**NaOH average**
	8.3 SD: 0.94	13.7 SD: 2.62	8 SD: 1.41	12.7 SD: 2.05	15.3 SD: 2.35	5 SD: 0
PVC	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning averages**	**NaOH average**
	0 SD: 0	0 SD: 0	17.3 SD: 0.47	0 SD: 0	0 SD: 0	0 SD: 0
Total average for the cleaning method:						
	5.5	7	10.9	6.4	8.1	7

Table 2: SD and averages of the preliminary results

GLASS	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning average**	**NaOH average**
	4.3 SD: 3.68	19.3 SD: 0.94	19 SD: 0.81	20 SD: 0	19.7 SD: 0.47	17 SD: 0
ALUMINIUM	**Gel-lift average**	**H_2O average**	**Mikrosil average**	**Tape-lift average**	**No cleaning average**	**NaOH average**
	16.3 SD: 0.47	18 SD: 1.41	20 SD: 0	20 SD: 0	13 SD: 0	11.3 SD: 8.01

PVC	Gel-lift average	H_2O average	Mikrosil average	Tape-lift average	No cleaning average	NaOH average
	9.7 SD: 2.05	11.3 SD: 8.01	17.7 SD: 2.05	0 SD: 0	19.7 SD: 0.47	3.7 SD: 5.18
Total average for the cleaning method:						
	3	16.2	18.9	13.3	17.5	10.7

Main study results and discussion

The results were analysed by initially checking the significance of the data by surface type, using the Friedman test. Following this, a Wilcoxon test was undertaken with a Bonferroni correction.

The statistical significance of every pair- cleaned and developed fingermarks (e.g. tape-lift/C; tape-lift/CNA). This was undertaken using the Friedman K-related samples with the Bonferroni correction value (0.0018).

The r value shows the effect size of the samples suggesting that it shows the relationship between the samples. Small effect size of 0.2 suggests a small significance, 0.5 effect size suggests medium significance and 0.8 suggests a large significance (Bhandari, 2020).

Friedman Test was undertaken on all samples of the glass, aluminium, and PVC surface. Before the Friedman test, a normality test was undertaken for every surface, and the data was concluded as not normally distributed (Laerd Statistics, 2018).

Table 3: Friedman test on surface types.

Surface Type	Friedman Significant Difference
Glass	Statistically significant difference (p=.001)

PVC	Statistically significant difference (p=.001)
Aluminium	Statistically significant difference (p=.001)

Because all the data was statistically significant(p=.001), a Wilcoxon with Bonferroni correction (0.0018) was undertaken for each surface type and every possible pair of cleaning methods. The alternative hypothesis was accepted, or the null hypothesis was accepted. Bonferroni correction was used with the efforts to decrease the risk of Type 1 error occurring in the data analysis (Armstrong, 2014). Type 1 error is when the data is classed as significantly different, however, the data is not actually significantly different (Armstrong, 2014). However, Armstrong (2014) argues that when Type 1 error is decreased, this increases the chance of Type 2 error. Type 2 error is when the difference in the data cannot be found (Armstrong, 2014). Laerd Statistics (2018) argues that the Bonferroni correction must be applied to the data collected from the Wilcoxon signed-rank tests.

Regarding the not significantly different samples, regardless of the surface type, the minimum and maximum value scored may be of use for the interpretation of the results as well. However, some samples may have a higher number of lower results but have a higher minimum value for example. Therefore, it is difficult to create a valid conclusion using these results. With regard to SD, the success of the method cannot be solely based on SD. Since a lower SD suggests a consistency in the results, it is likely that a cleaning method scored low results consecutively. This may suggest that the cleaning method is not successful. Nevertheless, the cleaning method is poor due to the consecutively low results, but the SD is lower. Hence why the minimum and maximum scores are mentioned in the tables, since this can be used as an additional set of data to evaluate the cleaning method. The chi squared value was additionally used to show the statistical significance between the samples in this experiment (University of Southampton, 2020).

Key:

- /C=Cleaned
- /CNA= cyanoacrylate fumed and BY40 stain

Glass surface: Wilcoxon-ranked Test results:

The null hypothesis was accepted: there will not be a difference between the cleaning method. The following pairs from the Wilcoxon-rank test results:

Example: No clean was compared against No clean/CNA, Tape-lift/C, H_2O/C, H_2O/CNA, and Mikrosil/CNA.

Table 4: Wilcoxon-rank test; all glass samples with no statistically significant difference

No clean- Median=16; SD=2.828 compared against: 1. No clean/CNA- Median=17; SD=2.209 No statistically significant difference (p= .011, r=.423) 2. Tape-lift/C- Median=19; SD=5.704 No statistically significant difference (p=.036; r=.349) 3. H_2O/C- Median=18; SD=3.194 No statistically significant difference (p=.014; r=.409) 4. H_2O/CNA- Median=16.50; SD=3.875 No statistically significant difference (p=.090; r=.283) 5. Mikrosil/CNA- Median= 18; SD=4.158 No statistically significant difference (p=.069; r=.303)

No clean/CNA- Median= 17; SD=2.209 compared against:

1. Tape-lift/C- Median=19; SD=5.704

No statistically significant difference ($p=.680$; $r=.069$)

2. H_2O/C- Median=18; SD=3.194

No statistically significant difference ($p=0.672$; $r=.071$)

3. H_2O/CNA- Median=16.50; SD=3.875

No statistically significant difference ($p=0.332$; $r=.162$)

4. Mikrosil/CNA- Median=18; SD=4.158

No statistically significant difference ($p=0.36$; $r=.160$)

H_2O/CNA- Median=16.50; SD=3.875 compared against:

1. Mikrosil/CNA- Median=18; SD=4.158

No statistically significant difference ($p=.261$; $r=.186$).

Tape-lift/C- Median=19; SD=5.704 compared against:

1. Tape-lift/CNA- Median=19; SD=2.155

No statistically significant difference ($p=.005$; $r=.467$)

2. H_2O/C- Median=18; SD=3.194

No statistically significant difference ($p=.424$; $r=.133$)

3. H_2O/CNA- Median= 16.50; SD=3.875

No statistically significant difference ($p=.502$; $r=.112$)

4. Mikrosil/CNA- Median=18; SD=4.158

No statistically significant difference ($p=.843$; $r=.033$)

H_2O/C- Median=18; SD=3.194 compared against:

1. H_2O/CNA- Median=16.50; SD=3.875

No statistically significant difference (p=.182; r=.222).

2. Mikrosil/CNA- Median=18; SD=4.158

No statistically significant difference (p=.836; r=.035).

The following samples were statistically significant, suggesting that the alternative hypothesis was accepted using the Wilcoxon-ranked test:

Table 5: Wilcoxon-rank test; all glass samples with statistically significant difference

No clean- Median=16; SD=2.828 compared against:

Minimum value:7

Maximum value:17

1. Tape-lift/CNA- Median= 19; SD=2.155

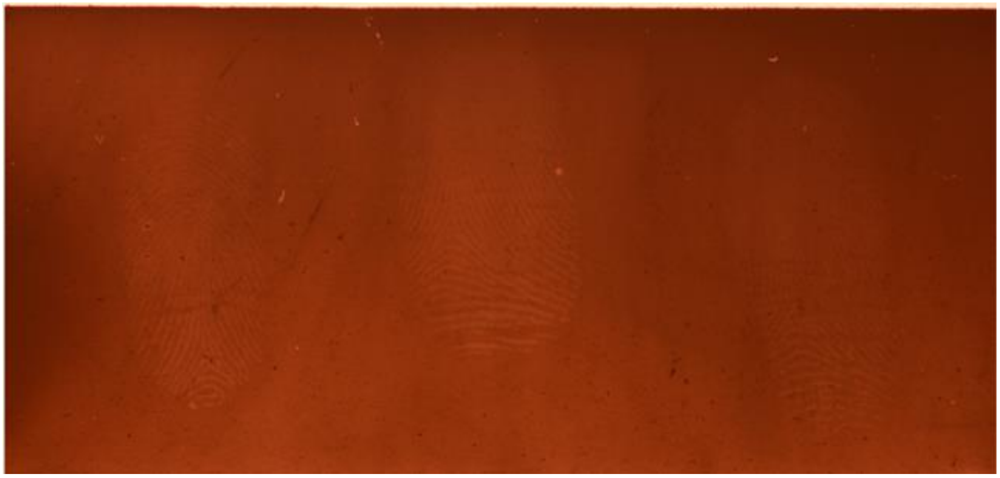
Minimum value:10

Maximum value:20

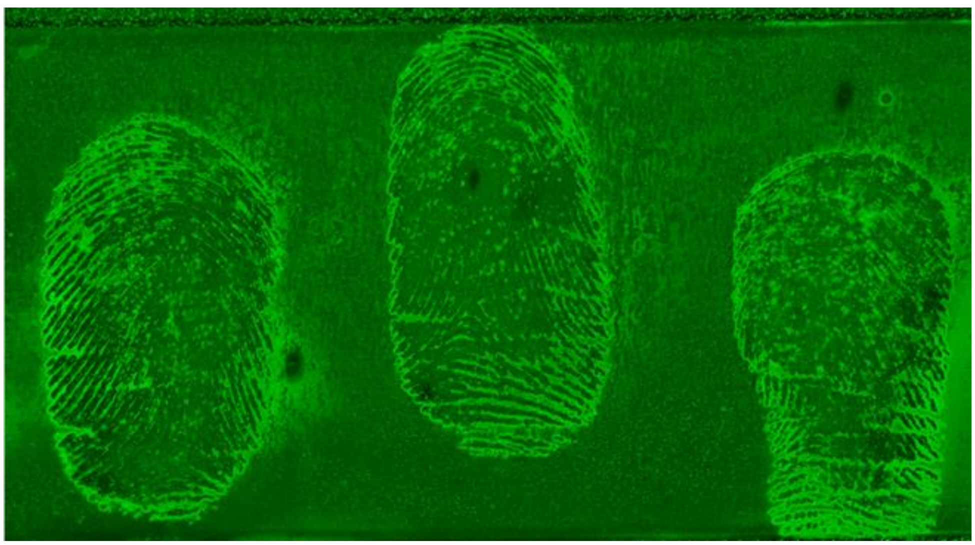
Statistically significant difference (p=0.001; r=.781).

Therefore, suggests tape-lift/CNA is the better cleaning method due to the higher minimum, maximum scores and median value. Figures 5 A) and B) show random examples of the two cleaning methods with tape-lift/CNA having a higher average score for the three fingermarks on the surface.

However, this could be because the No clean has not been developed using cyanoacrylate fuming and BY40. Additionally, Mikrosil/CNA and No clean/CNA were found to not be statistically significant.



A)



B)

Figure 5: Glass; immediate sooting; No clean (A) tape-lift/CNA (B) sample 2

No clean/CNA- Median= 17; SD=2.209 compared against:

Minimum value:12

Maximum value:20

1. <u>Tape-lift/CNA- Median=19; SD=2.155</u>

Minimum value:10

Maximum value:20

Statistically significant difference (p=0.001; r=.622).

Therefore, Tape-lift/CNA is the better cleaning method due to the lower SD. However, No clean/CNA has a higher Minimum score, this could suggest that the No clean/CNA is a better cleaning method since its SD is not too much higher than the Tape-lift/CNA SD.

Mikrosil/C- Median=0; SD=O compared against:

Minimum value:0

Maximum value:0

1. **No clean/CNA- Median= 17; SD=2.209**

Minimum value:12

Maximum value:20

Statistically significant different (p=0.001; r=.876)

2. No clean- Median= 16; SD=2.828

Minimum value:7

Maximum value:17

Statistically significant difference (p=0.001; r=.879)

3. Tape-lift/C- Median=19; SD=5.704

Minimum value:3

Maximum value:20

Statistically significantly different (p=.001; r=.880)

4. Tape-lift/CNA- Median=19; SD=2.155

Minimum value:10

Maximum value:20

Statistical significantly different (p=.001; r=.885).

5. H_2O/CNA- Median=16.50; SD=3.875

Minimum value:6

Maximum value:20

Statistically significant difference (p=.001; r=.874).

6. H_2O/C- Median=18; SD=3.194

Minimum value:8

Maximum value:20

Statistically significant (p=0.001; r=.875).

7. Mikrosil/CNA- Median=18; SD=4.158

Minimum value:7

Maximum value:20

Statistically significant difference (p=0.001; r=.875).

This suggests that No clean/CNA, No clean, tape-lift/C, tape-lift/CNA, H_2O/CNA and H_2O/C yield better results than Mikrosil/C. Mikrosil/C yielded no results, and all of the cleaning methods have higher medians, SD's, minimum and maximum scores. The SD of Mikrosil/C is significantly low due to no variety in the results as the minimum and maximum scores are 0.

With regards to Mikrosil/CNA, due to Mikrosil/C (Figure 6) not scoring any results, it is concluded that cyanoacrylate fuming and BY40 development is needed following the cleaning using Mikrosil.

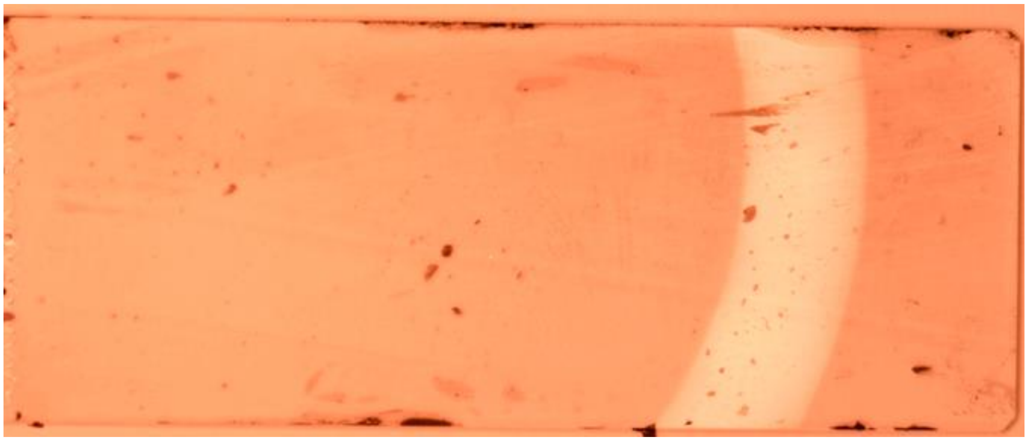


Figure 6: Glass; 7 days sooting; Mikrosil/C sample 2

Tape-lift/CNA-Median=19; SD=2.155 compared against:

Minimum value:10

Maximum value:20

1. H$_2$O/C- Median=18; SD=3.194

Minimum value:8

Maximum value:20

Statistically significant difference (p=.001; r=.571).

2. H$_2$O/CNA-Median=16.50; SD=3.875

Minimum value:6

Maximum value:20

Statistically significant difference (p=.001; r=.712).

3. Mikrosil CNA=Median=18; SD=4.158)

Minimum value:7

Maximum value:20

Statistically significant difference (p=.001; r=.545).

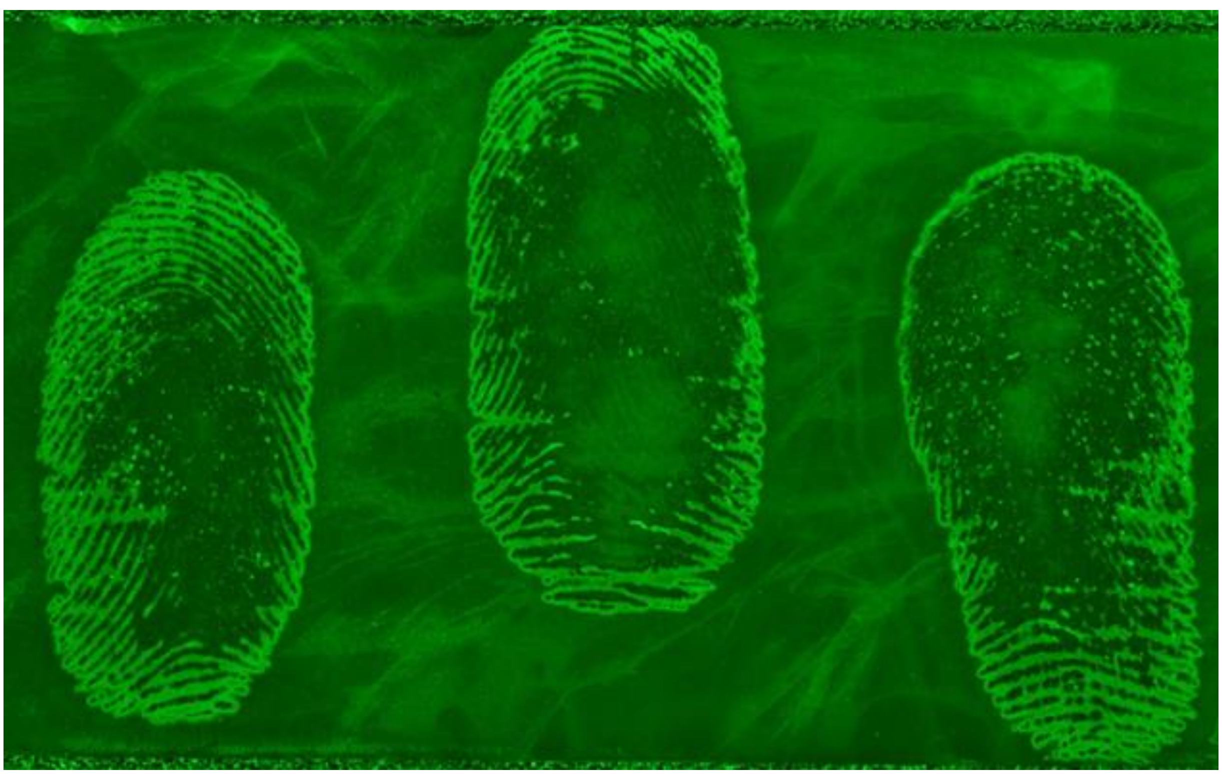
Overall, tape-lift/CNA is the better cleaning method than H$_2$O/C, H$_2$O/CNA and Mikrosil/CNA. This is because tape-lift/CNA has a lower SD, and a higher minimum score than any of these cleaning methods.

Glass surface: Friedman Test

Table 6: Glass surface Friedman K-related test

Glass surface Related samples	**Friedman Significant Difference and chi2**
No Clean; No Clean/CNA	No Clean-Median=16; SD=2.828 No Clean/CNA-Median=17; SD=2.209 No statistically significant difference (p=.028; chi2=4.829) The null hypothesis is accepted. Suggesting that cyanoacrylate fuming and BY4O stain may not be needed for this surface. However, it may be beneficial to develop the fingermarks if possible because it would make the analysis of the fingermark easier. As the cyanoacrylate fuming and BY40 stain make the ridge detail fluoresce, rather than the No clean where the analysis would be more difficult due to the lack of contrast between the background and the ridge detail (Figure 7 A), B). Additionally, the cyanoacrylate fuming, and the staining may be of more use if the soot is thicker, rather than in small amount (Figure 7 A). This would have to be considered by the examiner because as seen in Figure 7 B), C), some of the second fingermark has not been cyanoacrylate fumed. This could be due to the larger amounts of soot in the middle of the fingermark; therefore, cyanoacrylate fuming may not be useful for fingermarks which have a lot of soot on them.

A)



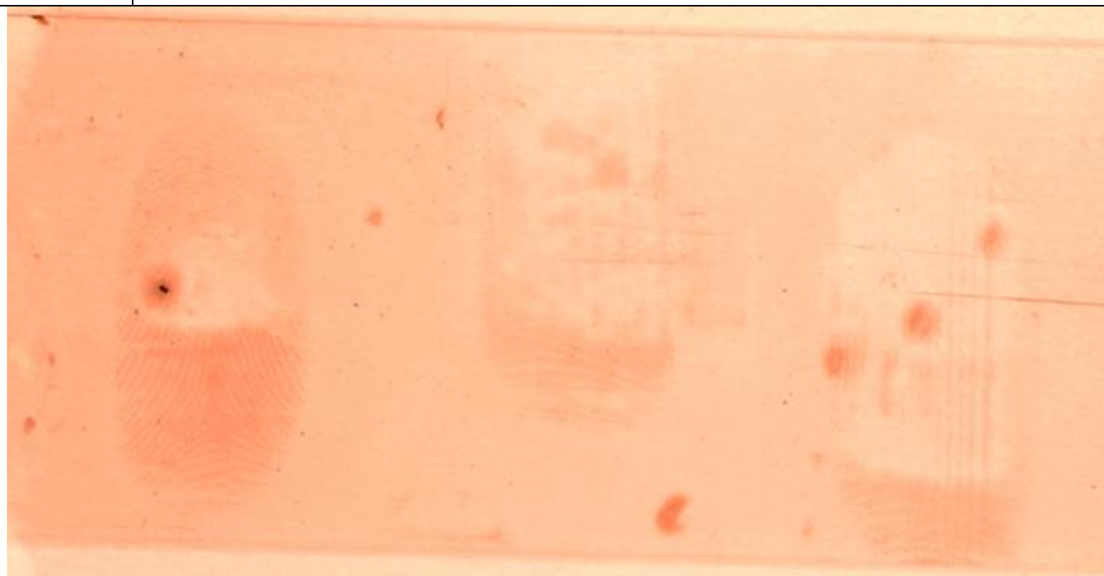
B)

C)

Figure 7: Glass; 7 days sooting; No clean (A) No clean/CNA (B) No clean/CNA- Enhanced (C) Sample 2

Tape-lift/C; Tape-lift/CNA	Tape-lift/C-Median=19; SD=5.704 Tape-lift/CNA-Median=19; SD=2.155 No statistically significant difference (p=.028; chi2=4.800) The null hypothesis is accepted. However, the tape was only applied once to the surface. Therefore, if the tape-lift method was applied more than once this could mean that the cyanoacrylate fuming and BY40 stain may be needed. This is similar to Mikrosil/C because it was found that cyanoacrylate fuming and BY40 is needed to visualise the cleaned ridge detail. This is evidenced in Figures 8 A and B as the ridge detail in the second and third fingermark is not easily seen due to the lack of soot on the ridge detail but when it has been developed, the ridge detail is revealed.

<table>
<tr><td></td><td>Furthermore, tape-lift/CNA has scored a higher minimum value of 10 in comparison to tape-lift/C which scored a minimum value of 3. Suggesting that the development methods are needed in some samples.</td></tr>
<tr><td colspan="2">



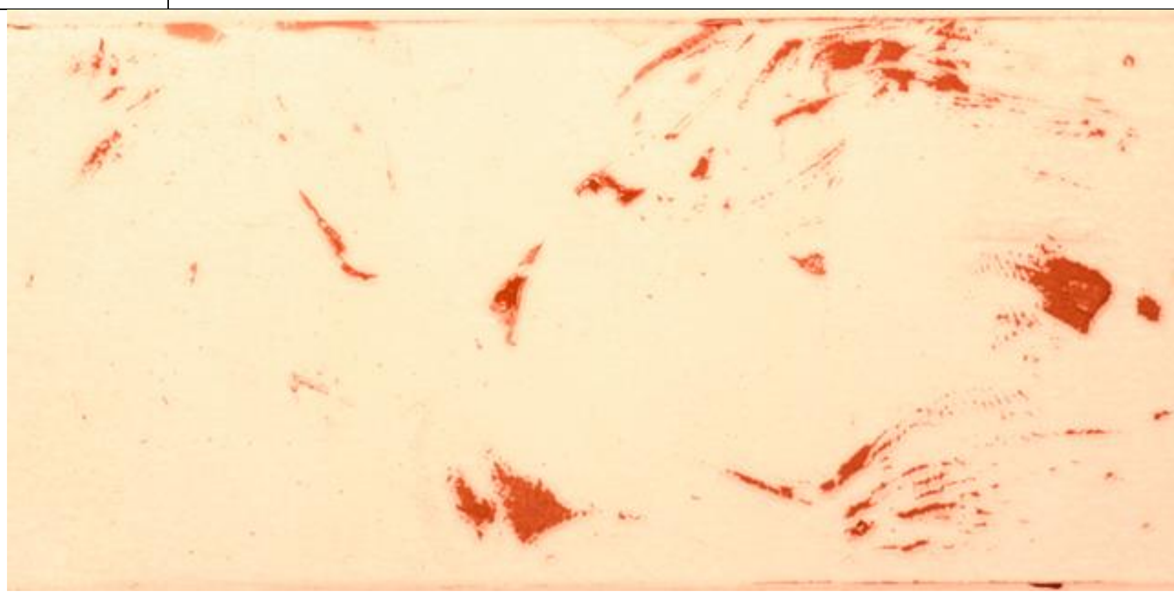
A)

B)

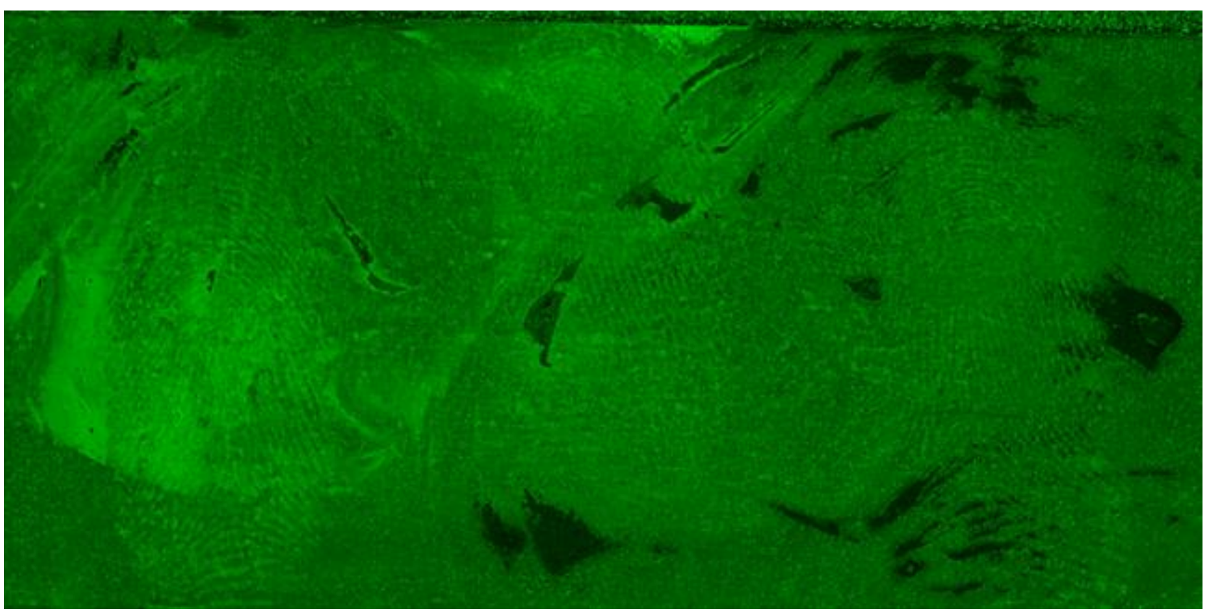
Figure 8: Glass; 3 days sooting; Tape-lift/C (A); Tape-lift/CNA (B) Sample 1

</td></tr>
<tr><td>Mikrosil/C;
Mikrosil/CNA</td><td><u>Mikrosil/C-Median=0; SD=0</u>
<u>Mikrosil/CNA-Median=18; SD=4.158</u>
Statistically significant difference (p=.001; ch2=36). The alternative hypothesis was accepted.</td></tr>
</table>

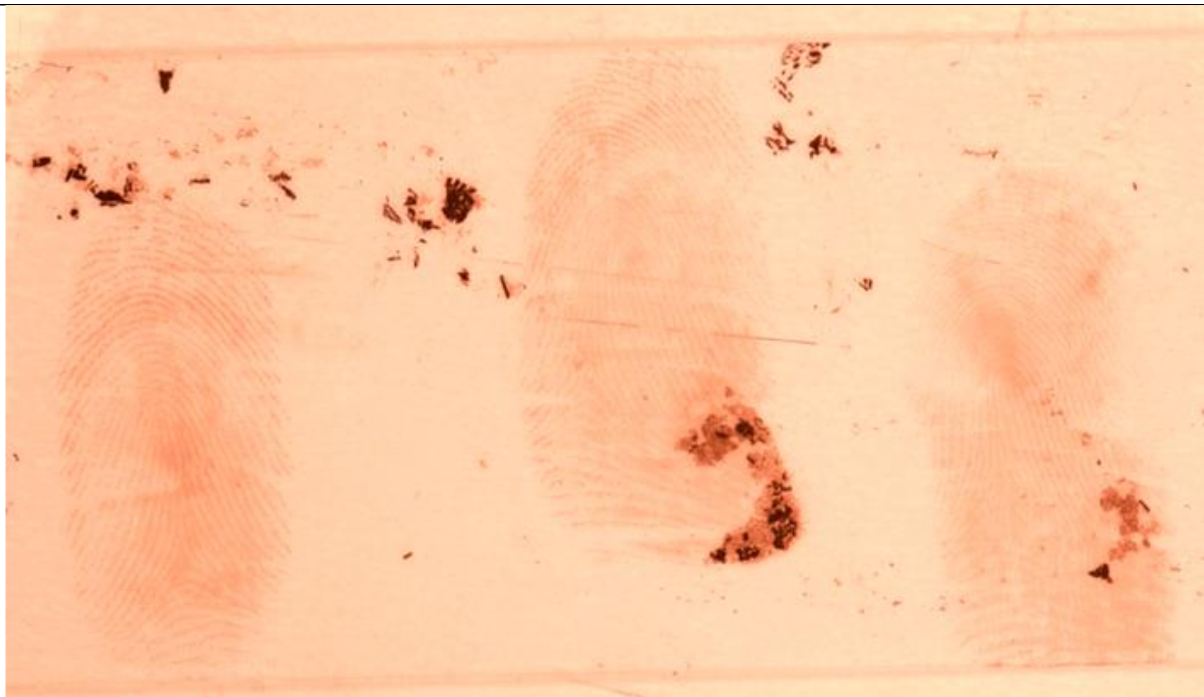
	Due to Mikrosil/C scoring no results (Figure 9, A), this suggests Mikrosil/CNA is the better method and Mikrosil/C needs developing using cyanoacrylate fuming and BY40. This could be because a single application of the Mikrosil paste removed the soot from the ridge detail in the fingermark. This allowed the cyanoacrylate fuming to attach to the ridge detail (Figure 9, B) (Ramotowski, 2013).



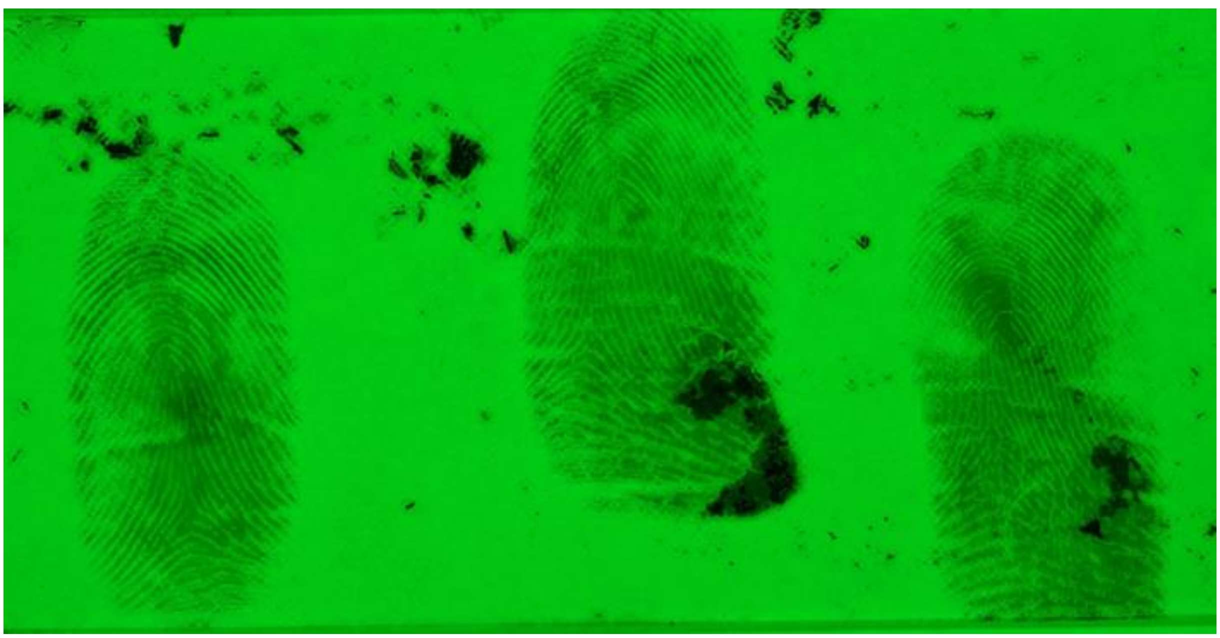
A)



B) ***Figure 9: Glass; 2 days sooting; Mikrosil/C (A); Mikrosil/CNA (B) Sample 1***	
H_2O/C; **H_2O/CNA**	<u>H_2O/C-Median:18; SD=3.194</u> <u>H_2O/CNA-Median:16.50; SD=3.875</u> No statistically significant difference (p=.857; chi2=0.032). The null hypothesis is accepted. The reason there is not a significant difference between the cleaned and developed samples could be because the H_2O soak does not remove the soot from the ridge detail. It is likely for the cyanoacrylate fuming to not attach to the ridge detail hence why there is no difference between the cleaned and the developed fingermarks. Therefore, the results are very similar to each other (Figure 10 A, B). Therefore, development methods may not be needed in the use of H_2O soak. However, the minimum score of H_2O/CNA is lower (6) than the minimum score of H_2O/C (8). This may suggest that the development method leads to the loss of ridge detail. Instead, it could be suggested to visualise the cleaned fingermarks under a fluorescent light to provide a better contrast between the ridge detail and the background (Figure 10 B).



A)



B)

Figure 10: Glass; 3 days sooting; H_2O/C (A) H_2O/CNA (B); Sample 1; Developed

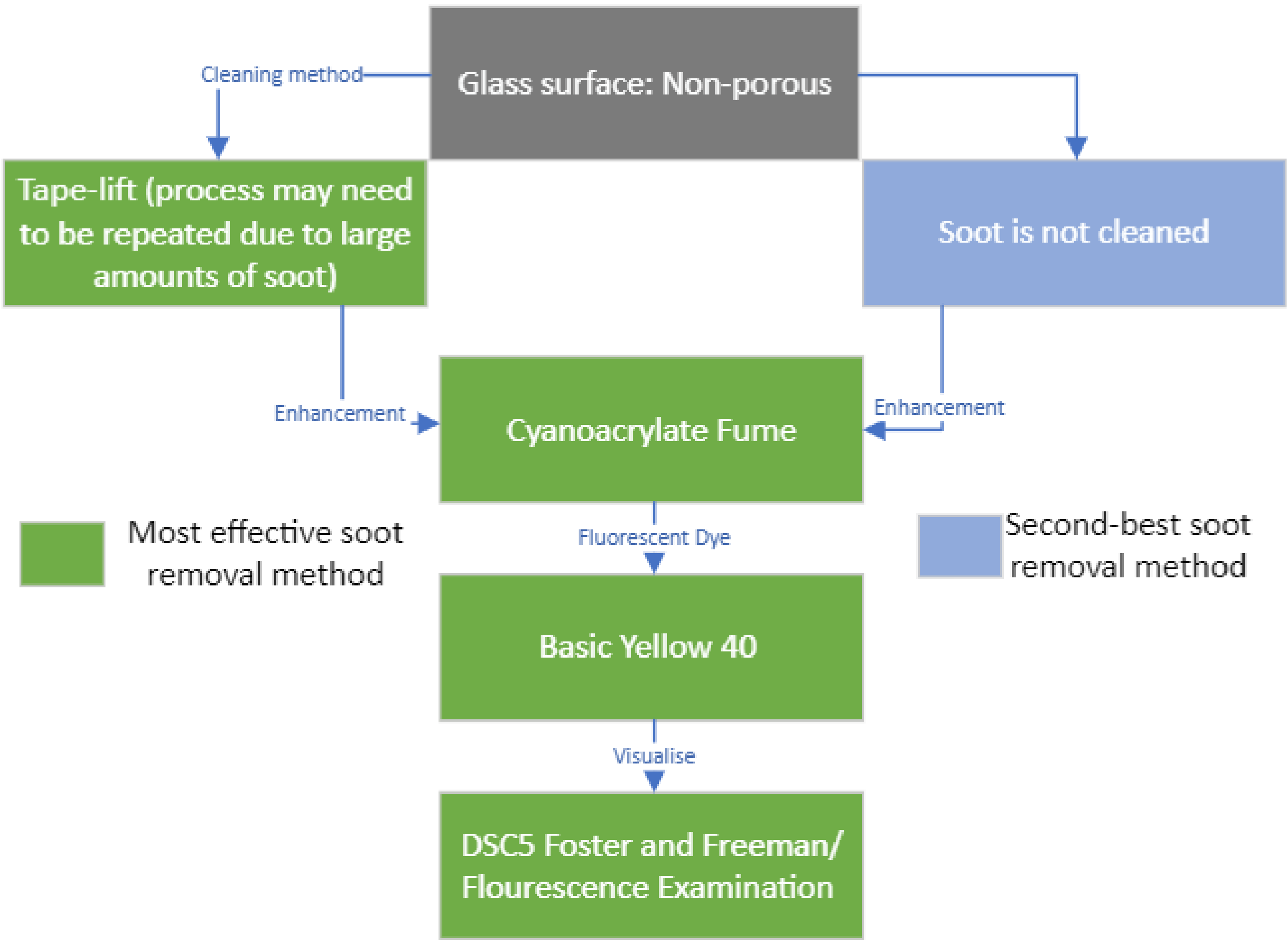
These results could suggest that Tape-lift/CNA may be the best method for the glass surface cleaning. This is because it has the lowest SD=2.155 and a high median=19 score. Due to tape-lift cleaning the ridge detail sufficiently, this allows the CFM polymers to attach to the eccrine and sebaceous sweat of the fingermark (Ramotowski, 2013) (Figures 8 A, B). Tape-lift being successful for this study could be supported by guidance provided by the Home Office (2022) since tape-lift is one of the soot cleaning methods recommended by them. However, they recommend that this method is repeated. Ahmad et al. (2011) found that the best soot cleaning method for glass surface is tape-lift, the researchers also found that this method can be used in combination with brushing the soot off and NaOH 2% wash. Ahmad et al. (2011) repeated the tape-lift method. Since success has been seen without the method being repeated in the author's research, it could be suggested that the repetitiveness may not be needed. However, this may be dependent on the soot type (Home Office, 2022).

The second-best method is No clean/CNA because it has a little higher SD=2.209 and a high median=17 score. Cyanoacrylate fuming is advised to be applied to this method because it makes the visualisation of the ridge detail better, negatively, the median score is also lower. However, this method may not be useful with higher amount of soot on the ridge detail because it may not cyanoacrylate fume. Flowchart 1 shows a simplified method for the best cleaning methods for the glass surface.

On the other hand, No clean/CNA has a higher minimum score of 12 in comparison to the minimum score of tape-lift/CNA (10). This could be due to the soot amount on the samples, for instance, if there was little to no soot on the No clean samples, this would have made it easier to see the ridge detail.

Results showed that CFM used after the H_2O cleaning methods causes a loss in the detail of the fingermark. This could be due to the chemical development used on the fingermark that could cause degradation of the ridge detail. Conversely, the use of the fluorescent light makes the contrast better, suggesting that the fingermark was graded higher due to the contrast between the ridge detail and the background. CFM may not be needed because H_2O does not clean the ridge detail from the soot. This has led to the cyanoacrylate not attaching to the ridge detail of the fingermark.

Lastly, Mikrosil performed the worst for the glass surface. This could be due to Mikrosil having stronger adhesive properties than tape-lift. This could have caused the ridge detail to be picked up by the Mikrosil paste. However, the amount of soot on the samples could have been lower in comparison to the amount of soot tape-lift has cleaned. Therefore, due to the lowest soot amounts, the Mikrosil adhesive would stick harshly to the ridge detail.



Flowchart 1: Glass surface soot cleaning method

Aluminium surface: Wilcoxon-ranked test results

The null hypothesis was accepted: there will not be a difference between the cleaning method for the following pairs from a Wilcoxon-ranked test:

Table 7: Wilcoxon-rank test; all aluminium samples with no statistically significant difference

No clean-Median=14; SD=7.940 compared against:

1. Tape-lift/C-Median=17; SD=5.234

No statistically significant difference (p=.003; r=0.000).

2. Mikrosil/CNA-Median=16; SD=8.222

No statistically significant difference (p=.500; r=0.112).

No clean/CNA-Median=18; SD=2.846 compared against:

1. Tape-lift/C-Median=17; SD=5.234

No statistically significant difference (p=.050; r=0.326).

2. Tape-lift/CNA-Median=17; SD=5.340

No statistically significant difference (p=.140; r=0.246).

3. H_2O/C-Median=19; SD=1.254

No statistically significant difference (p=.003; r=0.491)

4. H_2O/CNA-Median=19; SD=2.077

No statistically significant difference (p=.542; r=0.102)

5. Mikrosil/CNA-Median=16; SD=8.222

No statistically significant difference (p=.005; r=0.468)

Tape-lift/C-Median=17; SD=5.234 compared against:

1. Tape-lift/CNA-Median=17; SD=5.340

No statistically significant difference (p=.346; r=0.157).

2. <u>H_2O/CNA-Median=19; SD=2.077</u>

No statistically significant difference (p=.031; r=0.360).

3. <u>Mikrosil/CNA-Median=16; SD=8.222</u>

No statistically significant difference (p=.030; r=0.362).

Tape-lift/CNA-Median=17; SD=5.340 compared against:

1. <u>H_2O/CNA-Median=19; SD=2.077</u>

No statistically significant difference (p=0.080; r=0.292).

2. <u>Mikrosil/CNA-Median=16; SD=8.222</u>

No statistically significant difference (p=.018; r=0.393).

H_2O/CNA-Median=19; SD=2.077 compared against:

1. <u>H_2O/C-Median=19; SD=1.254</u>

No statistically significant difference (p=0.002; r=0.511).

The following samples were statistically significant, suggesting that the alternative hypothesis was accepted for the following pairs from a Wilcoxon-ranked test:

Table 8: Wilcoxon-rank test; all aluminium samples with statistically significant difference

No clean (Median=14; SD=7.940) compared against:

Minimum score:0

Maximum score:20

1. <u>No clean/CNA-Median=18; SD=2.846</u>

Minimum score:8

Maximum score:20

Statistically significant difference ($p=0.001$; $r=0.745$).

Therefore, No clean/CNA was more successful due to the lower SD and higher minimum score. This is due to the reflective properties of the aluminium surface since the sooted ridge detail would not cyanoacrylate fume.

2. Tape-lift/CNA-Median=17; SD=5.340

Minimum score:4

Maximum score:20

Statistically significant difference ($p=.001$; $r=0.578$).

Therefore, tape-lift/CNA is the better cleaning method because it scored a lower SD and a higher minimum score.

3. H_2O/C-Median=19; SD=1.254

Minimum score:15

Maximum score:20

Statistically significant difference ($p=.001$; $r=0.786$).

This suggests that H_2O/C is a better cleaning method because of the low SD and a higher minimum score.

4. H_2O/CNA-Median=19; SD=2.077

Minimum score:14

Maximum score:20

Statistically significant difference ($p=.001$; $R=0.67$).

This suggests that H_2O/CNA is the better cleaning method due to the lower SD and the higher minimum score.

5. Mikrosil/C-Median=0.00; SD=4.241

Minimum score:0

Maximum score:16

Statistically significant difference ($p=.001$; $r=0.657$).

This suggests that Mikrosil/C is a better cleaning method due to the lower SD, however, No clean scored a higher maximum value than Mikrosil/C. Also, the Mikrosil/C could have a lot more zero or low scores hence why it has a lower SD (Figure 11). Therefore, No clean may be the better method.

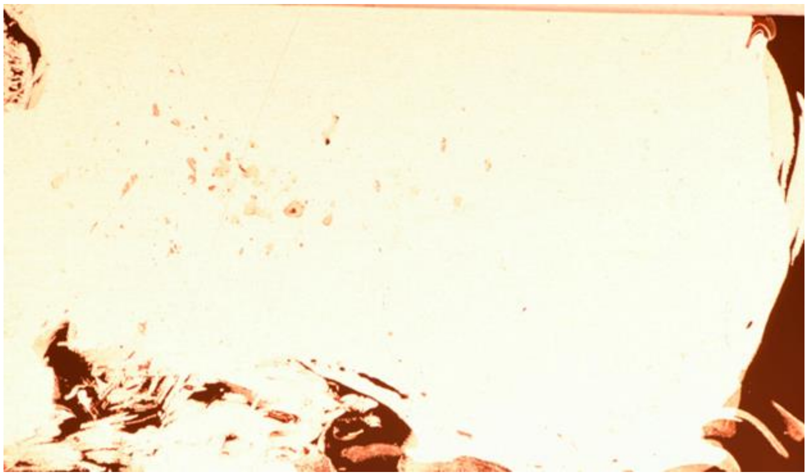


Figure 11: Aluminium; 2 days sooting; Mikrosil/C; Sample 2

No clean/CNA, Tape-lift/CNA, H_2O/C, H_2O/CNA, Mikrosil/C are better cleaning methods than No clean. However, this could be due to the lack of development on the No clean samples.

Mikrosil/C-Median=0.00; SD=4.241 compared against:

Minimum score:0

Maximum score:16

1. <u>No clean/CNA-Median=18; SD=2.846</u>

Minimum score:8

Maximum score:20

Statistically significant difference (p=.001; r=0.861).

This suggests that No clean/CNA is the better cleaning method due to the lower SD and a higher minimum and maximum score.

2. <u>Tape-lift/C-Median=17; SD=5.234</u>

Minimum score:5

Maximum score:20

Statistically significant difference (p=0.001; r=0.836) against Mikrosil/C.

This suggests that Mikrosil/C is a better cleaning method due to the lower SD, however, Mikrosil/C has a lower minimum and maximum score.

3. <u>Tape-lift/CNA-Median=17; SD=5.340</u>

Minimum score:4

Maximum score:20

Statistically significant difference (p=0.001; r=0.826) against Mikrosil/C.

This suggests that Mikrosil/C is a better cleaning method due to the lower SD, however, Mikrosil/C has a lower minimum and maximum score than tape-lift/CNA.

4. <u>H_2O/C-Median=19; SD=1.254</u>

Minimum sccore:15

Maximum score:20

Statistically significant difference (p=.001; r=0.880).

H_2O/C scored a minimum score of 15 and a maximum of 20. This suggests that H_2O/C is a better cleaning method due to a lower SD and a higher minimum score.

5. H_2O/CNA-Median=19; SD=2.077

Minimum score:14

Maximum score:20

Statistically significant difference (p=.001; r=0.862).

This suggests that H_2O/CNA is a better cleaning method due to the lower SD and a higher minimum score.

6. Mikrosil/CNA-Median=16; SD=8.222

Minimum score:0

Maximum score:20

Statistically significant difference (p=.001; r=0.744).

Mikrosil/CNA scored a minimum score of 0 and a maximum score of 20. This suggests that Mikrosil/C is a better cleaning method due to the lower SD, however, the Mikrosil/CNA has a higher maximum score.

H_2O/C-Median=19; SD=1.254 compared against:

Minimum score:15

Maximum score:20

1. Tape-lift/C-Median=17; SD=5.234

Minimum score:5

Maximum score:20

Statistically significant difference (p=.001; r=0.657).

This suggests that H_2O/C is a better cleaning method due to the lower SD and a higher minimum score.

2. Tape-lift/CNA-Median=17; SD=5.340

Minimum score:4

Maximum score:20 Statistically significant (p=.001; r=0.549). This suggests that H_2O/C is the better cleaning method due to the lower SD and a higher minimum score. 3. <u>Mikrosil/CNA-Median=16; SD=8.222</u> Minimum score:0 Maximum score:20 Statistically significant difference (p=.001; r=0.762) against H_2O/C. This suggests that H_2O/C is a better cleaning method due to the lower SD and a higher minimum score.

H_2O/CNA-Median=19; SD=2.077 compared against: Minimum score:14 Maximum score:20 1. <u>Mikrosil/CNA (Median=16; SD=8.222)</u> Statistically significant difference (p=.001; r=0.544). Minimum score:0 Maximum score:20 This suggests that H_2O/CNA is the better cleaning method due to the low SD and a higher minimum score.

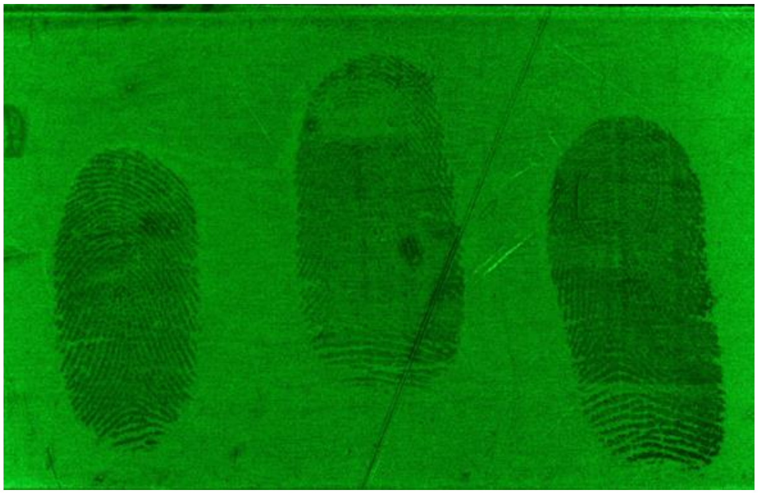
Aluminium surface: Friedman Test

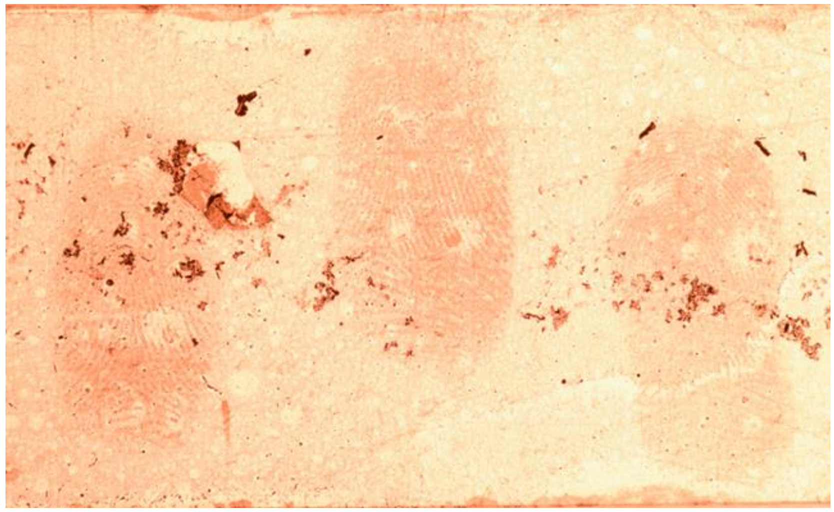
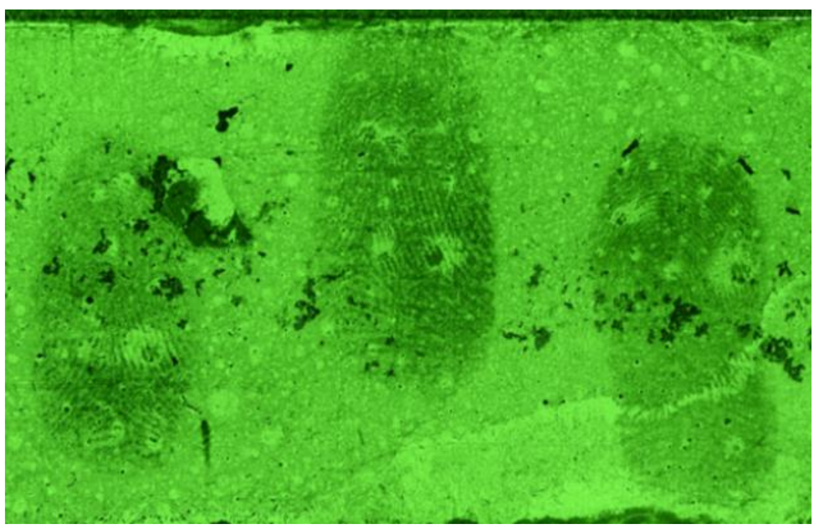
Table 9: Aluminium surface Fridman K-related test

Aluminium surface:	**Friedman Test**

Related samples	
No clean; No clean/CNA	**No clean- Median=14; SD=7.940** Minimum score:8 Maximum score:20 **No clean/CNA- Median=18; SD=2.846** Minimum score:0 Maximum score:20 There was a statistically significant difference (p=.001; chi2=20.829). Due to the higher median value and the lower SD in No clean/CNA, No clean/CNA is a better method. This shows that cyanoacrylate fuming and BY40 is needed to visualise the ridge detail.  ***A)***

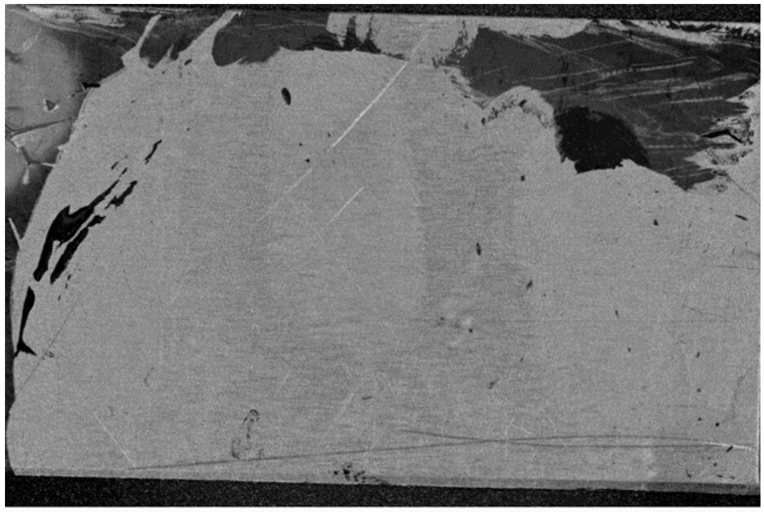
	 ***B)*** ***Figure 12: Aluminiumm;2 days No clean (A) No cleaning/CNA (B) sample1***
Tape-lift/C; Tape-lift/CNA	**Tape-lift/C- Median=17; SD=5.234** Minimum score:5 Maximum score:20 **Tape-lift/CNA- Median=17; SD=5.340** Minimum score:4 Maximum score:20 There was not a statistically significant difference (p=.221; chi2=1.500) Cyanoacrylate fuming may not be needed for the visualisation of ridge detail following this cleaning method. This could be due to the ridge detail not being cleaned from the soot (Figure 13 A, B). Therefore, the ridge detail does not fluoresce. However, cyanoacrylate fuming may be possible if the tape-lift method was repeated multiple times until the ridge detail is latent.

	 ***A)***  ***B)*** ***Figure 13: Aluminium; 2 days sooting; Tape-lift/C (A) Tape-lift/CNA (B); Sample 2***
H_2O/C; **H_2O/CNA**	**H_2O/C -Median=19; SD=1.254** Minimum sccore:15 Maximum score:20 **H_2O/CNA -Median=19; SD=2.077** Minimum score:14 Maximum score:20 There was not a statistically significant difference (p=.034; chi2=4.481).

	This could be due to the same reason tape-lift does not need cyanoacrylate fuming, because the ridge detail still has soot on the ridge detail (Figure 14 A, B). However, the reflectiveness of aluminium may be useful under fluorescent light. However, the cyanoacrylate fuming and BY40 staining steps may be skipped.  ***A)***  ***B)*** ***Figure 14: Aluminium 3 days sooting; H_2O/C (A) H_2O/CNA (B); sample 1; DSC5***
Mikrosil/C; Mikrosil/CNA	**Mikrosil/C -Median=0.00; SD=4.241** Minimum score:0 Maximum score:16 **Mikrosil/CNA -Median=16; SD=8.222**

	Minimum score:0 Maximum score:20 There was a statistically significant difference (p=.001; chi2=26.000). This could be because Mikrosil/CNA scored a higher maximum score (20), whereas just cleaned scored a lower maximum score (16), both scored a 0 as a minimum score. Due to Mikrsoil cleaning the ridge detail from soot very sufficiently, cyanoacrylate fuming and BY40 are needed steps in the development of the fingermarks (Figure 15 A, B).

A)



B)

Figure 15: Aluminium; 2 days sooting; Mikrosil/C (A) Mikrosil/CAN (B); Sample 1

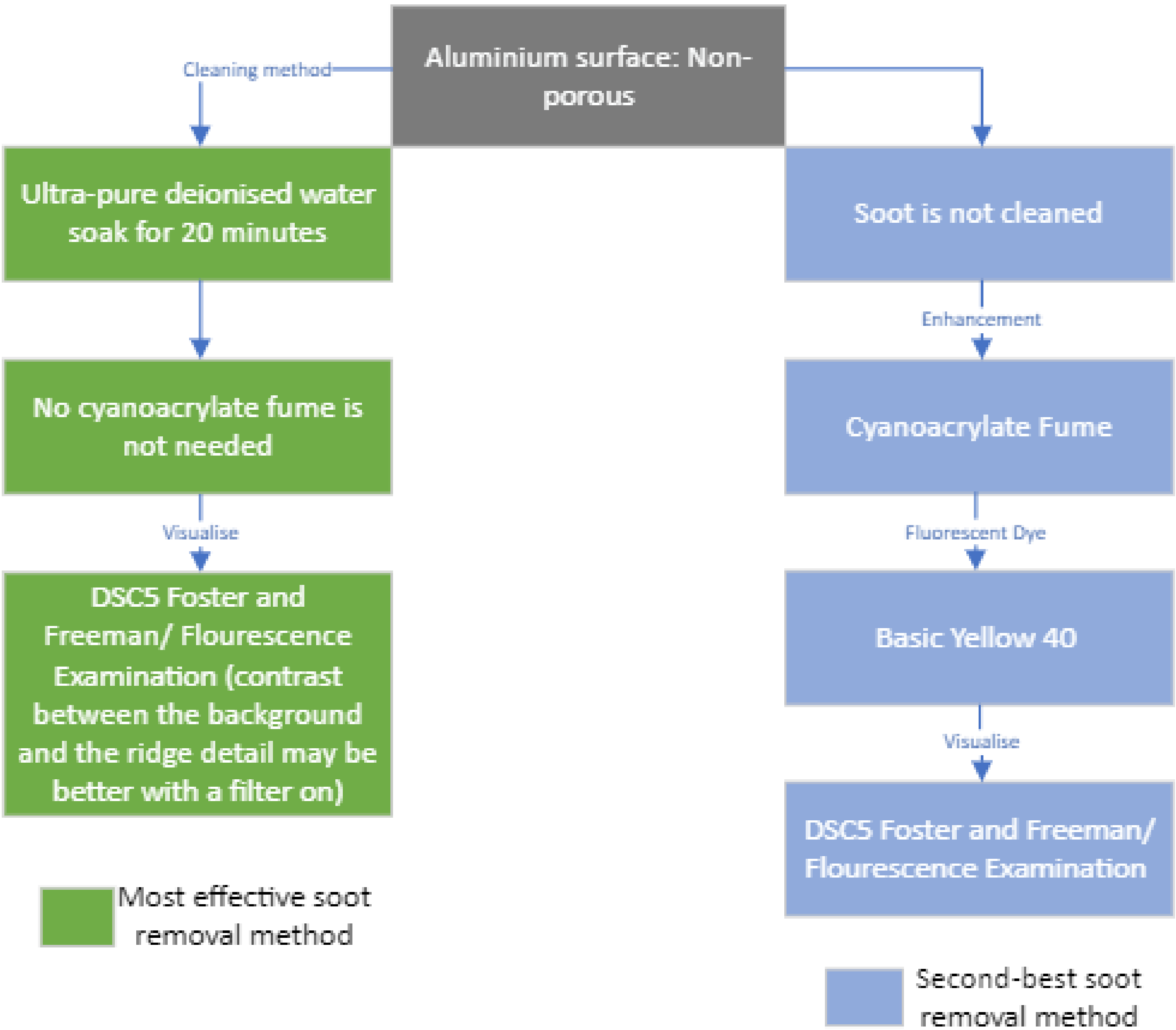
The best cleaning method for the aluminium surface may be H_2O/CNA due to the high median= 19 score and lowest SD=2.077. However, no statistical difference was found between H_2O/C and H_2O/CNA, suggesting that the CNA development stage undertaken may not be needed. This could be due to the ridge detail not being cleaned correctly which caused the ridge detail to not be cyanoacrylate fumed. However, it may be beneficial to use a light source to create a better contrast between the ridge detail and the aluminium surface. Flowchart 2 shows a simplified method for the best cleaning methods for the aluminium surface.

The second-best cleaning method was No clean/CNA, due to the low SD=2.844 and high Median=18 score. No clean/CNA is better than No clean because the fluorescent light creates a better contrast between the ridge detail and the background. Therefore, it may be better to skip the cyanoacrylate method and BY40 staining method and instead, just apply fluorescent light on the sample.

Additionally, H_2O/CNA and H_2O/C are the better cleaning methods due to the higher minimum amounts scored (14, 15), whereas, No clean/CNA scored a low minimum score of 0. However, this could be due to large amounts of soot on the samples. This could suggest that the fingermark could be exposed to minimal cleaning methods such as a light brushing so it reveals some of the ridge detail (Bleay, Bradshaw and Moore, (2006) and Home Office (2022). Similar to the guidance the Home Office (2022) has provided guidance on the different types of soot, soot amount and has categorised cleaning methods according to how destructive they can be to the fingermarks.

The worst method was Mikrosil/CNA as it has a very high SD=8.22. This suggests that there is a huge variety of results, therefore it may not be a reliable method to use. However, the Mikrosil method cleaned the ridge detail well as seen in Figure 14 A, B. However, it cleaned it so well that the cyanoacrylate fuming could not attach to the eccrine and sebaceous sweat because it would have been removed with the Mikrosil (Ramotowski, 2013). Conversely, the ridge detail may not be visible due to the aluminium surface reflecting the light which causes the loss of ridge detail.

Trapecar (2012) found that cyanoacrylate fuming is a better development method than small particle reagent of fingermarks on metal surfaces after being exposed to stagnant water. This experiment does not focus on soot removal, however, they found that the fingermark quality begins to decrease after four hours of stagnant water exposure. However, some fingermarks were recovered following exposure for 1 week. Positively, this research supports the findings of this experiment since the samples were soaked in stagnant water to attempt to clean the soot.



Flowchart 2: Aluminium surface soot cleaning method

PVC surface: Wilcoxon-ranked Test

The null hypothesis was accepted: there will not be a difference between the cleaning method for the following pairs from a Wilcoxon-ranked test:

Table 10: Wilcoxon-rank test; all PVC samples with no statistically significant difference

No clean- Median=0.00; SD=5.457 compared against:

1. Tape=lift/C- Median=0.00; SD=0.667

No statistically significant difference (p=.039; r=0.343).

2. H_2O/C- Median=0.00; SD=1.626

No statistically significant difference (p=.046; r=0.333).

3. H_2O/CAN- Median=2.50; SD=8.051

No statistically significant difference (p=.003; R=0.498).

4. Mikrosil/C- Median=0.00; SD=2.730

No statistically significant difference (p=.125; r=0.256).

H_2O/CNA- Median=2.50; SD=8.051 compared against:

No clean/CNA- Median=10; SD=7.461

No statistically significant different (p=.064; r=0.309).

Tape-lift/C- Median=0.00; SD=0.667 compared against:

1. H_2O/C- Median=0.00; SD=1.626

No statistically significant difference (p=.276; r=0.182).

2. Mikrosil/C- Median=0.00; SD=2.730

No statistically significant difference (p=0.414; r=0.136).

H_2O/C- Median=0.00; SD=1.626 compared against:

1. Mikrosil/C- Median=0.00; SD=2.730

No statistically significant difference (p=1.000; r=0).

The following samples were statistically significant, suggesting that the alternative hypothesis was accepted for the following pairs from a Wilcoxon-ranked test:

Table 11: Wilcoxon-rank test; all PVC samples with statistically significant difference

No clean-Median=0.00; SD=5.457 compared against:

Minimum score:0

Maximum score:17

1. No clean/CNA-Median=10; SD=7.461

Statistically significant difference (p=.001; r=0.663).

Minimum score:0

Maximum score:20

No clean is a better cleaning method due to the lower SD, however, No clean/CNA showed a higher maximum score. This could suggest that CNA provides a little bit more detail than no CNA.

2. Tape-lift/CNA-Median=17; SD=4.661

Statistically significant difference (p=.001; r=0.816).

Minimum score:5

Maximum score:20

Tape-lift/CNA is the better cleaning method because it scored a lower SD and scored a higher minimal and maximum score, in comparison to No clean.

3. Mikrosil/CNA-Median=20; SD=2.652

elicited a statistically significant difference (p=.001; r=0.868).

Minimum score:13

Maximum score:20

Mikrosil/CNA is a better cleaning method due to the low SD and higher minimum and maximum scores.

No clean/CNA-Median=10; SD=7.461 (Figure 16) compared against:

Minimum score:0

Maximum score:20

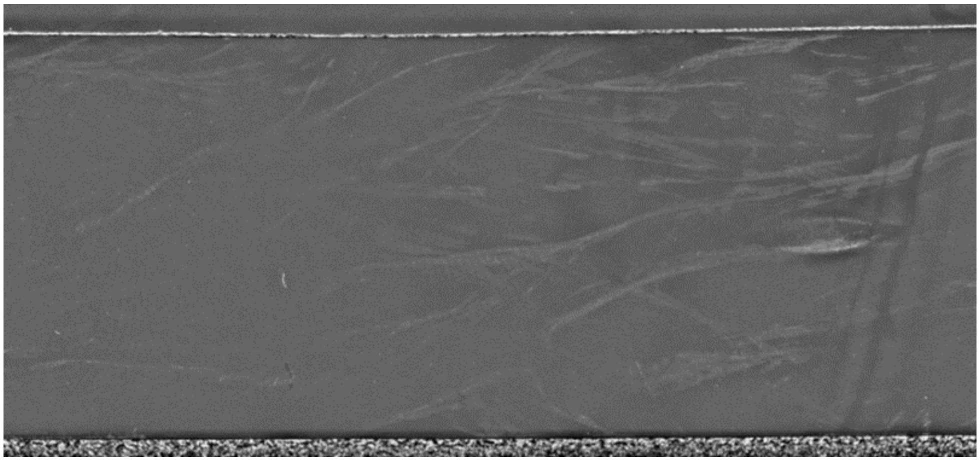


Figure 16: PVC; 7 days sooting; No clean/CNA; Sample 2

1. Tape-lift/C-Median=0.00; SD=0.667

Minimum score:0

Maximum score:4

Statistically significant difference (p=.001; r=0.73)

Despite tape-lift/C has a lower SD, the maximum score is 4, whereas, No clean/CNA maximum score is 20. Suggesting, No clean/CNA is the better cleaning method.

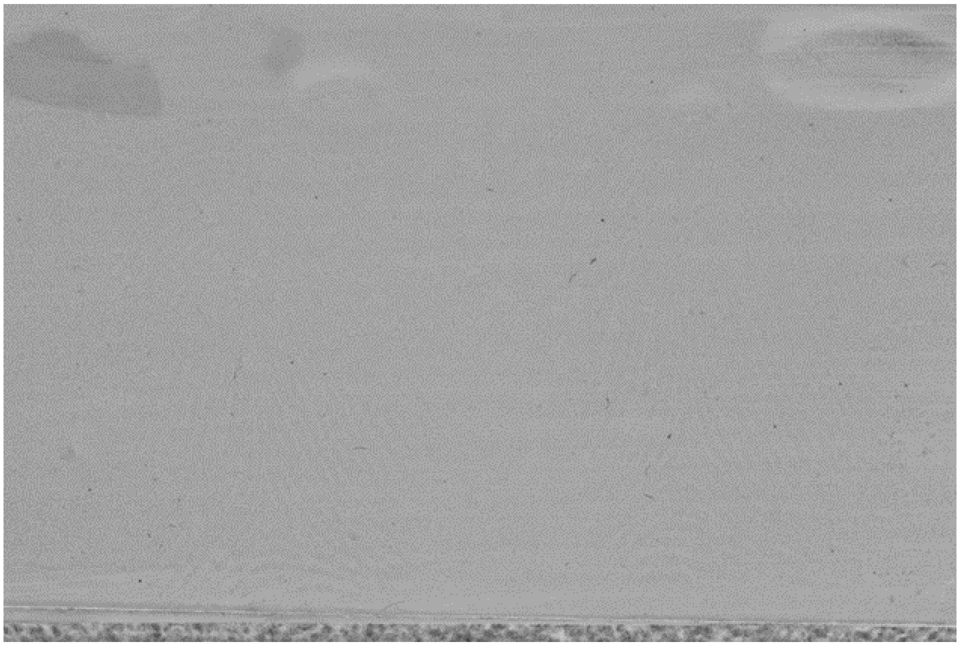
2. Tape-lift/CNA-Median=17; SD=4.661 (Figure 17)

Minimum score:5

Maximum score:20

Statistically significant difference (p=.001; r=0.54).

This suggests that tape-lift/CNA yielded better results due to the lower SD and a higher minimum score.



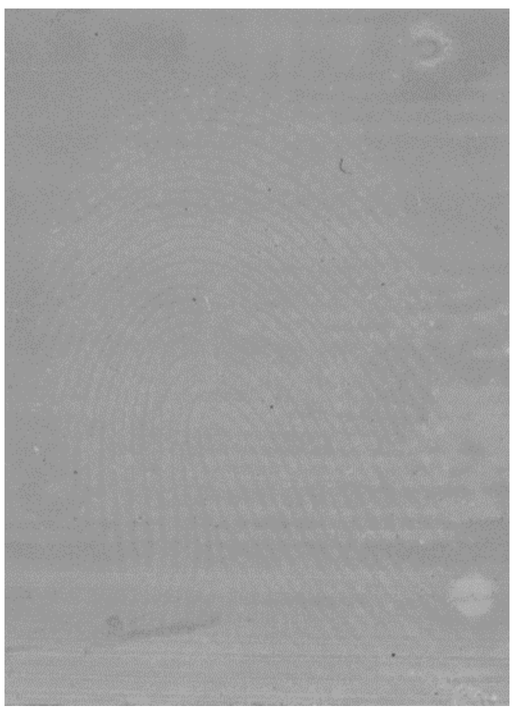


Figure 17: PVC; 3 days sooting; Tape-lift/CNA; sample 3

3. H_2O/C-Median=0.00; SD=1.626 (Figure 18)

Minimum score:0

Maximum score:7

Statistically significant difference (p=.001; r=0.73).

This suggests that H_2O/C yields better results due to the lower SD, however, it has a low maximum score.

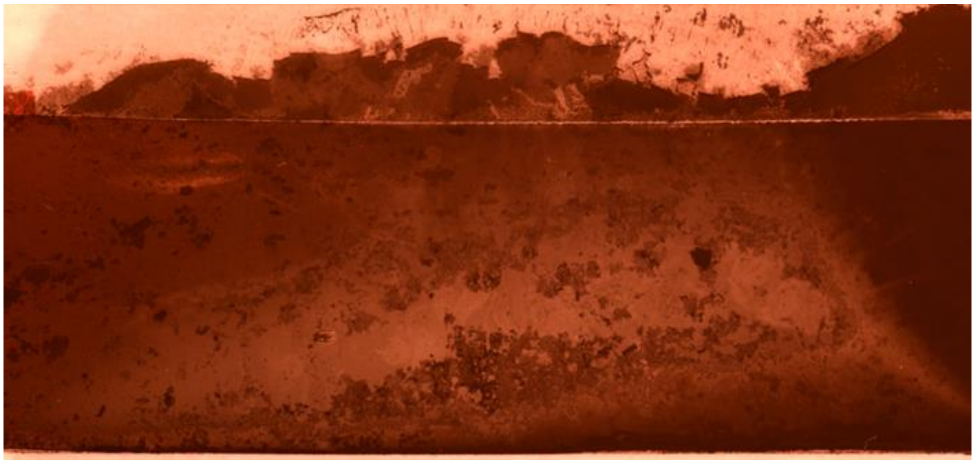


Figure 18: PVC; 3days sooting; H_2O/C; sample 3

4. Mikrosil/C-(Median=0.00; SD=2.730

Minimum score:0

Maximum score:16

Statistically significant difference (p=.001; r=0.721).

This suggests that No clean/CNA is a better cleaning method, however, Mikrosil/C scored a higher maximum value.

5. Mikrosil/CNA-Median=20; SD=2.652

Minimum score:13

Maximum score:20

Statistically significant difference (p=.001; r=0.770).

Mikrosil/CNA (Figure 19) is the better cleaning method due to the lower SD and a higher minimum score.

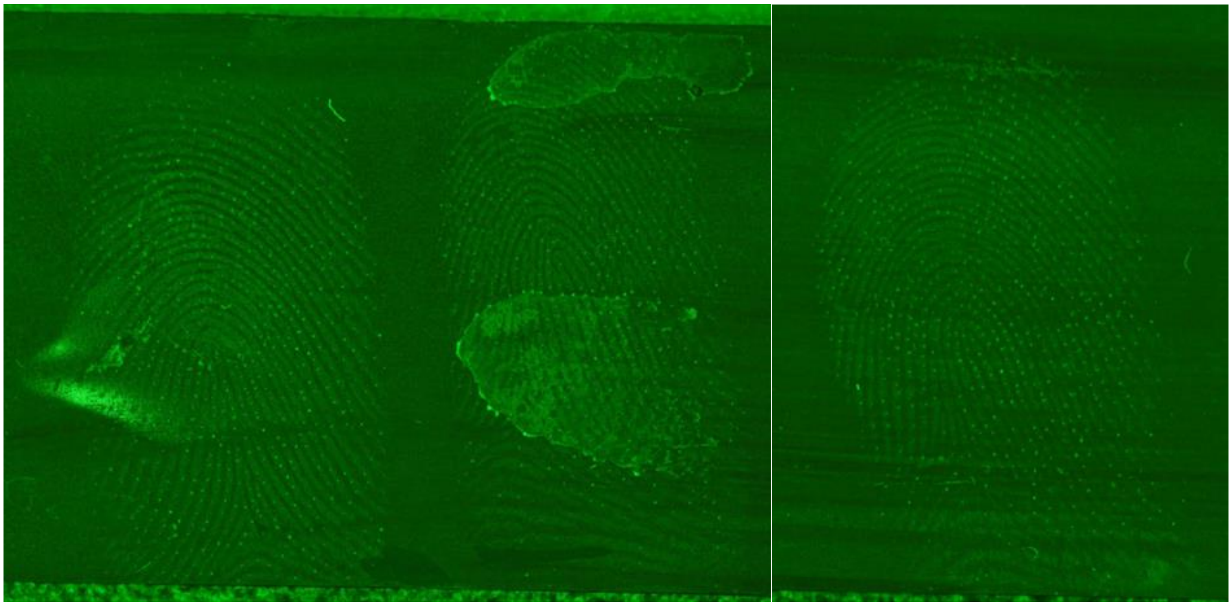


Figure 19: PVC 3 days sooting; Mikrosil/CNA; Sample 3

Tape-lift/C-Median=0.00; SD=0.667 compared against:

Minimum score:0

Maximum score:4

Tape-lift/C has a low SD due to the lack of a variety in scores, this suggests that it is not a good cleaning method. The SD will not be included in the interpretation of the rest of the results.

1. Tape-lift/CNA-Median=17; SD=4.661

Minimum score:5

Maximum score:20

Statistically significant difference (p=0.001; r= .874)

This suggests that tape-lift/CNA is the better cleaning method due to the higher minimum and maximum scores.

2. H_2O/CNA-Median=2.50; SD=8.05

Minimum score:0

Maximum score:19

Statistically significant difference (p=.001; r=.622)

This suggests that H_2O/CNA is the better cleaning method because it scored a higher maximum score.

3. Mikrosil/CNA- Median=20; SD=2.652

Minimum score:13

Maximum score:20

Statistically significant difference (p=0.001; r=.901)

This suggests that Mikrosil/CNA is the better cleaning method due to the higher minimum and maximum score.

Tape-lift/CNA-Median=17; SD=4.661 compared against:

Minimum score:5

Maximum score:20

1. H_2O/C- Median=0.00; SD=1.626

Minimum score:0

Maximum score:7

Statistically significant difference (p=0.001; r=.874)

H_2O/C has a lower SD due to the lack of variety in scores since the maximum score is 7. This mean that tape-lift/CNA is the better cleaning method because it has scored a higher minimum and maximum score.

2. H_2O/CNA-Median=2.50; SD=8.051

Minimum score:0

Maximum score:19

Statistically significant difference (p=.001; r=.666)

This suggests that tape-lift CNA is a better cleaning method due to the lower SD and a higher minimum and maximum score.

3. <u>Mikrosil/C- Median=0.00; SD=2.730</u>

Minimum score:0

Maximum score:16

Statistically significant difference ($p=.001$; $r=.866$)

This suggests that tape-lift/CNA is the better cleaning method due to the higher minimum and maximum scores, despite that Mikrosil/C has a lower SD, however, this is due to the lack of a variety in scores.

4. <u>Mikrosil/CNA- Median=2.50; SD=8.051</u>

Minimum score:13

Maximum score:20

Statistically significant difference ($p=.001$; $r=.696$)

This suggests that Mikrosil/CNA is the better cleaning method due to the higher minimum and maximum scores. However, Tape-lift/CNA has a lower SD, which could mean that the scores are consistent.

H_2O/C-Median=0.00; SD=1.626 compared against:

Minimum score:0

Maximum score:7

The SD if H_2O/C may not be used as a comparator because the maximum score reached is 7, suggesting that there is a lack of a variety of scores, hence why the SD is low.

1. <u>H_2O/CNA-Median=2.50; SD=8.051</u>

Minimum score:0

Maximum score:19

Statistically significant difference ($p=.001$; $r=.621$)

H_2O/CNA is the better cleaning method due to the higher maximum score.

2. <u>Mikrosil/CNA-Median=20; SD=2.652</u>

Minimum score:13

Maximum score:20

Statistically significant difference (p=.001; r=.897)

This suggests that Mikrosil/CNA is the better cleaning method due to the higher minimum and maximum scores.

H_2O/CNA-Median=2.50; SD=8.051 compared against:

Minimum score:0

Maximum score:19

1. <u>Mikrosil/C- Median=0.00; SD=2.730</u>

Minimum score:0

Maximum score:16

Statistically significant difference (p=.001; r=.583)

H_2O/CNA is the better cleaning method due to the higher maximum score, however, Mikrosil/C has a lower SD.

2. <u>Mikrosil/CNA-Median=20; SD=2.652</u>

Minimum score:13

Maximum score:20

Statistically significant difference (p=.001; r=.828)

Mikrosil/CNA is the better cleaning method due to the higher minimum and maximum score and SD.

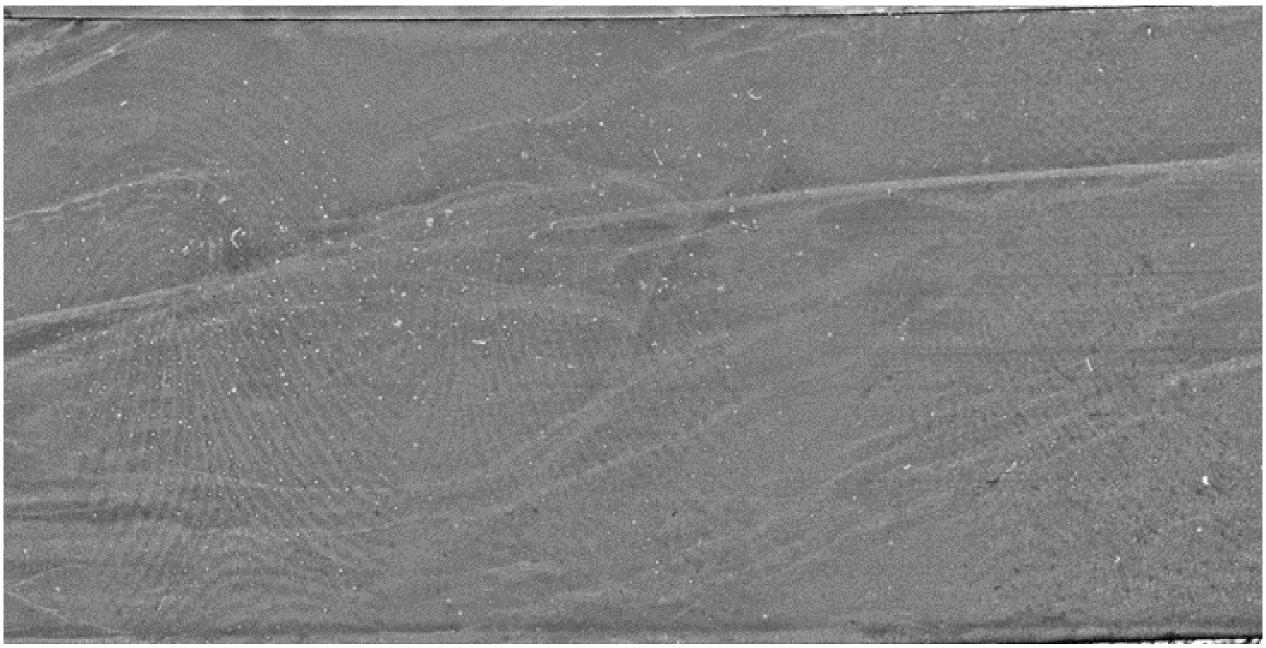
Mikrosil/CNA-Median=20; SD=2.652 compared against: Minimum score:13 Maximum score:20 1. <u>Mikrosil/C-Median=0.00; SD=2.730</u> Minimum score:0 Maximum score:16 Statistically significant difference (p=.001; r=.898) Mikrosil/CNA is better due to the lower SD score and a higher minimum and maximum score.

PVC surface: Friedman Test

Table 12: Glass surface Fridman K-related test

PVC surface: Related samples	Friedman Significant Difference and chi2
No clean: **No clean/CNA**	**No clean** Minimum; Maximum score:0; 17 SD=5.457; Median=0 **No clean/CNA** Minimum; Maximum score:0; 20 SD=7.461 Median=10 Statistically significant difference p=.003; Chi2=9.000 No clean/CNA is the better cleaning method due to the higher maximum number and median score. However, the SD of No clean/CNA is higher than the SD of No clean. The median of No clean could show that the majority of the scores are 0, suggesting that the method is not very successful, but the SD is lower than the more successful method (Figure 20 A, B).

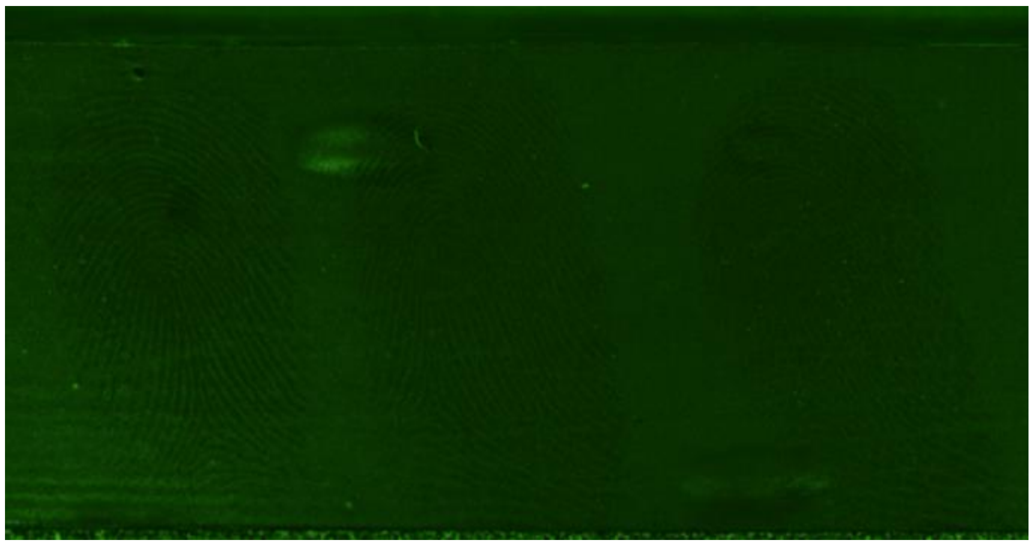
A)



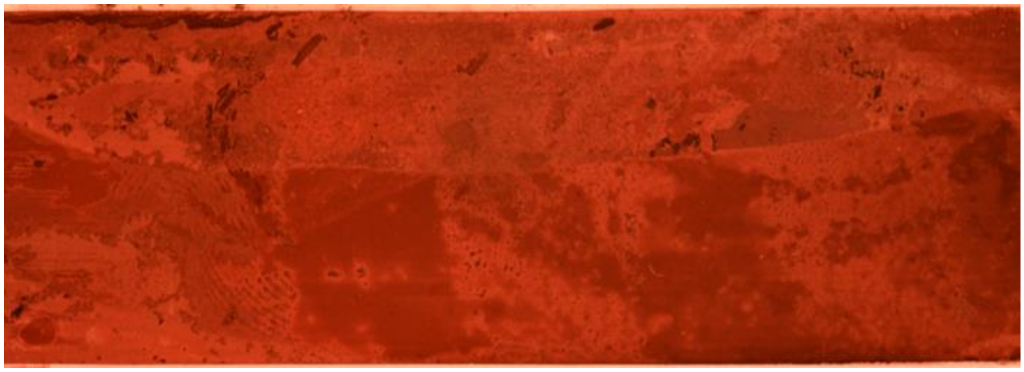
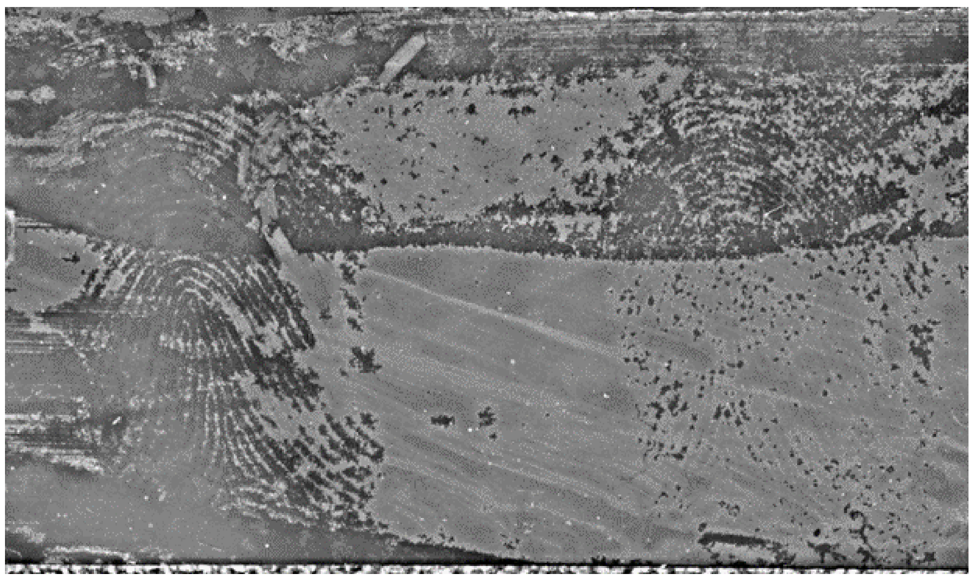
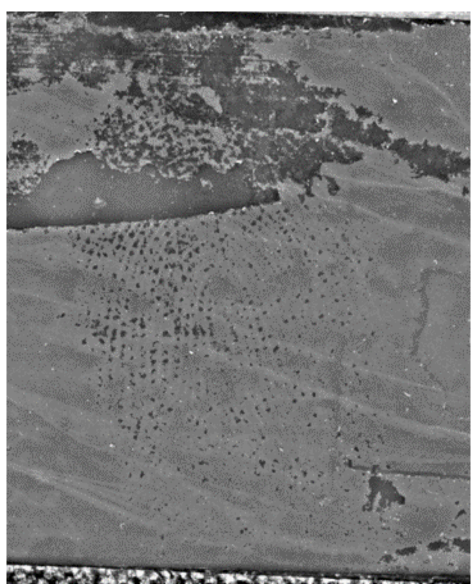
B)

Figure 20: PVC 3 days sooting; No clean/C (A) No clean/CNA (B); Sample 2

Tape-lift/C; Tape-lift/CNA	**Tape-lift/C-Median=0; SD=0.667 (Figure 21 A)** Minimum score:0 Maximum score:4 **Tape-lift/CNA-Median=17; SD=4.661 (Figure 21 B)** Minimum score:5 Maximum score:20 Statistically significant difference p=0.001; 36.000.

<table>
<tr><td></td><td>
A)

B)
Figure 21: PVC 7days sooitng; Tape-lift/C A) Tape-lift/CAN B); Sample 2
Tape-lift/CNA is the better cleaning method because it scored a higher minimum score (5) and a higher maximum score (20) than tape-lift cleaned which scored a minimum (0) and maximum (4) score.</td></tr>
<tr><td>**H_2O/C; H_2O/CNA**</td><td>**H_2O/C-Median=0; SD=1.626 (Figure 22 A)**
Minimum score:0
Maximum score:7

H_2O/CNA-Median=2.50; SD=8.051 (Figure 22 B)
Minimum score:0
Maximum score:19</td></tr>
</table>

	Statistically significant difference p=0.001; chi2=18.000  ***A)***  

	B) ***Figure 22: PVC; 3days sooting; H_2O/C A) H_2O/CNA B); Sample 1*** This could suggest that H_2O/CNA scored was the better cleaning method due to the higher maximum score (19) than H_2O/C (7). Despite, H_2O/C having a lower SD, the score ranges from 0-7, suggesting there is a lack of a variety in scores, hence why the SD is lower.
Mikrosil/C; **Mikrosil CNA**	**Mikrosil/CNA-Median=20; SD= 2.652** Minimum score:13 Maximum score:20 (Refer to Figure 18) **Mikrosil/C-Median=0; SD=2.730 (Figure 23)** Minimum score:0 Maximum score:16 Statistically significant difference p=0.001; chi2=32.111  ***Figure 23: PVC; 3days sooting; Mikrosil/C; Sample 3*** Mikrosil/CNA (Figure 19) and Mikrosil/C are statistically significant. Mikrosil/CNA could be the better cleaning method due to the higher minimum (13) and maximum (20) score, whereas Mikrosil/CNA scored a lower minimum (0) and maximum (16) score.

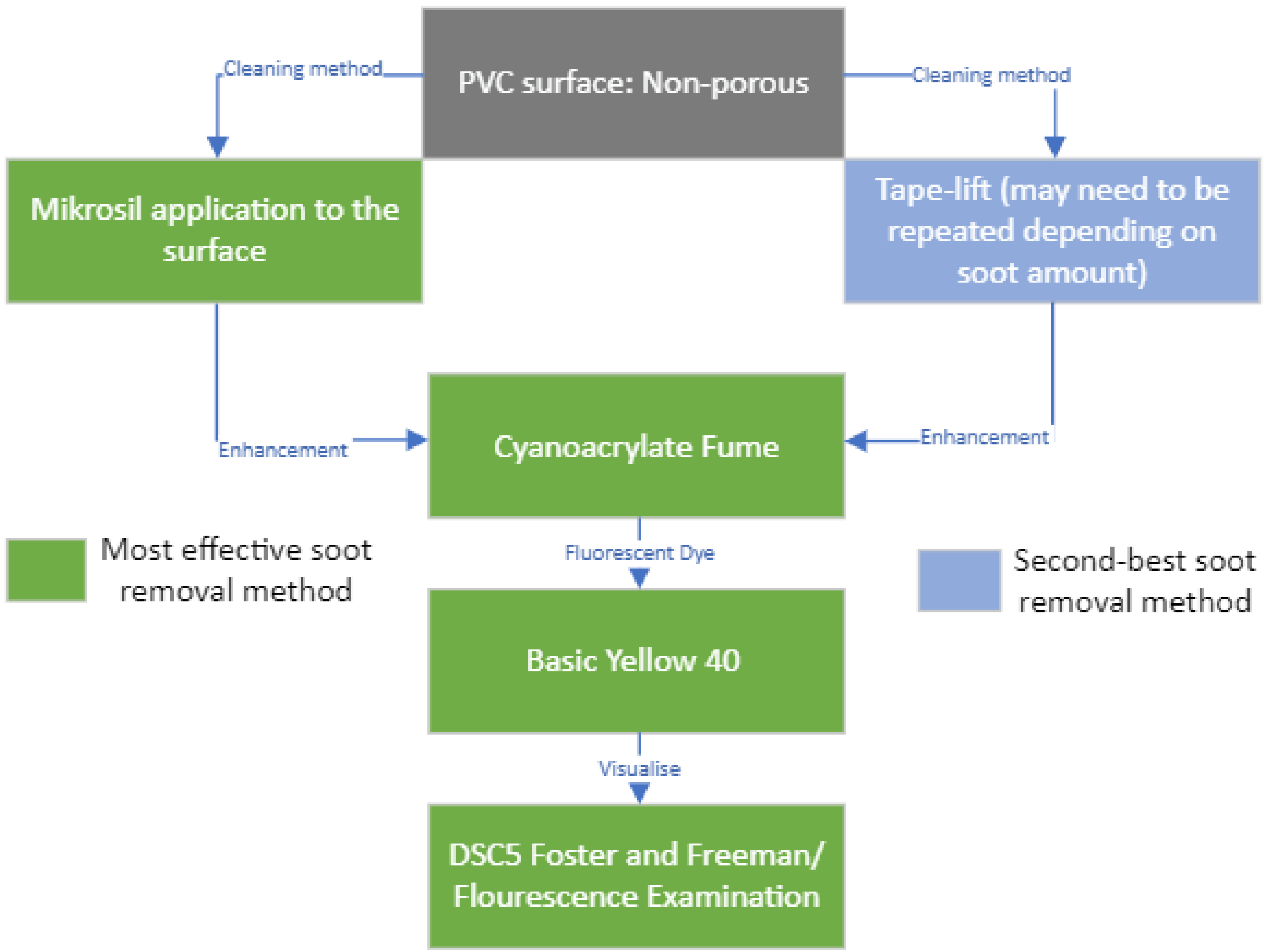
Mikrosil/CNA has performed the best for the PVC surface, due to the higher median=20 score and the lowest SD=2.652 score. Therefore, Mikrosil method requires to be developed using CFM due to the lower median=0 score, suggesting that fingermarks are not visible.

The second-best cleaning method for PVC surface is Tape-lift/CNA, this is because of the high median=17 score, however, this method scored a high SD=4.661 score. This suggests that the methods who have adhesive properties are better methods for the PVC surface. Factors which could have affected the success of both Mikrosil and Tape-lift methods could be the amount of soot on the surface. However, it can also be seen in figure 21 that tape-lift/C did not clean the ridge detail from the soot, suggesting that the polymers of the CFM method could not attach to the sebaceous and eccrine sweat of the fingermark. Therefore, Mikrosil is a better method because the ridge detail is cleaned, CFM and fluoresces. However, tape-lift/CNA was found to be better than tape-lift/C even though the ridge detail was not cyanoacrylate fumed. This could be because the fluorescent light used created a better contrast between the ridge detail and the background. Moore et al. (2008) concluded that silicone rubber casting compound (Isomark) worked best as a soot removal method, however, they focused on the soot removal of bloody fingermarks. Therefore, this could suggest that this research may not be applicable to general soot removal as they focused on keeping the blood mark intact. They also have not tested the use of this method on a plastic or a PVC surface, however, they have tested this soot removal method on non-porous surfaces.

Flowchart 3 shows a simplified method for the best cleaning methods for the PVC surface.

Additionally, the minimum score of Mikrosil/CNA was 13, whereas the minimum score of tape-lift/CNA was 5. This helps conclude that Mikrosil/CNA is the better cleaning method for this surface.

The worst methods used for PVC were H_2O/C (Median=0) and No clean (Median=0). The CFM versions of these methods scored better results; however, the methods overall performed the worst for this surface type. As seen in Figure 22 A, following the H_2O method, it looks as though there is a dry layer of soot on the surface. This has caused ridge detail loss, as it looks as though it has flaked off, this could have occurred due to layers of soot drying on the ridge detail (Figure 22 A).



Flowchart 3: PVC surface soot cleaning methods

General discussion of methods

To ensure fairness in the results of the cleaning methods, the samples were stuck to the middle shelf in random order. Positively, this allowed cleaning methods to be tested for a variety of soot amounts. The average amount of burn time for the main study fires was 9 minutes 19 seconds. Conversely, the soot amount should have been recorded. Similarly, to the way Home Office (2022) have done this, as each sample could be placed in a light, medium or heavy soot category. Following the category selection, Home Office (2022) provide different methods suited for each category. Another category used by Home

Office (2022) is the type of soot on the samples, this varies between dry soot, sticky, and charring. For this experiment, only dry soot was experimented with. However, the category selection, especially the soot amount may be subjective, similarly to the use of fingermark grading system. Additional steps were taken to increase the soot amount. For instance, the sawdust was placed in a pile, in the middle of the tray, above the middle of the samples. The sawdust was also spread out in the middle tray, but this burned out too quickly and did not create much soot.

The samples were cleaned before fingermark deposition using disinfectant wipes, to ensure there were no fingermarks on the surfaces before deposition. However, the preliminary study helped discover that the dry traces of the disinfectant react with cyanoacrylate, which disturbed the visualisation of the fingermark (Figure 24). To stop this from occurring, the samples were immediately wiped dry with blue roll.

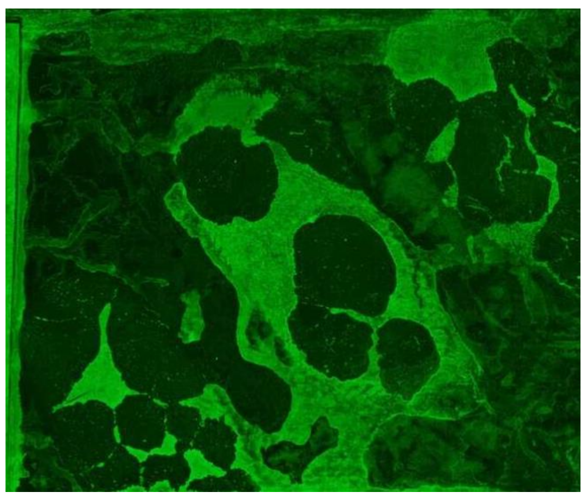


Figure 24: Plastic sample from preliminary study

Positively, the method used by the author of this research does not replicate a real-life arson scenario. This is good because it would be unlikely for the researcher to know the highest temperature reached, therefore this research did not focus on the different temperatures reached.

The Aluminium surface made it difficult to see the developed ridge detail because the surface is reflective. Cyanoacrylate fuming does not attach itself to soot obscured ridge detail. Therefore, the No clean method, the ridge detail would not cyanoacrylate fume. However, this allowed the visualisation of the ridge detail due to the reflective properties of the surface (Figure 25).

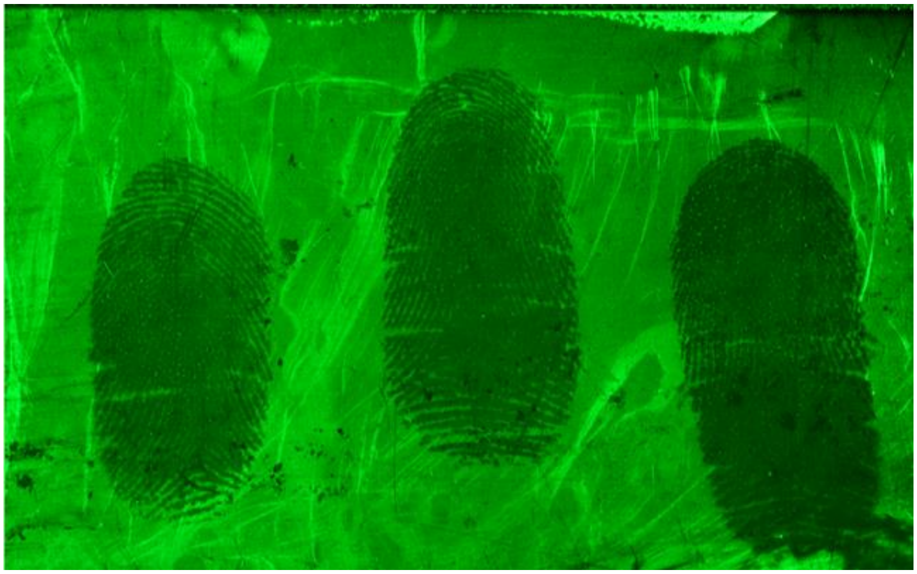


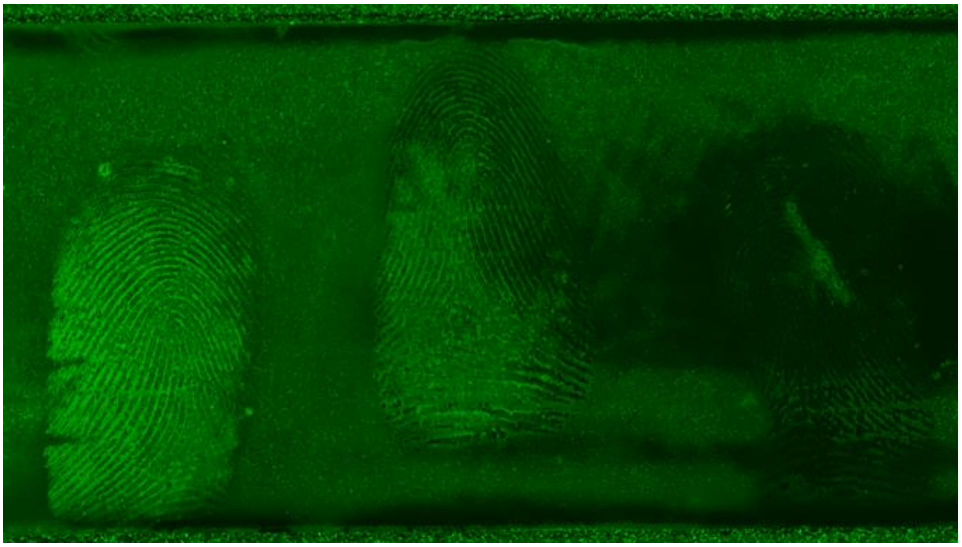
Figure 25: Aluminium; 2 days; No clean/CNA; Sample 3

Tape-lift soot removal method

Tape-lift was not repeated like recommended by Bleay, Bradshaw and Moore (2006) and Home Office (2022), this decision was made to ensure reproducibility and keep the data consistent. Tape-lift has shown success in cleaning the glass surface successfully whilst keeping the ridge detail consistent (Figures 8 A, B). Caution should be taken when tape-lift is used to lift powdered fingermarks. As the tape should be unrolled rapidly because otherwise it creates lines in the ridge detail (Figure 8 A, fingermark 3). This may occur when the tape is unrolled slowly and the adhesive on the tape stretches and eventually goes back its original place, however, it becomes distorted. The ridge detail may become distorted due to an accumulated adhesive in that part of the tape. Glass (2008) briefly explains how the lines are created in the tape. However, this source is not per reviewed making it unreliable. No other research was found by the author regarding this issue with the use of tape-lift. This research did not involve the repeat of this method.

In Figure 26, the third fingermark has not been fully cleaned from the soot using a single application of this method. Figure 26 B) shows that due to this, the ridge detail of the fingermark has been lost and not CFM correctly.

A)



B)

Figure 26: Image A) Tape-lift/C; Image B) Tape-lift/CNA; Glass; Immediate sooting

O'Hagan (2018) suggests that the tape-lift method should be repeated until there is no more soot being picked up by the tape-lift, they suggest this would take three repeats of the method. Negatively, O'Hagan (2018) argues that the method is highly damaging to the fingermark and suggest that the method can only be used on 'baked on' fingermarks.

Tape-lift soot cleaning method is classed as a medium impact technique on the fingermark according to the Home Office (2022) and can be used for any amount of soot presence, according to the category set by the Home Office (2022). This is also the same for Mikrosil since it is an adhesive method of soot removal (Home Office, 2022).

It could be suggested that the tape-lift cleaning method was repeated more than once, as seen in Figure 26 A) and B), the third fingermark had not been fully cleaned off from the soot. Due to the soot obscured ridge detail, the cyanoacrylate did not attach to the oils in the fingermark because they were covered by soot (Ramotowski, 2013). The Home Office (2022) uses either a roller or a piece of tissue following the application of the tape of the surface, this is done with the aims of removing air bubbles. However, in this experiment, air bubbles were removed by sliding the hand across the tape instead. A roller may have removed more bubbles, this may have made the soot stick to the tape more than just the use of a hand.

It could be suggested that if tape-lift was applied more than once it could create similar results to Mikrosil. Mikrosil was also only applied once to the samples, regardless of the surface type and it cleaned the ridge detail fully, this was then successfully subjected to cyanoacrylate.

Mikrosil soot removal method

Not many studies have been undertaken on Mikrosil as a soot removal method. Home Office (2022) and Bleay, Bradshaw and Moore (2006) mention the use of a silicone rubber casting for soot removal. However, they give Mikrosil as an example and do not assess how useful the method is (Bleay, Bradshaw and Moore, 2006). The Home Office (2022) suggest the use of a silicone rubber casting, however they do not specify which is best to use, since there are many silicone-rubber casting products in the industry, different products may react differently to different surfaces. Mikrosil can be difficult to use because it solidifies quickly. This suggests that the mixture must be applied quickly and onto small areas. Therefore, Mikrosil would be difficult to use on larger areas of interest (O'Hagan, 2018). As of 2018, Metropolitan Police used Liquid Latex for larger areas or even a whole crime scene, the latex is sprayed onto the surfaces, sometimes multiple times (O'Hagan, 2018). However, (Home Office, 2022) suggests its application through a sponge or using a brush, they do not mention the liquid latex being sprayed on like seen in O'Hagan (2018).

There is no evidence to show whether DNA can be extracted following Mikrosil application. O'Hagan and Calder (2020) states that an ultrasonic bath must be used to remove the soot from the surface. However, they do not specify which cleaning method must be used first, Mikrosil or an ultrasonic bath. They also add that due to the need of an ultrasonic bath, the expert is limited to the size of the object of interest (O'Hagan and Calder, 2020).

H_2O soot removal method

This cleaning method has not been used in research on its own before, therefore there is a lack of research to support these results. Home Office (2022) state that the water pressure should be low when samples are rinsed, however, this is specifically for fluorescent dye staining rinse. Regardless, caution was taken during the use of this method to ensure that the water pressure was not directly applied to the samples due to this. More specifically, when the water was poured into the tray to soak the samples in, the water was poured further away from the samples.

It is often noticed that with the H_2O method the ridge detail would not be cyanoacrylate fumed, stained and fluoresce. This could suggest that H_2O cleaning method solidifies the soot onto the ridge detail once it is dry leading to the ridge detail being occupied by the soot. However, this is not the case for No clean/CNA method, as the ridge detail fluoresces without any cleaning methods applied but with accumulated soot on top of the ridge detail. The No cleaning method, the soot is not stuck but just sitting on top of the surface and protects the ridge detail (O'Hagan, 2018). H_2O method may be useful for as the first cleaning method and a second cleaning method may be needed such as tape-lift to further clean the ridge detail. The H_2O method may have worked more successfully for the PVC surface if it was a rinse, rather than a soak. This is because the soot obscured PVC samples became hydrophobic, this meant that the samples had to be forced under water. Once the surface was forced under water it created an air bubble which had soot under it. The lines of where the water would not be able to penetrate through the hydrophobic soot is evident in Figure 27.

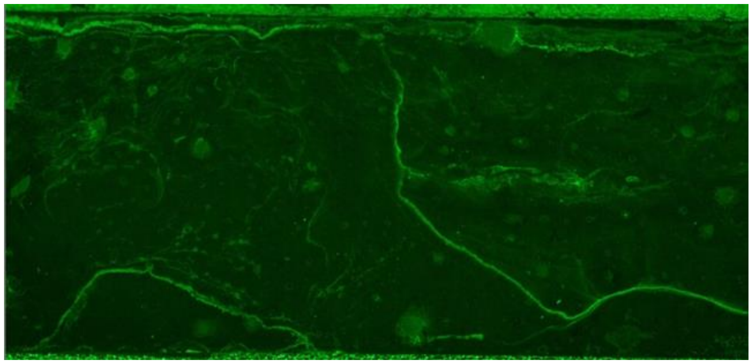


Figure 27: Bubble formed on PVC sample; PVC 2 days sooting; H_2O/CNA

Similar results were seen with some glass samples (Figure 28). This has caused the potential loss of some ridge detail in the fingermarks seen below. This issue may occur on samples which have had large amounts of soot on them. However, the soot amount was not measured or recorded. Additionally, a rinse rather than a soak of the samples may be much more affective. Following the rinse, an additional cleaning method may need to be used. To attempt to salvage the fingermark following this method, tape-lift application may be useful. This is because tape-lift can be used for fingermarks that look ‘baked on’ (O’Hagan, 2018).

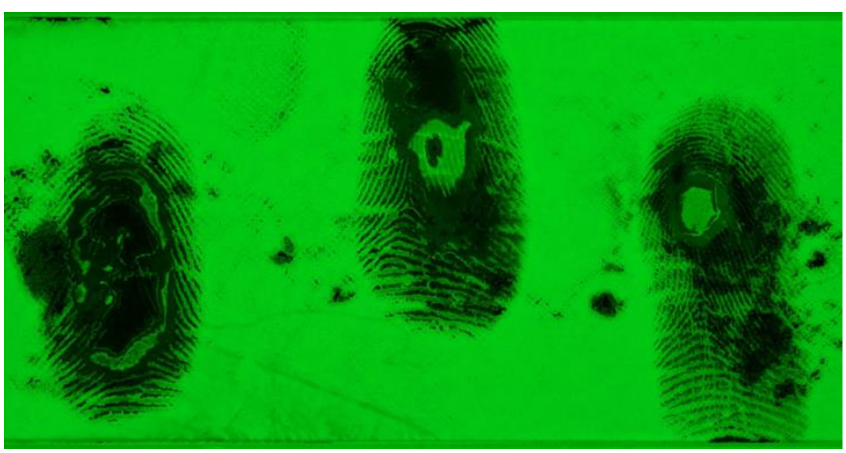


Figure 28: Glass 3 days sooting; H_2O/CNA

Inconsistencies in the success of this method on aluminium surface was also seen. For example, applying the Fingermark Grading System to Figure 29, Criterion 2 is regarding the ridge continuity within the fingermark. Following the cleaning method, very little to no ridge detail was seen. Unless, when the fingermark was deposited, too much or too little force was applied (Fieldhouse, 2011a).

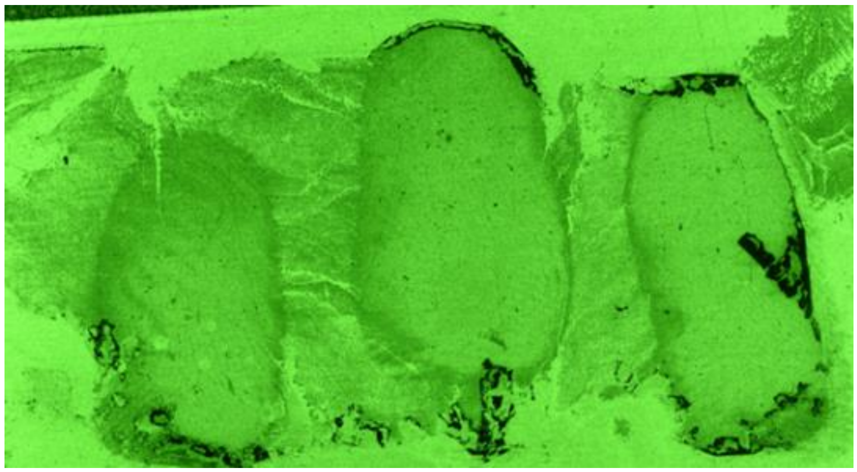


Figure 29: Aluminium 7 days sooting; H_2O/CNA

O'Hagan (2018) states that the soot should be brushed off the fingermark and then water should be used as a secondary method. However, there is no specification as to whether the water should be used as a soak or a rinse (O'Hagan, 2018). O'Hagan (2018) acknowledges that the use of this method is likely to require the sample to be brought to and treated at a laboratory. Additionally, the reasons why H_2O soak may not be a very successful method could be due to fresh soot being exceptionally hydrophobic which almost makes it waterproof (Zuberi et al., 2005). Zuberi et al. (2005) argue that the soot begins to absorb water once it has begun to age. Aging of soot involves the exposure of soot to oxygen (Zuberi et al., 2005). However, they do not specify how many days it takes for the soot to become hydrophilic, their research is specifically for environmental soot. Due to these disadvantages of water soaking, adhesive methods may be better options of cleaning soot from fingermarks. Instead of a water soak, ultra-sonic bath with distilled water may be useful as a soot removal method. Stow and McGurry (2006) discovered that some quality of the fingermark was lost following the ultra-sonic bath method for 30 minutes. They found that ultra-sonic bath has some success with a mix of petrol's and soot but little success with fingermarks recovered from a petrol bomb. Other research shows the use of a water wash and soap, negatively however, the amino acids in the fingermark would wash off due to the soap, making it impossible to do chemical treatments such as Ninhydrin on the fingermark (O'Hagan and Calder, 2020).

Since it was discovered that the best cleaning method for the aluminium surface was H_2O soak without CFM and BY40 dye, this could suggest that the Bleay, Bradshaw and Moore (2006) and the Home Office (2022) were correct in arguing that CFM is not suitable for fingermarks exposed to water.

Positively, Korzik et al. (2023) researched the amount of DNA available in fingermarks after being exposed to stagnant and flowing spring water from 24 hours for up to 1 week. However, they found that ridge detail was still visible even after 1 week of exposure and found that even though DNA may be lost, the ridge detail of the fingermark may be used for identification purposes. However, this research predominantly focused on the DNA extraction, therefore, they may not have explored the difference in detail quality between the different time periods. These results are different in comparison to Trapecar (2012) findings. Trapecar (2012) found a decline in the quality of the fingermarks following stagnant water exposure for 1 week. Trapecar (2012) categorised the fingermark quality from A to D with A having at least 12 characteristics in the fingermark and D having no fingermark visible.

No clean

This method has shown success as the second-best cleaning method for the glass and aluminium surfaces. It has been discovered that soot can be used as a visualisation and enhancement method (O'Hagan, 2018). O'Hagan (2018) describes the use of Camphor which is set alight and produces large volume of soot which subsequently falls onto the fingermark. A brushing method is used to remove the extra soot on the fingermark, and it reveals the ridge detail (O'Hagan, 2018). This is why some samples were not cleaned but developed using cyanoacrylate fuming straight away. On the other hand, the Camphor method still requires some interference with the soot on the surface.

The Fingermark Grading System

The use of the Fingermark Grading System (Fieldhouse and Gwinnett, 2016) can be subjective, making the results from the research unreliable (Hanna, Chadwick and Moret, 2023). The issue of subjectivity comes from different experience levels as some researchers may have more knowledge and experience than others which could create a difference in the gradings (Hanna, Chadwick and Moret, 2023). However, Fieldhouse and Gwinnett (2016) ensured that every criterion is explained and also provided picture examples when the grading system is used. However, when the fingermarks were deposited for the purposes of this study, a fingerprint sampler was not used (Fieldhouse, 2011). The use of a fingerprint samples would have kept the deposition of the fingermark consistent (Fieldhouse, 2011). Fieldhouse (2011) often compares the way different individuals would deposit fingermarks, rather than the same person reproducing the fingermarks consistently by applying the same amount of force each time. Despite, this inconsistency can be seen in some fingermarks deposited by the fingermark donor in this research (Figure 30). Therefore, to improve this research, the use of a fingerprint sampler would be beneficial (Fieldhouse, 2011).

Figure 30: Lack of consistency in the fingermark deposition

Conversely, the grading system used for this research has clear explanations and examples provided to the examiners. Due to this it can be suggested that even examiners with little experience would be able to use the grading system correctly. In order to make this research more reliable, each fingermark could be compared using the Automated Fingerprint Identification System (Home Office, 2022) following the cleaning methods to find whether the cleaning method would have caused damage to the fingermark to make an identification impossible.

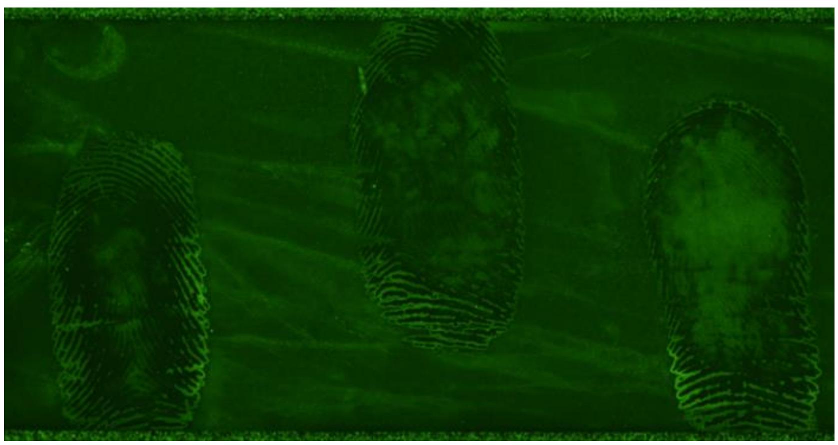
ACE-V (Analysis, Comparison, Evaluation and Verification) is a process that is followed by fingerprint experts (Stevenage and Pitfield, 2016). Three fingerprint experts are needed to undertake the verification process of ACE-V (Stevenage and Pitfield, 2016), in this research instead of involving three different people to agree or disagree with the gradings, the researcher regraded some of the fingermarks. 72 fingermarks were randomly chosen and re-graded (Appendix D). The results from the regrading are as follows: fifty-four fingermarks had no change in the gradings total, ten fingermarks had a +/-1 difference in the regrading total, five fingermarks had a +/- 2 to 3 differences in the regarding total and lastly, only three fingermarks had a +/-10 and below differences in the regrading. However, this could be because the author has gained more experience from the grading overall and from thus experience, the re-gradings have changed in comparison to the original gradings.

The Home Office grading system could have been used; however, this grading system does not have different criterions. Positively, the Fingermark Grading System has a total score out of 20 (Fieldhouse, 2011a), whereas the Home Office grading system has a 0-4 Class (Hockey, Dove and Kent, 2021). Fieldhouse (2011a) has provided four different criterions: the quantity of the fingermark available the quantity of the fingermark that has a usable friction ridge detail for analysis, the friction ridge continuality, and the contrast between the background and the ridge detail.

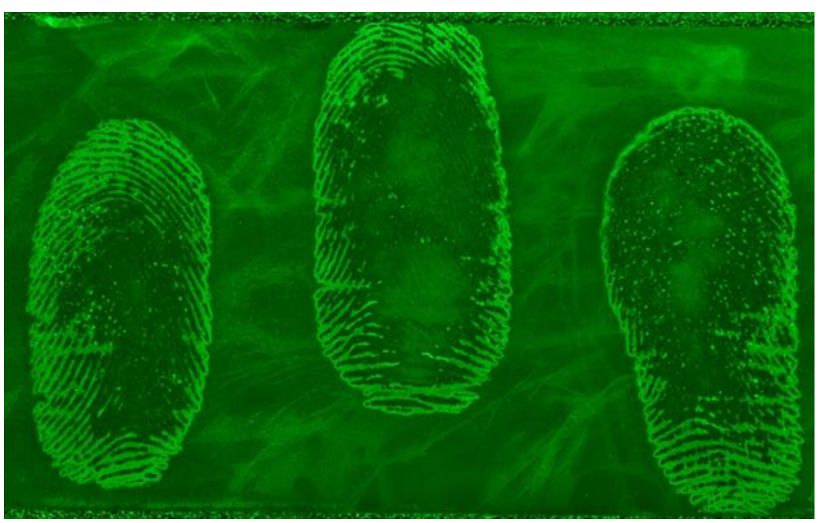
Cyanoacrylate fuming

In this experiment, fingermarks were also developed using cyanoacrylate fuming and BY40 (Home Office, 2022). Samples which have been exposed to the cleaning methods but did not cyanoacrylate fume (Figure 27) could be due to the soot sticking to the sebaceous particles in the fingermark (Wei et al., 2017). Wei et al. (2017) explains that this may occur due to the hydrogen and electrostatic interaction and van der Walls force.

However, this does not explain why some of the No clean samples which were cyanoacrylate fumed still fluoresced (Figure 31 A, B). It can be seen that fluorescence gets lost with more accumulated soot on the surface (Figure 30, A). This could suggest that the soot amount of the sample may contribute to the ability to cyanoacrylate fume the ridge detail successfully. Since cyanoacrylate attaches to the eccrine and sebaceous sweat in the ridge detail (Ramotowski, 2013) and the thicker levels of soot. The higher levels of soot may have covered the eccrine and sebaceous sweat, making the cyanoacrylate fuming not being able to attach to those sweats. There is no research that could support this theory.



A)



B)

Figure 31: Glass; 3 days sooting; Sample 2 (A); 7 days sooting; Sample 2 (B); No clean/CNA

Home Office (2022) argues that cyanoacrylate fuming cannot be used to develop fingermarks that have been exposed to temperatures as high as 500°C. Because the eccrine sweat sustains such high temperatures Home Office (2022). Due to the fingermarks in this experiment being cyanoacrylate fumed and dyed, it could suggest that the fire had not reached 500°C. This shows a limit of this research as house fires reach higher temperatures than this.

Due to the chances of the fingermarks being exposed to water in an arson scene, the use of cyanoacrylate fuming and BY40 may not be the best development method to use. Research by Dhall, Sodhi and Kapoor (2013) shows that fingermarks exposed to temperatures between 100-900°C can be developed using small particle reagent and viewed using fluorescent light (505-550nm wavelength). They explored 2 different solutions of the small particle reagent, one with eosin B and another with eosin Y. Eosion B made the fingermarks fluoresce better, eosin Y did not show good results with tin cans. This method could be more successful than cyanoacrylate fuming because small particle reagent can be used on surfaces that have been wetted (Dhall, Sodhi and Kapoor, 2013). Bumbrah (2016) states that solution attaches to the fatty/oily elements of the fingermark. This is also a cheap and effective method to use (Bumbrah, 2016).

Positively, research by Trapecar (2012) has shown that fingermarks exposed to water for long periods of time are suitable for CFM. In this author's experiment, the samples were left to dry fully before they were cyanoacrylate fumed, whereas Trapecar (2012) ensured that the fingermarks were dried in a room temperature for 30 minutes and then they were cyanoacrylate fumed. However, the author did not time how long it took for the drying process and did not time how long it would have taken for the fingermarks to be cyanoacrylate fumed following the cleaning methods. Other research which has used CFM and BY40 to develop the fingermarks following NaOH cleaning method which contains water, suggesting that cyanoacrylate fuming can still be used (Stow and McGurry, 2006).

4.Conclusion

To conclude, fingermark evidence is often overlooked at arson crime scenes due to the assumptions that the evidence gets destroyed in the fire (Bleay, Bradshaw and Moore, 2006; Deans, 2006). However, research on the recovery of soot obscured fingermarks is becoming of interest, therefore, there is some research available on how to clean the soot from the fingermarks. For instance, a recently updated Fingermark Visualisation Manual has some guidance on soot removal methods (Home Office, 2022). The author explored different soot cleaning methods on three non-porous surfaces: glass, aluminium, and PVC. In the preliminary study of this experiment, the author found that NaOH 0.5% soak for 20 minutes and gel-lift were not successful cleaning methods. Therefore, these methods were not used in the main study, instead, a 20 minutes ultra-pure deionised water soak, Mikrosil, tape-lift and No clean were tested. All 432 fingermarks were subjected to cyanoacrylate fuming and stained using Basic Yellow 40, they were visualised using a DSC5 Foster and Freeman instrument. It was concluded that the best cleaning method for the glass surface is tape-lift and then subjected to cyanoacrylate fuming and Basic Yellow 40. The fingermarks were graded using the Fingermark Grading System (Fieldhouse and Gwinnett, 2016), the fingermarks were graded after the application of the cleaning methods and after the development using cyanoacrylate fuming and BY40. Regarding the aluminium surface, the best cleaning method was H_2O soak, however, for this surface and cleaning method, the cyanoacrylate fuming and BY40 stain is not needed. Although, the surface may be best to view using different fluorescent lights using the DSC5 Foster and Freeman instrument. The best cleaning method for the PVC surface was found to be Mikrosil, however, cyanoacrylate fuming, BY40 and visualisation using the correct fluorescent light is needed to reveal the fingermark.

Positively, even though the temperature of the fire was not recorded for this experiment, in real-lift arson scenes it is unlikely for the fingerprint examiners to know what temperatures the fire has reached. Negatively, the soot amount was not recorded, therefore the cleaning methods used in this experiment may not be valid for larger or smaller amounts of soot. This research also did not test multiple cleaning methods together. Also, the use of a fingermark grading system can be very subjective, this is why some of the fingermarks were re-graded to see whether there is a difference in the results. From which a difference in the gradings was established, however, the majority of the results were the same. Additionally, the grading system used for this experiment focuses on four criterions which were explained, and picture examples were provided that aided the process. Fingermarks exposed to water may not be suitable for CFM due to the salts dissolving in the water (Home Office, 2022).

5.Further Work

With regards to future work, it would be interesting to investigate dual recovery- DNA and fingerprint evidence whilst using the same cleaning methods. For instance, there is no research available on Mikrosil's property of DNA retention/recovery. Additionally, once the first few tape-lift applied to the sample have removed enough soot from the surface, the soot could be treated as a powdered fingermark. Therefore, the last tape-lift could be stuck to an acetate sheet and then put through AFIS. Instead of using a grading system, the fingermarks could be put through AFIS to attempt the identification through the number of minutiae found by the software. This would have to be compared to a control sample. Conversely, the soot may contain contaminants or unknown materials (Home Office, 2022) in comparison to the fingermark powder used in laboratory-based environment. Potential research could be finding out whether using strong air blower to blow away the soot straight from the scene of fire could be research, this may reveal a developed fingermark from the soot.

6.References

Ahmad, U.K., Mei, Y.S., Bahari, M.S., Huat, N.S. and Paramasivam, V.K. (2011). The effectiveness of soot removal techniques for the recovery of fingerprints on glass fire debris in petrol bomb cases. *The Malaysian Journal of Analytical Sciences*, [online] 15(2), pp.191–201. Available at: https://mjas.analis.com.my/wp-content/uploads/2018/11/Yew-Su-Mei.pdf [Accessed 24 Feb. 2024].

Armstrong, R.A. (2014). When to use the Bonferroni correction. *Ophthalmic and Physiological Optics*, 34(5), pp.502–508. doi:https://doi.org/10.1111/opo.12131.

Bhandari, P. (2020). *What is Effect Size and Why Does It Matter? (Examples)*. [online] Scribbr. Available at: https://www.scribbr.co.uk/stats/effect-sizes/ [Accessed 20 Mar. 2024].

Bleay, S., Bradshaw, G. and Moore, J. (2006). *Fingerprint Development and Imaging Newsletter*. [online] *Home Office Scientific Development Branch*, Hertfordshire: Home Office Scientific Development Branch, pp.2–32. Available at: https://assets.publishing.service.gov.uk/media/5ef5f7af86650c129caf10e1/Fingerprint_Update__Special_Edition_-_Arson_26-06.pdf [Accessed 6 Feb. 2024].

Boseley, R., Jitraporn Vongsvivut, Appadoo, D., Hackett, M. and Lewis, S. (2021). Monitoring the chemical changes in fingermark residue over time using synchrotron infrared spectroscopy. [online] doi:https://doi.org/10.26434/chemrxiv-2021-qsbtd.

Bumbrah, G.S. (2016). Small particle reagent (SPR) method for detection of latent fingermarks: A review. *Egyptian Journal of Forensic Sciences*, [online] 6(4), pp.328–332. doi:https://doi.org/10.1016/j.ejfs.2016.09.001.

Bumbrah, G.S. (2017). Cyanoacrylate fuming method for detection of latent fingermarks: a review. *Egyptian Journal of Forensic Sciences*, [online] 7(1). doi:https://doi.org/10.1186/s41935-017-0009-7..

Clutter, S.W., Bailey, R., Everly, J.C. and Mercer, K. (2009). The Use of Liquid Latex for Soot Removal from Fire Scenes and Attempted Fingerprint Development with Ninhydrin. *Journal of Forensic Sciences*, 54(6), pp.1332–1335. doi:https://doi.org/10.1111/j.1556-4029.2009.01143.x.

Colella, O., Miller, M., Boone, E., Buffington-Lester, S., Curran, F.J. and Simmons, T. (2019). The Effect of Time and Temperature on the Persistence and Quality of Latent Fingerprints Recovered from 60-Watt Incandescent Light Bulbs. *Journal of Forensic Sciences*, 65(1), pp.90–96. doi:https://doi.org/10.1111/1556-4029.14133.

Criminal Damage Act 1971,.c.48. [online] Available at: https://www.legislation.gov.uk/ukpga/1971/48 [Accessed 8 Jan. 2024].

Deans, J. (2006). Recovery of Fingerprints from Fire Scenes and Associated Evidence. *Science & Justice*, 46(3), pp.153–168. doi:https://doi.org/10.1016/s1355-0306(06)71589-1.

Department U. S. Department of Justice (2014). *The fingerprint : sourcebook.* [online] United States: Createspace Independent Publishing Platform. Available at: https://irp.fas.org/eprint/fingerprint.pdf [Accessed 16 Mar. 2024].

Dhall, J.K. and Kapoor, A.K. (2016). Development of latent prints exposed to destructive crime scene conditions using wet powder suspensions. *Egyptian Journal of Forensic Sciences*, [online] 6(4), pp.396–404. doi:https://doi.org/10.1016/j.ejfs.2016.06.003.

Dhall, J.K., Sodhi, G.S. and Kapoor, A.K. (2013). A novel method for the development of latent fingerprints recovered from arson simulation. *Egyptian Journal of Forensic Sciences*, [online] 3(4), pp.99–103. doi:https://doi.org/10.1016/j.ejfs.2013.03.002.

dstl (2020). Fingermark Visualisation Newsletter. *GOV.UK*, [online] pp.1–16. Available at: https://assets.publishing.service.gov.uk/media/5f1ab58ee90e07456caf0c63/2020_Jul_Dstl_Fingermark_Visualisation_Newsletter__5_v1.0_O.pdf [Accessed 15 Mar. 2024].

Fieldhouse, S. (2011a). Consistency and reproducibility in fingermark deposition. *Forensic Science International*, [online] 207(1-3), pp.96–100. doi:https://doi.org/10.1016/j.forsciint.2010.09.005.

Fieldhouse, S. and Gwinnett, C. (2016). The design and implementation of a proficiency test for assessors of fingermark quality, to facilitate collaborative practise in fingermark research. *Science & Justice*, [online] 56(4), pp.231–240. doi:https://doi.org/10.1016/j.scijus.2016.03.001.

Fieldhouse, S., Parsons, R., Bleay, S. and Walton-Williams, L. (2020). The effect of DNA recovery on the subsequent quality of latent fingermarks: A pseudo-operational trial. *Forensic Science International*, 307, p.110076. doi:https://doi.org/10.1016/j.forsciint.2019.110076.

Fieldhouse, S., Platt, A., Stubbs-Hayes, F. and Bleay, S. (2015). Latent fingermark interaction with Iron Oxide Wet Powder Suspension; an investigation into inter and intra participant variation. [online] Available at: https://www.researchgate.net/publication/314082106_Latent_fingermark_interaction_with_Iron_Oxide_Wet_Powder_Suspension_an_investigation_into_inter_and_intra_participant_variation [Accessed 24 Feb. 2024].

Fieldhouse, S.J. (2011b). An Investigation into the Use of a Portable Cyanoacrylate Fuming System (SUPERfume®) and Aluminum Powder for the Development of Latent Fingermarks*. *Journal of Forensic Sciences*, [online] 56(6), pp.1514–1520. doi:https://doi.org/10.1111/j.1556-4029.2011.01847.x.

Foster+Freeman (2022). *DCS® 5 | Foster + Freeman*. [online] Foster+Freeman. Available at: https://fosterfreeman.com/dcs-5/ [Accessed 3 Feb. 2024].

Freinkel, R.K. and Woodley, D. (2001). *The biology of the skin*. [online] New York: Parthenon Pub. Group, pp.9–420. Available at: https://www.google.co.uk/books/edition/The_Biology_of_the_Skin/HxYN3db9R3MC?hl=en&gbpv=1 [Accessed 16 Mar. 2024].

GELLIFTERS (n.d.). *BVDA Gellifters*. [online] *BVDA*. Available at: https://www.bvda.com/images/content/downloads/Gellifter_manual_EN.pdf [Accessed 12 Mar. 2024].

Glass, D. (2008). *What's With Those Lines on the Transparent Tape?* [online] A Moment of Science - Indiana Public Media. Available at: https://indianapublicmedia.org/amomentofscience/whats-with-those-lines-on-the-transparent-tape.php [Accessed 31 Mar. 2024].

GOV.UK (2023). *Economic and social cost of fire*. [online] GOV.UK. Available at: https://www.gov.uk/government/publications/economic-and-social-cost-of-fire/economic-and-social-cost-of-fire#:~:text=The%20estimated%20total%20economic%20and [Accessed 8 Jan. 2024].

Hanna, T., Chadwick, S. and Moret, S. (2023). Fingermark quality assessment, a transversal study of subjective quality scales. *Forensic Science International*, [online] 350, pp.111783–111783. doi:https://doi.org/10.1016/j.forsciint.2023.111783.

Hockey, D., Dove, A. and Kent, T. (2021). Guidelines for the use and statistical analysis of the Home Office fingermark grading scheme for comparing fingermark development techniques. *Forensic Science International*, [online] 318, p.110604. doi:https://doi.org/10.1016/j.forsciint.2020.110604.

Home Office (2013). *Home Office Science Centre for Applied Science and Technology An Introduction*. [online] GOV.UK. Available at: https://assets.publishing.service.gov.uk/media/5a7c48f5e5274a1b00422bc3/intro-to-cast-may13.pdf [Accessed 1 Mar. 2024].

Home Office (2022). *Fingermark Visualisation Manual.* Second Edition ed. [online] London: The Stationery Office Tso, pp.1–985. Available at: https://assets.publishing.service.gov.uk/media/65d35b9e0f4eb10064a9810d/Fingermark_Visualisation_Manual_2nd_Edition_2022.pdf [Accessed 11 Mar. 2024].

Home Office (2024). *Fire statistics data tables*. [online] GOV.UK. Available at: https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables#full-publication-update-history [Accessed 30 Mar. 2024].

Jackson, A.R.W. and Jackson, J.M. (2017). *Forensic science*. 4th ed. Harlow: Pearson Education Limited.

Korzik, M.L., De Alcaraz-Fossoul, J., Adamowicz, M.S. and San Pietro, D. (2023). Preliminary Study: DNA Transfer and Persistence on Non-Porous Surfaces Submerged in Spring Water. *Genes*, [online] 14(5), p.1045. doi:https://doi.org/10.3390/genes14051045.

Laerd Statistics (2018). *Friedman Test in SPSS Statistics - How to run the procedure, understand the output using a relevant example | Laerd Statistics.* [online] Laerd.com. Available at: https://statistics.laerd.com/spss-tutorials/friedman-test-using-spss-statistics.php [Accessed 8 Mar. 2024].

Leicestershire Fire and Rescue Service (2023). *Joint Arson Reduction Strategy 2020 - 2023*. [online] Leicestershire Fire and Rescue Service. Available at: https://leics-fire.gov.uk/wp-content/uploads/2020/08/arson-reduction-strategy-2020-2023.pdf [Accessed 8 Jan. 2024].

Madkour, S., Sheta, A., El Dine, F.B., Elwakeel, Y. and AbdAllah, N. (2017). Development of latent fingerprints on non-porous surfaces recovered from fresh and sea water. *Egyptian Journal of Forensic Sciences*, [online] 7(1). doi:https://doi.org/10.1186/s41935-017-0008-8.

Moore, J., Bleay, S., Deans, J. and NicDaeid, N. (2008). *Recovery of Fingerprints from Arson Scenes: Part 2 - Fingerprints in Blood*. 1st ed. pp.2–27.

O'Hagan, A. (2018). A review of fingerprint recovery within an arson crime scene. *Foresic Research & Criminology International Journal*, [online] 6(5), pp.315–325. doi:https://doi.org/10.15406/frcij.2018.06.00223.

O'Hagan, A. and Calder, R. (2020). DNA and fingerprint recovery from an arson scene. *Forensic Research & Criminology International Journal*, [online] 8(1), pp.15–29. doi:https://doi.org/10.15406/frcij.2020.08.00303.

Ramotowski, R. (2013). *Lee and Gaensslen's Advances in fingerprint technology [electronic re.* 3rd ed. [online] Boca Raton, Fla., London: Crc Press, pp.263–293. Available at: https://www.vlebooks.com/Product/Index/119400?page=0&startBookmarkId=-1 [Accessed 6 Feb. 2024].

Ready (2023). *Home Fires | Ready.gov*. [online] www.ready.gov. Available at: https://www.ready.gov/home-fires#:~:text=Room%20temperatures%20in%20a%20fire [Accessed 21 Mar. 2024].

Reed, H., Stanton, A., Wheat, J., Kelley, J., Davis, L., Rao, W., Smith, A., Owen, D. and Francese, S. (2016). The Reed-Stanton press rig for the generation of reproducible fingermarks: Towards a standardised methodology for fingermark research. *Science & Justice*, [online] 56(1), pp.9–17. doi:https://doi.org/10.1016/j.scijus.2015.10.001.

Robson, R., Ginige, T., Mansour, S., Khan, I. and Assi, S. (2022). Analysis of fingermark constituents: a systematic review of quantitative studies. *Chemical Papers*, [online] 76(8), pp.4645–4667. doi:https://doi.org/10.1007/s11696-022-02232-x.

Ronde, A. de, Kokshoorn , B., Poot, C.J. de and Puit , M. de (2019). The evaluation of fingermarks given activity level propositions. *Forensic Science International*, [online] 302, p.109904. doi:https://doi.org/10.1016/j.forsciint.2019.109904.

Sears, V., Bowman, V., Bleay, S. and Bandley, H. (2022). *Fingermark Visualisation Manual.* 2nd ed. [online] The Stationery Office Tso, pp.1–985. Available at: https://assets.publishing.service.gov.uk/media/65d35b9e0f4eb10064a9810d/Fingermark_Visualisation_Manual_2nd_Edition_2022.pdf [Accessed 30 Mar. 2024].

Spawn, M. (2004). *Effects of Fire on Fingerprint Evidence*. [online] Available at: http://spawngroup.com/media/EFFECTS_OF_FIRE_ON_FINGERPRINTS.pdf [Accessed 1 Mar. 2024].

Stevenage, S.V. and Pitfield, C. (2016). Fact or friction: Examination of the transparency, reliability and sufficiency of the ACE-V method of fingerprint analysis. *Forensic Science International*, [online] 267, pp.145–156. doi:https://doi.org/10.1016/j.forsciint.2016.08.026.

Stow, K.M. and McGurry, J. (2006). The recovery of finger marks from soot-covered glass fire debris. *Science & Justice*, [online] 46(1), pp.3–14. doi:https://doi.org/10.1016/s1355-0306(06)71562-3.

Trapecar, M. (2012). Finger marks on glass and metal surfaces recovered from stagnant water. *Egyptian Journal of Forensic Sciences*, [online] 2(2), pp.48–53. doi:https://doi.org/10.1016/j.ejfs.2012.04.002.

University of Southampton (2020). *Chi Square | Practical Applications of Statistics in the Social Sciences | University of Southampton*. [online] Southampton.ac.uk. Available at: https://www.southampton.ac.uk/passs/full_time_education/bivariate_analysis/chi_square.page [Accessed 31 Mar. 2024].

Wei, Q., Zhu, Y., Liu, S., Gao, Y., Li, X., Shi, M., Zhang, X. and Zhang, M. (2017). Candle Soot Coating for Latent Fingermark Enhancement on Various Surfaces. *Sensors*, [online] 17(7), p.1612. doi:https://doi.org/10.3390/s17071612.

Zuberi, B., Johnson, K.A., Aleks, G.K., Molina, L.T., Molina, M.J. and Laskin, A. (2005). Hydrophilic properties of aged soot. *GEOPHYSICAL RESEARCH LETTERS*, [online] 32(1), pp.1–4. doi:https://doi.org/10.1029/2004gl021496.

7.Appendix

Appendix A

This document contains the first Risk Assessment that has been signed off.

Link: PRA 1st signed off.docx

Procedure:

- Academics or session lead to complete Risk Assessment for all practical classes/activities, Technical team for all support aspects this is then reviewed as required
- Researchers/Experimenters are to complete a Risk Assessment in consultation with their project advisor and technical staff as appropriate.
- No laboratory work is to commence without a suitable and comprehensive risk assessment being signed off by a competent person detailed in the laboratory handbook.
- Researchers/Experimenters to keep copies of Risk Assessments when working in the laboratories.

Notes:

- The risk assessment must be reviewed when any changes are made to the equipment, materials, procedure, personnel or if there is a near miss or accident
- Any staff member can stop experimental work if no risk assessment is in place, or if, in their opinion, there is a risk to safety. If anybody else has concerns, they must raise it immediately to a member of staff.
- Add rows as necessary
- If substances are used, then you must fill out the COSHH section 3-6. The COSHH regulations link is available here: - Control of substances hazardous to health (COSHH). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (hse.gov.uk)

Risk assessment Reference **(Technical Services Only)**	

School/Service	Staffordshire University		
Name	Teodosia L. Krumova	Supervisor name	David Flatman-Fairs
Email address	K013708L@student.staffs.ac.uk	Supervisor email	d.p.flatman-fairs@staffs.ac.uk
level of study	Level 6	Course title	Forensic Investigation
Module number	FORE60369-2023-SUG1-2023-SUG2	Module title	FORENSIC RESEARCH PROJECT
Session/project title	Recovery of Soot Obscured Fingermarks		
Ethics approved (use BABAO for skeletal remains)	Yes ☒ No ☐		

Description of experimental procedure/practical session (500 words max) Petrol or diesel will be used to set a 10x10cm piece of carpet on fire in the burn box at Staffordshire University, Science Centre. Fingermarks would be deposited by myself on three types of surfaces: plastic, metal, and glass. The metal sheets and plastic would be cut into small pieces. Every surface would have three fingermarks deposited onto each piece of material. I would ensure I rub my hands together or rub my hands through my hair to create more oil for the fingermarks to successfully transfer onto the surfaces. The sheets of different surfaces would be placed in the burn box with the fingermark facing down so the soot covers the fingermarks. Time between sooting would be as follows: immediately put in the burn box after deposition to created soot, 24 hours after deposition, two days, three days, and a week after deposition. The fingermarks would then be cleaned from the soot using brushing, rinsing using water, rinsing using NaOH or peeling off using Silicone Rubber Casting Compound. To develop the fingermarks Cyanoacrylate fuming will be used and Basic Yellow 40 staining. A control of each set of fingermarks will be made.

Risk Assessment

Risk assessment score

Consequence

		Negligible (minimal first aid only) 1	Minor (minor injuries) 2	Moderate (major injury) 3	Major (life changing injury) 4	Catastrophic (Danger of death) 5
Likelihood	Almost certain 5	5	10	15	20	25
	Likely 4	4	8	12	16	20
	Possible 3	3	6	9	12	15
	Unlikely 2	2	4	6	8	10
	Rare 1	1	2	3	4	5

Hazard list

Hazards inherent in the work, record details and possible injury: (e.g., Equipment, procedures, general chemical hazards, invertebrate work, body fluid sampling etc.)	Risk score	Record precautions which will be taken: (*e.g.,* Include any standard operating procedures, codes of practice, faculty policies you will be following) **Use Hierarchy of Control Measures to reduce risks.**	New risk score
Cutting metal and plastic sheets to smaller pieces	2	Thicker gloves used whilst cutting the metal and plastic sheets into smaller pieces using scissors. Goggles and laboratory coat will also be worn..	1
Cyanoacrylate fuming Overheating Cyanoacrylate can produce toxic hydrogen cyanide Risk of dangerous fumes	4	Use the MVC3000 for all samples. This should prevent the glue from being excessively heated and will contain the fumes. Fuming cabinet will not be opened until the cycle is complete.	1
Burn Box Setting the carpet on fire could lead to me burning myself	6	Protective gloves would be worn whilst setting the carpet on fire. It will also be ignited at arm's length using a long wooden splint. Goggles and laboratory coat will be worn.	1
Sodium Hydroxide Being in physical contact with Sodium Hydroxide could cause skin damage, nasal irritation as well as eye damage if it is a low amount of Sodium Hydroxide. A larger amount of it could cause severe burns or death.	6	Wearing nitrile gloves, long clothing and a laboratory coat that covers all exposed skin will decrease the chance of this happening. If a spillage occurs onto my clothes, I would carefully, but rapidly, remove the clothes to prevent it from spreading even more and rinse any potentially exposed skin under running water for at least 5 minutes. Goggles will be worn. sample washing will take place in a fume cupboard wherever possible.	2

Hazards inherent in the work, record details and possible injury: (e.g., Equipment, procedures, general chemical hazards, invertebrate work, body fluid sampling etc.)	Risk score	Record precautions which will be taken: (*e.g.,* Include any standard operating procedures, codes of practice, faculty policies you will be following) **Use Hierarchy of Control Measures to reduce risks.**	New risk score
Basic Yellow 40 Stain Could cause skin, eye or respiratory irritation of it comes into contact with the skin or inhaled	4	Personal Protective Equipment, including gloves, goggles and laboratory coat will be worn. Ensuring clothing covers all parts of skin.	2
Mikrosil Casting Putty Should not be swallowed	2	Full PPE (Personal Protective Equipment), including goggles, gloves and laboratory coat, ensuring there is no exposed skin. Will not put it near mouth.	1
Environmental factors in the laboratory I could come into contact with substances used in the laboratory previously that I am unaware of that could be hazardous to me.	4	Full PPE (Personal Protective Equipment), including goggles, gloves and laboratory coat, ensuring there is no exposed skin. The laboratory is thoroughly cleaned every day.	1
Flammable liquids The flammable liquids used to set the carpet on fire could get spilled onto a surface becoming a fire hazard and has noxious fumes.	6	Keep away from electronics Ensure it is dispensed safely so it does not get onto other surfaces. keep in fume cupboard except when transferring to burn box. Full PPE (Personal Protective Equipment), including goggles, gloves and laboratory coat. Ignitable liquids used in the fume cupboard when not being used in the burn box	1
Gelatine Lifter If in contact with eye it may cause irritation, may cause irritation to skin, may cause respiratory infection if inhaled	2	Full PPE (Personal Protective Equipment), including goggles, gloves and laboratory coat.	1

Who may be at risk?

Staff – Day shift	Staff – Out of hours	Postgraduate students	Undergraduate students	New or expectant mothers	Contractors	Public	Other, please state below
☒	☐	☐	☒	☐	☐	☐	

What level of risk do you assign to this work?

Low	Medium Low	Medium	High
☐	☒	☐	☐

If the risk assessment is classified as high, then **no work** is to be undertaken. First, follow hierarchy of controls to reduce risks.
If no COSHH assessment is required, then please click here.

Control of Substances Hazardous to Health (COSHH)

COSHH assessment

Control of substances hazardous to health (COSHH). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (hse.gov.uk)

Links and table below to aid completing the COSHH assessment.

Minimum PPE are lab coat/safety glasses

Addition PPE:		
Fume cupboard (FC)	Laminar flow cabinets (LF)	Microbiological Safety cabinet (Cab)
Nitrile gloves (NG)	Vinyl gloves (VG)	Cryogenic gloves (CG)
Face shield (FS)	Face Mask FFP1	Face Mask FFP2
Face Mask FFP3	Respirator (R)	Other (provide details)
All INFORMATION CAN BE FOUND WITHIN MSDS (MATERIAL SAFETY DATA SHEETS) ON THE INTERNET, SCIENCES CHEMICAL DATABASE ON-LINE WITHIN EACH OF THE LABORATORIES		

Use safety data sheets where possible.

Hazard and Precaution statements list, should also be stated on the MSDS - GHS Classification (nih.gov)

Work Exposure Limits (WEL) if not stated on (M)SDS - EH40/2005 Workplace exposure limits (hse.gov.uk)

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
Cyanoacrylate fuming	C	FFP1, NG	G	2g per run	H315: Causes skin irritation.	P261: Avoid breathing vapours.	0.3ppm in minutes

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
					H319: Causes serious eye irritation. H335: May cause respiratory irritation. EUH202: Cyanoacrylate. Danger. Bonds skin and eyes in seconds. Keep out of the reach of children	P271: Use only outdoors or in a well-ventilated area. P280: Wear protective gloves. P302+352: IF ON SKIN: Wash with plenty of soap and water. P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+313: If eye irritation persists: Get medical attention	
Basic Yellow 40 Stain	C	FFP2, FC, NG	L	Approx 250mL per run	H302 - Harmful if swallowed. H319 - Causes serious eye irritation.	P264 - Wash hands thoroughly after handling.	

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
						P261 - Avoid breathing dust. P280 - Wear protective gloves, protective clothing, eye protection. P301+P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. P305+P351+P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.	
Ethanol- solvent in Basic Yellow 40	C	NG, FC	L	Basic yellow 40 is 96% ethanol	H225 Highly flammable liquid and vapor. H319 Causes serious eye irritation.	P210 Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.	1000 ppm c 8 ho permissible 1000 ppm c 10 ho airborne

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
						P233 Keep container tightly closed. P240 Ground and bond container and receiving equipment. P241 Use explosion-proof electrical/ ventilating/ lighting/ equipment. P242 Use non-sparking tools. P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.	1000 p short term
Sodium Hydroxide	Corrosive to metals (Category 1) H290	NG, FC	L	0.5% approx. 250mL per run	H290 May be corrosive to metals.	P234 Keep only in original container. P260 Do not breathe dust or mist.	2 mg/m3- hours

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
	Skin corrosion (Category 1A) H314 Serious eye damage (Category 1) H318 Acute aquatic toxicity (Category 3), H402				H314 Causes severe skin burns and eye damage. H402 Harmful to aquatic life.	P264 Wash skin thoroughly after handling. P273 Avoid release to the environment. P280 Wear protective gloves/ protective clothing/ eye protection/ face protection. P301 + P330 + P331 IF SWALLOWED: rinse mouth. Do NOT induce vomiting. P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower. P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a	

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
						position comfortable for breathing. P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P310 Immediately call a POISON CENTER or doctor/ physician. P321 Specific treatment (see supplemental first aid instructions on this label). P363 Wash contaminated clothing before reuse.	

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
						P390 Absorb spillage to prevent material damage. P405 Store locked up. P406 Store in corrosive resistant stainless-steel container with a resistant inner liner. P501 Dispose of contents/ container to an approved waste disposal plant.	
Diesel	A	FC, NG	L	10mL per run	H226: Flammable liquid and vapour. H304: May be fatal if swallowed and enters airways. H315: Causes skin irritation. H332: Harmful if inhaled.	P102: Keep out of reach of children. P210: Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. P273 Avoid release to the environment	0,05 mg/m hours (di exhaust)

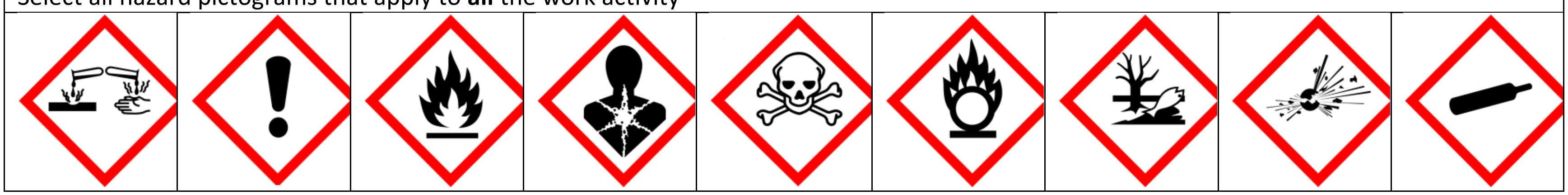
Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
					H351: Suspected of causing cancer H373: May cause damage to organs (Thymus, liver and bone marrow) H411: Toxic to aquatic life with long lasting effects.	P280: Wear protective gloves/protective clothing/eye protection/face protection. P301 + P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician P331: Do NOT induce vomiting. P405: Store locked up. P501: Dispose of contents/container in accordance with local / national regulations.	
Petrol	A	FC, NG	L	10mL per run	H224 - Extremely flammable liquid and vapour. H304 - May be fatal if swallowed	P102 - Keep out of reach of children. P101 - If medical advice is needed, have product	5mg.m^{-3} 8hrs or mg.m^{-3} in minutes

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
					and enters airways. H315 - Causes skin irritation. H336 - May cause drowsiness or dizziness. H340 - May cause genetic defects. H350 - May cause cancer.	container or label at hand P281 - Use personal protective equipment as required. P280 - Wear protective gloves, protective clothing and eye or face protection. P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. P241 - Use explosion-proof electrical, ventilating or lighting equipment P242 - Use non-sparking tools.	

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)
						P243 - Take action to prevent static discharges. P271 - Use only outdoors or in a well-ventilated area. P261 - Avoid breathing vapour. P264 - Wash hands thoroughly after handling	
Mikrosil Casting Putty	Not hazardous	NG	Pasty	Approximately 10mL	N/A	N/A	

Hazard pictograms

Select all hazard pictograms that apply to **all** the work activity



Corrosive (C)	Caution (H, I)	Flammable (F)	Longer Term Health Hazards (M)	Acute Toxicity (T+)	Oxidising (O)	Dangerous to the environment (W)	Explosive (E)	Gases Under Pressure (G)
☒	☒	☒	☒	☐	☒	☒	☐	☐

Special hazards

Are there any special hazards associated with work / procedure?	Yes ☐ No☒
If yes, then state:	
Is the activity/substances risk of thermal runaway or explosion?	Yes ☐ No☒
Does the activity involve handling or storing pyrophoric or unstable substances such as peroxides?	Yes ☐ No☒
Are any substances capable of forming an explosive atmosphere?	Yes ☐ No☒
If the answer is yes to any of the above questions in this section, a Dangerous substance, and Explosives Atmosphere (DSEAR) assessment must be completed	

Biological hazards

Microbiology

Microorganism	Strain	Source	Classification	Growth media	Hazard	Precaution
none						

Tissue Culture

Cell Line	Source	Classification	Growth media	Hazard	Precaution
none					

Genetic modification (GM)

Are genetic modification procedures required?	Yes ☐	No☒
If yes, then follow GM protocols		
Have you submitted a GM risk assessment?	Yes ☐	No☒
Has the GM risk assessment been approved?	Yes ☐	No☒

Human Tissue Act and other Policies

Are there any specific conditions to be adhered to e.g., Human Tissue Act, body fluid policy? (If yes give details below)	Yes ☐	No☒
Enter details here		
If working with body fluids, have you completed the body fluids declaration?	Yes ☐	No☒

Other biological material

Material (e.g. fluids, bone, meat etc.)	Hazard	Precaution	Quantity to be used
none			

Storage and Disposal

Storage requirements – How are the materials to be stored?
Store methanol in a locked cupboard that is suitable for chemical storage.

Disposal information – How will the waste be disposed?	Waste is to be stored in an appropriate container for specialist waste collection and disposal.
Are there any special disposal requirements? **If yes, please state requirements: -**	Yes ☐ No ☒

Emergency Plans

Do procedures require further emergency plans other than stated in codes of practice or standard procedure risk assessments? If yes, then state below		Yes ☒ No ☐
Spills	Diesel: Soak up diesel spillages using a non-combustible adsorbent material CYANOACRYLATE ADHESIVE: Absorb into dry earth or sand. (do not use cloths). Move into a closable, labelled salvage container for disposal by an appropriate method. Or polymerise slowly with water (~10:1, adhesive : water) and then scrape up. Sodium Hydroxide: Collect liquid and dilute with water and neutralize with dilute acid solution. Decant water to drain with excess water. Absorb with Suitable material. Wear protective eye-ware, gloves, and clothing. Basic Yellow 40: remove dust cloud by humidifying. Spills scooped into a closing container. Clean the left-over of the solution and clean it with water. Clothing has to be washed as well as the equipment used.	
Fire	Use the available fire distinguisher at site.	
First Aid	Use the available First Aid at site. If contact with Sodium hydroxide may require washing with dilute acid to neutralise the basic compound	
Other		

Approval

Risk assessment completed by	Teodosia Krumova
Date submitted	27/10/2023
Supervisor (or session lead) approval signed	David Flatman-Fairs
Date of supervisor approval	2/11/2023
H&S approval signed	A.Osborne
Date of H&S approval	2/11/2023
Review date	
Any other comments	

Appendix B:

This document contains the second Risk Assessment that has been signed off.

PRA 2nd signed off.docx

Procedure:

- Academics or session lead to complete Risk Assessment for all practical classes/activities, Technical team for all support aspects this is then reviewed as required
- Researchers/Experimenters are to complete a Risk Assessment in consultation with their project advisor and technical staff as appropriate.
- No laboratory work is to commence without a suitable and comprehensive risk assessment being signed off by a competent person detailed in the laboratory handbook.
- Researchers/Experimenters to keep copies of Risk Assessments when working in the laboratories.

Notes:

- The risk assessment must be reviewed when any changes are made to the equipment, materials, procedure, personnel or if there is a near miss or accident
- Any staff member can stop experimental work if no risk assessment is in place, or if, in their opinion, there is a risk to safety. If anybody else has concerns, they must raise it immediately to a member of staff.
- Add rows as necessary
- If substances are used, then you must fill out the COSHH section 3-6. The COSHH regulations link is available here: - Control of substances hazardous to health (COSHH). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (hse.gov.uk)

Risk assessment Reference **(Technical Services Only)**	

School/Service	Staffordshire University		
Name	Teodosia L. Krumova	Supervisor name	David Flatman-Fairs
Email address	K013708L@student.staffs.ac.uk	Supervisor email	d.p.flatman-fairs@staffs.ac.uk

level of study	Level 6	Course title	Forensic Investigation
Module number	FORE60369-2023-SUG1-2023-SUG2	Module title	FORENSIC RESEARCH PROJECT
Session/project title	Recovery of Soot Obscured Fingermarks		
Ethics approved (use BABAO for skeletal remains)	Yes ☐ No ☒		

<u>Description of experimental procedure/practical session (500 words max)</u>

Petrol or diesel will be used to set a 10x10cm piece of carpet on fire in the burn box at Staffordshire University, Science Centre. Fingermarks would be deposited by myself on three types of surfaces: plastic, metal, and glass. The metal sheets and plastic would be cut into small pieces. Every surface would have three fingermarks deposited onto each piece of material. I would ensure I rub my hands together or rub my hands through my hair to create more oil for the fingermarks to successfully transfer onto the surfaces. The sheets of different surfaces would be placed in the burn box with the fingermark facing down so the soot covers the fingermarks. Time between sooting would be as follows: immediately put in the burn box after deposition to created soot, 24 hours after deposition, two days, three days, and a week after deposition. The fingermarks would then be cleaned from the soot using brushing, rinsing using water, rinsing using NaOH or peeling off using Silicone Rubber Casting Compound. To develop the fingermarks Cyanoacrylate fuming will be used and Basic Yellow 40 staining. A control of each set of fingermarks will be made. Additionally, the DCS5 Foster and Freeman device will be used to visualise the fingermarks as well as alternative light sources.

Risk Assessment

Risk assessment score

		Consequence				
		Negligible (minimal first aid only) 1	Minor (minor injuries) 2	Moderate (major injury) 3	Major (life changing injury) 4	Catastrophic (Danger of death) 5
Likelihood	Almost certain 5	5	10	15	20	25
	Likely 4	4	8	12	16	20

	Possible 3	3	6	9	12	15
	Unlikely 2	2	4	6	8	10
	Rare 1	1	2	3	4	5

Hazard list

Hazards inherent in the work, record details and possible injury: (e.g., Equipment, procedures, general chemical hazards, invertebrate work, body fluid sampling etc.)	Risk score	Record precautions which will be taken: (*e.g.,* Include any standard operating procedures, codes of practice, faculty policies you will be following) **Use Hierarchy of Control Measures to reduce risks.**	New risk score
DSC5 Foster and Freeman	3	Use light shroud around the light source to reduce light leakage. Use correct camera filter. Take care in low light environments.	2
Alternative light sources	4	The use of the correct viewing goggles when handling certain lights, constantly referring to the sheet with guidance on what goggles need to be used with certain light sources. Whenever the light source is turned on, goggles must be worn, and goggles must be kept on until the light sources are turned off completely. Never shine the light source directly into eyes. Use in a controlled space only	2

Who may be at risk?

Staff – Day shift	Staff – Out of hours	Postgraduate students	Undergraduate students	New or expectant mothers	Contractors	Public	Other, please state below

☒	☐	☒	☒	☐	☐	☐	

What level of risk do you assign to this work?

Low	Medium Low	Medium	High
☐	☒	☐	☐

If the risk assessment is classified as high, then **no work** is to be undertaken. First, follow hierarchy of controls to reduce risks.

If no COSHH assessment is required, then please click here.

Control of Substances Hazardous to Health (COSHH)

COSHH assessment

Control of substances hazardous to health (COSHH). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (hse.gov.uk)

Links and table below to aid completing the COSHH assessment.

Minimum PPE are lab coat/safety glasses

Addition PPE:		
Fume cupboard (FC)	Laminar flow cabinets (LF)	Microbiological Safety cabinet (Cab)
Nitrile gloves (NG)	Vinyl gloves (VG)	Cryogenic gloves (CG)
Face shield (FS)	Face Mask FFP1	Face Mask FFP2
Face Mask FFP3	Respirator (R)	Other (provide details)
All INFORMATION CAN BE FOUND WITHIN MSDS (MATERIAL SAFETY DATA SHEETS) ON THE INTERNET, SCIENCES CHEMICAL DATABASE ON-LINE WITHIN EACH OF THE LABORATORIES		

Use safety data sheets where possible.

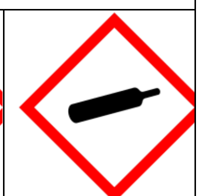
Hazard and Precaution statements list, should also be stated on the MSDS - GHS Classification (nih.gov)

Work Exposure Limits (WEL) if not stated on (M)SDS - EH40/2005 Workplace exposure limits (hse.gov.uk)

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)

Substance involved (e.g., chemicals including reagents, intermediates, products, and by-products):	Hazard Class (see below abbreviation letter e.g., C, F):	Handling precautions as above (abbreviation letter e.g., FC):	Physical State (solid (S), liquid (L), gas (G), mist (M), fume (F), dust (D)	Quantity and concentration to be used: ml/g, % solution/M	Hazard statement Code (H code)	Precautionary Statements (P-Code) Prevention	Workplace exposure lim (STEL/WEL)

Hazard pictograms

Select all hazard pictograms that apply to **all** the work activity								
 Corrosive (C)	 Caution (H, I)	 Flammable (F)	 Longer Term Health Hazards (M)	 Acute Toxicity (T+)	 Oxidising (O)	 Dangerous to the environment (W)	 Explosive (E)	 Gases Under Pressure (G)
☐	☐	☐	☐	☐	☐	☐	☐	☐

Special hazards

Are there any special hazards associated with work / procedure?	Yes ☐ No ☒
If yes, then state:	

Is the activity/substances risk of thermal runaway or explosion?	Yes ☐ No☒
Does the activity involve handling or storing pyrophoric or unstable substances such as peroxides?	Yes ☐ No☒
Are any substances capable of forming an explosive atmosphere?	Yes ☐ No☒
If the answer is yes to any of the above questions in this section, a Dangerous substance, and Explosives Atmosphere (DSEAR) assessment must be completed	

Biological hazards

Microbiology

Microorganism	Strain	Source	Classification	Growth media	Hazard	Precaution
none						

Tissue Culture

Cell Line	Source	Classification	Growth media	Hazard	Precaution
none					

Genetic modification (GM)

Are genetic modification procedures required?	Yes ☐ No☒

If yes, then follow GM protocols	
Have you submitted a GM risk assessment?	Yes ☐ No☒
Has the GM risk assessment been approved?	Yes ☐ No☒

Human Tissue Act and other Policies

Are there any specific conditions to be adhered to e.g., Human Tissue Act, body fluid policy? (If yes give details below)	Yes ☐ No☒
Enter details here	
If working with body fluids, have you completed the body fluids declaration?	Yes ☐ No☒

Other biological material

Material (e.g. fluids, bone, meat etc.)	Hazard	Precaution	Quantity to be used

Storage and Disposal

Storage requirements – How are the materials to be stored?	
Disposal information – How will the waste be disposed?	
Are there any special disposal requirements? **If yes, please state requirements: -**	Yes ☐ No☒

Emergency Plans

Do procedures require further emergency plans other than stated in codes of practice or standard procedure risk assessments? If yes, then state below	Yes ☐ No☒
Spills	

Fire	
First Aid	
Other	

Approval

Risk assessment completed by	Teodosia L. Krumova
Date submitted	04/12/2023
Supervisor (or session lead) approval signed	David Flatman-Fairs
Date of supervisor approval	06/12/23
H&S approval signed	A.Osborne
Date of H&S approval	08/12/2023
Review date	
Any other comments	

Appendix C

Link: disclaimer.docx

Research Ethics form:

RESEARCH ETHICS

Disclaimer Form

The following declaration should be made in cases where the researcher and the supervisor (where applicable) conclude that it is not necessary to apply for ethical approval for a specific research project.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	Teodosia L. Krumova
School	Staffordshire University

Student/Course Details (If Applicable)			
Student ID Number:		21013708	
Name of Supervisor(s)/Module Tutor:		David Flatman-Fairs	
PhD/MPhil project:	☐		
Taught Postgraduate Project/Assignment:	☐	Award Title:	
Undergraduate Project/Assignment:	☒	Module Title:	FORENSIC RESEARCH PROJECT : FORE60369-2023-SUG1-2023-SUG2

Project Title:	Recovery of Soot Obscured Fingermarks

Project Outline:	Researching the most successful way of recovering soot obsured fingermarks from possible arson scenes.		
Give a brief description of research procedure (methods, tests etc.)	Using different types of surfaces- metal, plastic and glass to deposit my own fingermarks on. Placing them in a burn box and sooting, followed by finding the best way to clean the soot off the fingermarks. The fingermarks will be cleaned using Sodium Hydroxide, Mikrosil Casting Compound, brushing and not cleanig at all. The fingermarks would be developed using cyanoacrylate fuming follwed by Basic Yellow 40 staining.		
Expected Start Date:	01/11/2023	Expected End Date:	29th March 2024

Declaration

I/We confirm that the University's Ethical Review Policy has been consulted and that all ethical issues and implications in relation to the above project have been considered. I/We confirm that ethical approval need not be sought. I/We confirm that:

The research does not involve human or animal participants	☒
The research does not present an indirect risk to non-participants (human or animal).	☒
The research does not raise ethical issues due to the potential social or environmental implications of the study.	☒
The research does not re-use previously collected personal data which is sensitive in nature, or enables the identification of individuals.	☒
Has a risk assessment been completed for this project?	☒ Yes ☐ N/A

Signature of Researcher:	Teodosia Krumova	Date:	23/20/2023
Signature(s) of Project Supervisor(s) (If student) OR Signature of Head of Department/ Senior researcher (if staff)	David Flatman-Fairs	Date:	26/10/23

NB: If the research departs from the protocol which provides the basis for this disclaimer then ethical review may be required and the applicant and supervisor (where applicable) should consider whether or not the disclaimer declaration remains appropriate. If it is no longer appropriate an application for ethical review **MUST** be submitted.

Appendix D:

This document contains all graded samples throughout the main study.

Appendix DSC5 fingermarks grading.docx

Appendix E:

This document contains the regraded fingermarks.

Regrade of fingermarks.docx.url

Regrading fingermarks

Regrading's were done of random samples to see whether there would be a difference in the gradings in comparison to the original gradings. A single sample was taken from every cleaning method for every surface type Overall, some differences were seen between the original gradings and the regrading's, however, the differences are not big. The only abnormality seen can be in sample '' Aluminium 7 days sooting Mikrosil sample 2'' because it had a big increase in the regrading. 72 fingermarks were regraded in total.

CLEANED	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	5	5	3	18
2nd print-middle finger	5	5	5	3	18
3rd print-ring finger	5	5	5	3	18

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	5	5	5	20
2nd print-	5	5	5	5	20

Aluminium immediate sooting: No cleaning sample 2

Aluminium immediate sooting: No cleaning sample 2 BY40

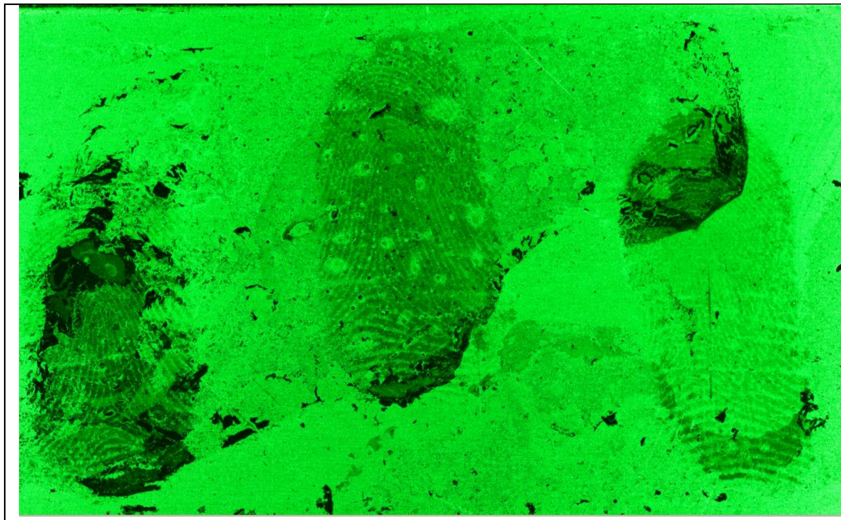
middle finger					
3rd print-ring finger	5	5	4	5	19

No differences in grading in No clean.

DIFFERENCES IN CNA:
1st fingermark- original 19 difference= 1
2nd fingermark- original 19 difference=1
3rd fingermark- original 17 diffrenece= 2

Aluminium 2 days sooting Ultra-pure wash sample 3

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	4	2	4	15
2nd print-middle finger	5	5	5	5	20
3rd print-ring finger	5	5	5	3	18
BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	3	3	4	15

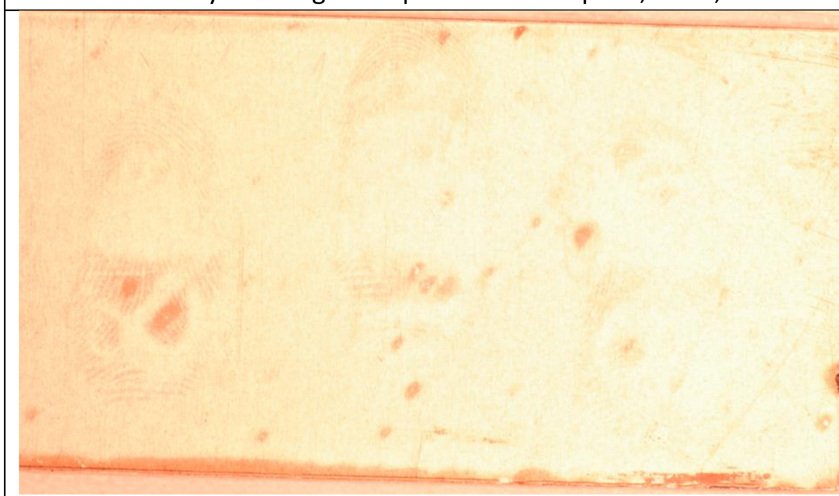


Aluminium 2 days sooting Ultra-pure wash sample 3; BY40;DSC5

2nd print- middle finger	5	5	4	4	18
3rd print- ring finger	5	4	3	4	16

No differences in H_2O/C; H20/CNA 1st fingermark

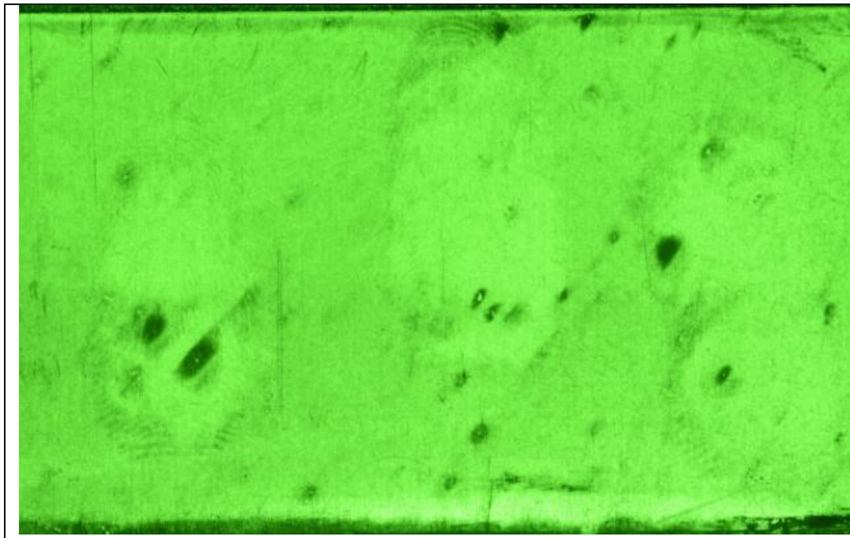
DIFFERENCES IN H_2O/CNA:
2nd fingermark- original 17 differences= 1
3rd fingermark- original 14 differences= 2



Aluminium 3 days sooting Tape-lift sample 2

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print- pointer finger	3	2	3	2	10
2nd print- middle finger	2	2	3	2	9
3rd print- ring finger	1	1	3	2	7

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print- pointer finger	3	2	3	3	11
2nd print-	2	2	3	3	10



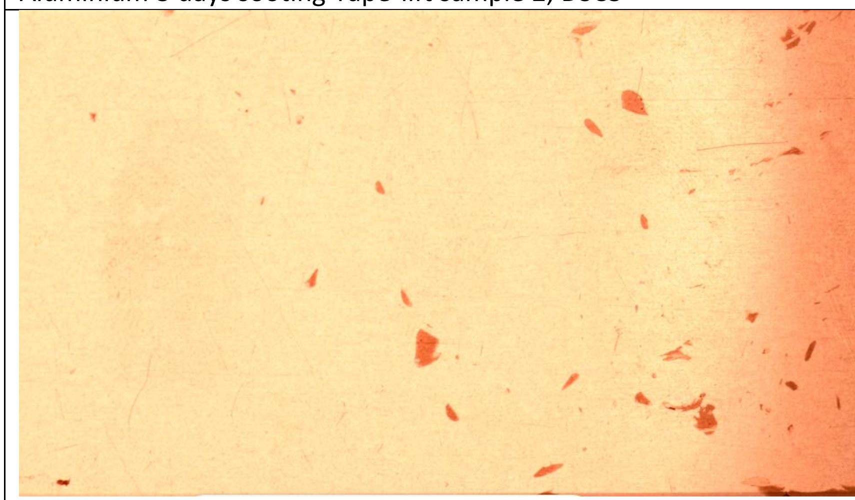
Aluminium 3 days sooting Tape-lift sample 2; DSC5

middle finger					
3rd print- ring finger	1	1	3	3	8

No differences in 2nd and 3rd fingermark of tape-lift/C
1st fingermark of tape-lift/CNA

DIFFERENCES IN
1st fingermark (tape-lift/C)- original= 11 differences=1

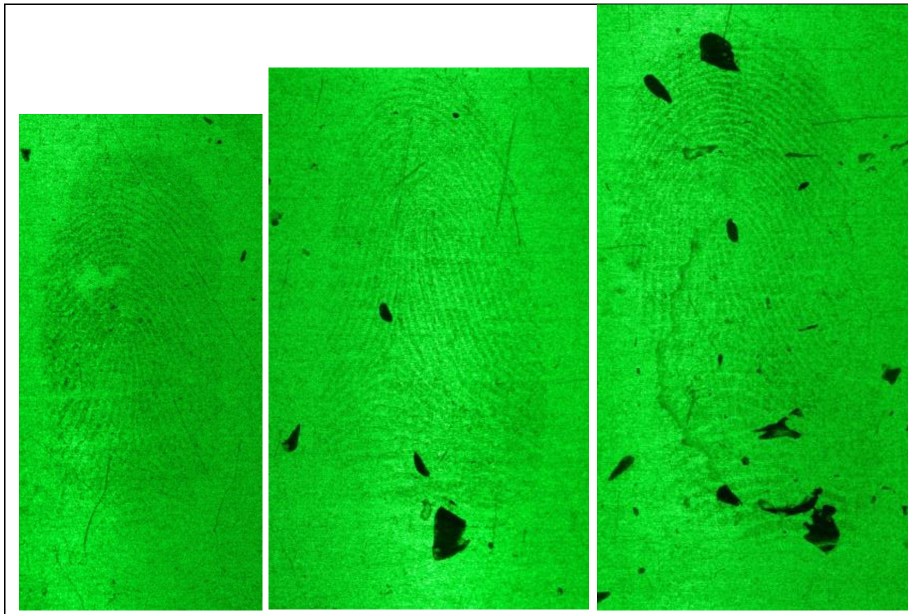
2nd fingermark (tape-lift/C) original= 9 difference= 1
3rd fingermark- (tape-lift/CNA)- original 7 differences=1



Aluminium 7 days sooting Mikrosil sample 2

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print- pointer finger	5	2	2	1	10
2nd print- middle finger	5	1	1	1	8
3rd print- ring finger	2	1	1	1	5

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-	5	5	5	5	20



Aluminium 7 days sooting Mikrosil sample 2; DSC5

pointer finger					
2nd print-middle finger	5	5	5	4	19
3rd print-ring finger	5	5	5	5	20

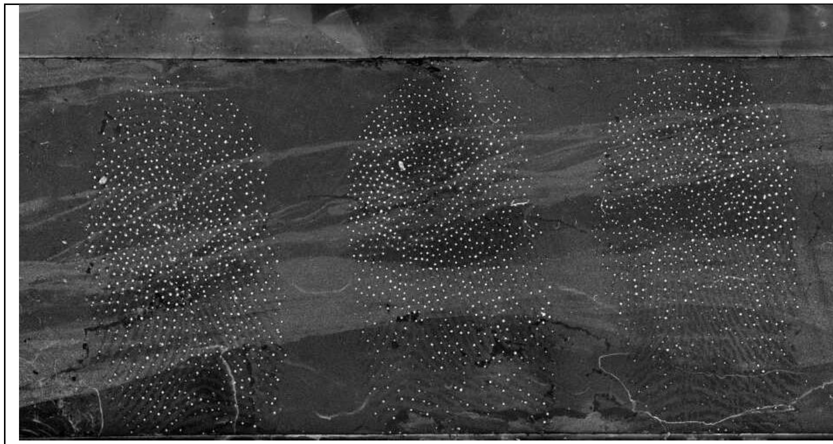
DIFFERENCES IN MIKORISL/C
1st fingermark-original-0 differences=10
2nd fingermark-original 0 differences=8
3rd fingermark-original 0 differences=5

No differences in Mikrosil/CNA

PVC immediate sooting: No cleaning sample 1

CLEANED	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	5	5	2	17
2nd print-middle finger	5	5	5	2	17
3rd print-ring finger	5	5	5	2	17

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-	5	4	4	3	16

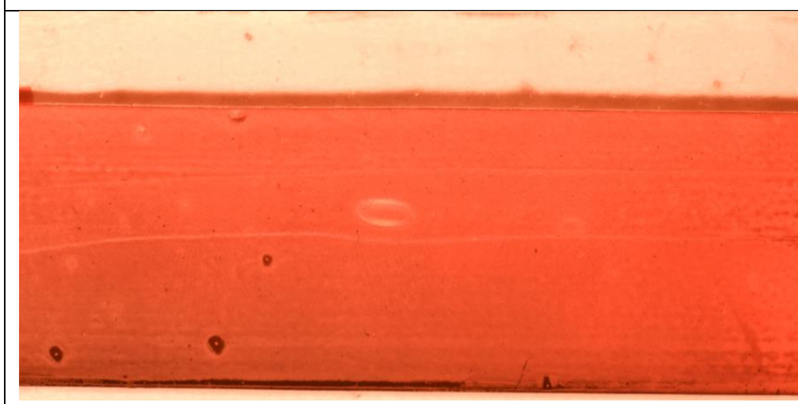


PVC immediate sooting: No cleaning sample 1 BY40; DSC5 enhanced

pointer finger					
2nd print-middle finger	5	4	4	3	16
3rd print-ring finger	4	4	4	3	15

No changes in PVC No clean.

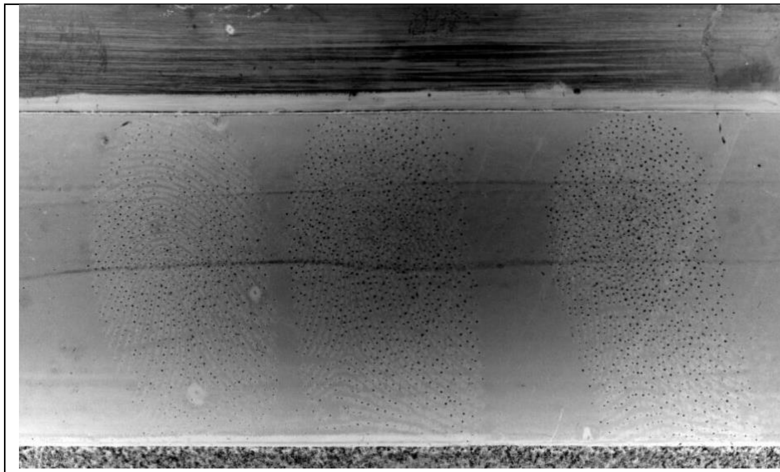
INCREASES in BY40
1st fingermark-original-13 differences=3
2nd fingermark-original- 13 differences=3
3rd fingermark-original 12 differences=3



PVC 2 days sooting Tape-lift sample 1

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	0	0	0	0	0
2nd print-middle finger	0	0	0	0	0
3rd print-ring finger	0	0	0	0	0

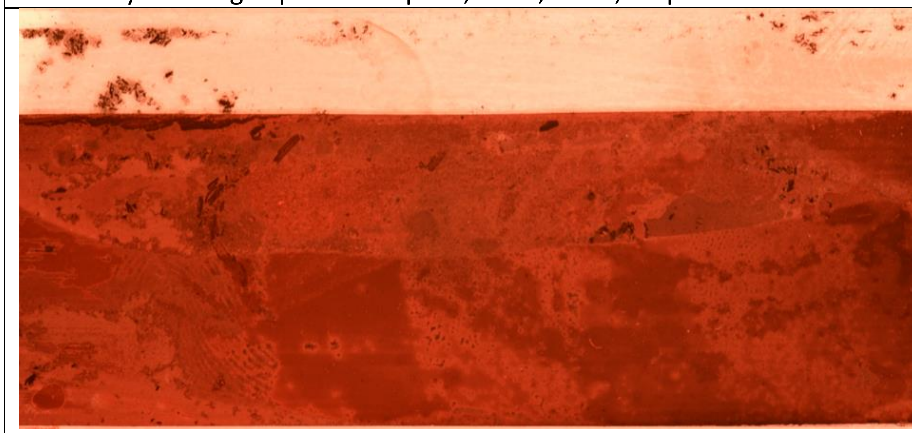
BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total



PVC 2 days sooting Tape-lift sample 1; BY40; DSC5; amplified

1st print-pointer finger	5	5	1	2	13
2nd print-middle finger	5	5	1	2	13
3rd print-ring finger	5	5	1	2	13

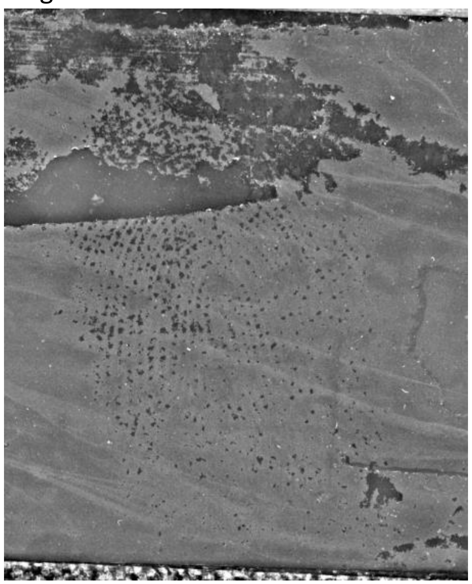
No difference in grading



PVC 3 days sooting Ultra-pure deionised water wash sample 1

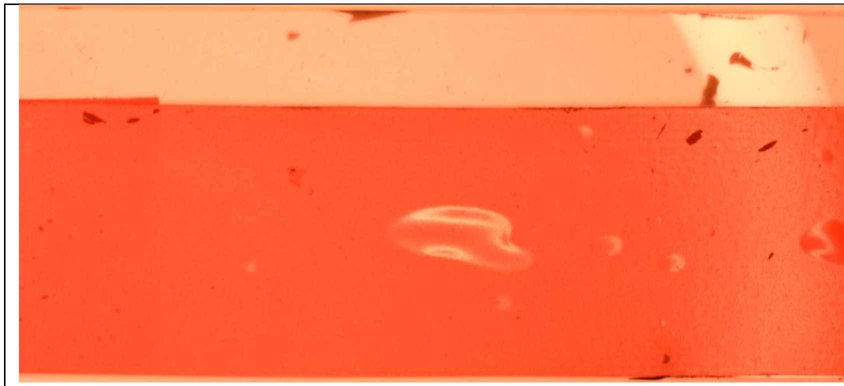
	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	2	2	2	1	7
2nd print-middle finger	0	0	0	0	0
3rd print-ring finger	0	0	0	0	0

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	4	5	4	4	17
2nd print-	5	5	3	3	16

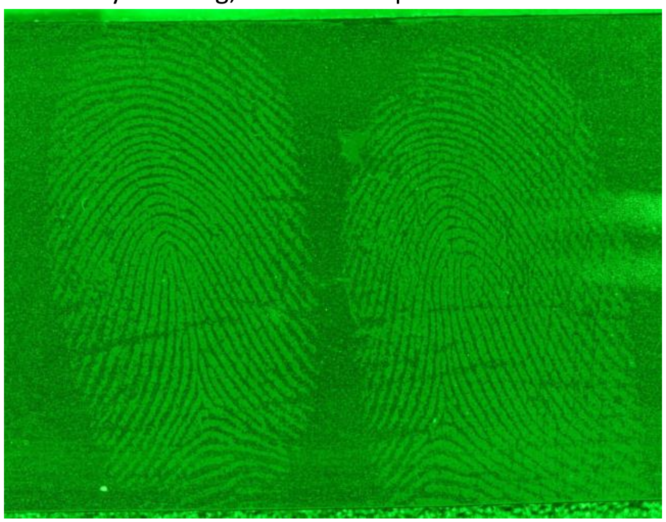
 PVC 3 days sooting Ultra-pure deionised water wash sample 1; DSC5; Fingermark 1 and 2  PVC 3 days sooting Ultra-pure deionised water wash sample 1; DSC5; Fingermark 3	middle finger					
	3rd print- ring finger	5	4	4	3	16

No differences in grading, apart from:

BY40 3RD FINGERMARK-original is 17 total differences=1



PVC 7 days sooting; Mikrosil sample 3

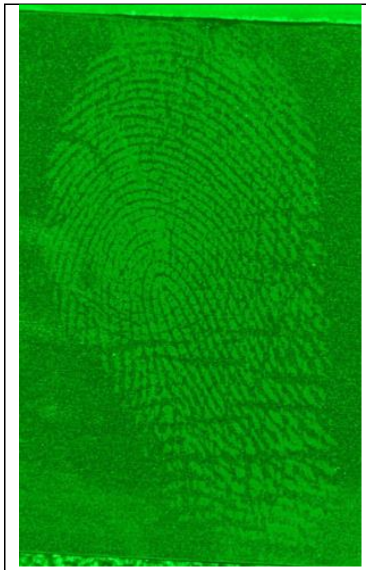


1st and 2nd Fingermarks

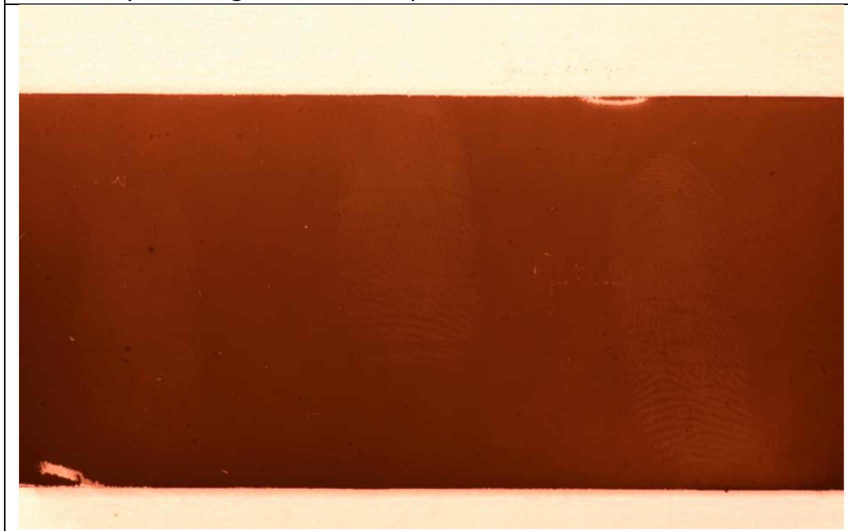
	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print- pointer finger	0	0	0	0	0
2nd print- middle finger	0	0	0	0	0
3rd print- ring finger	0	0	0	0	0

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print- pointer finger	5	5	5	5	20
2nd print- middle finger	5	5	5	5	20
3rd print- ring finger	4	5	5	5	19

NO DIFFERENCE IN GRADING



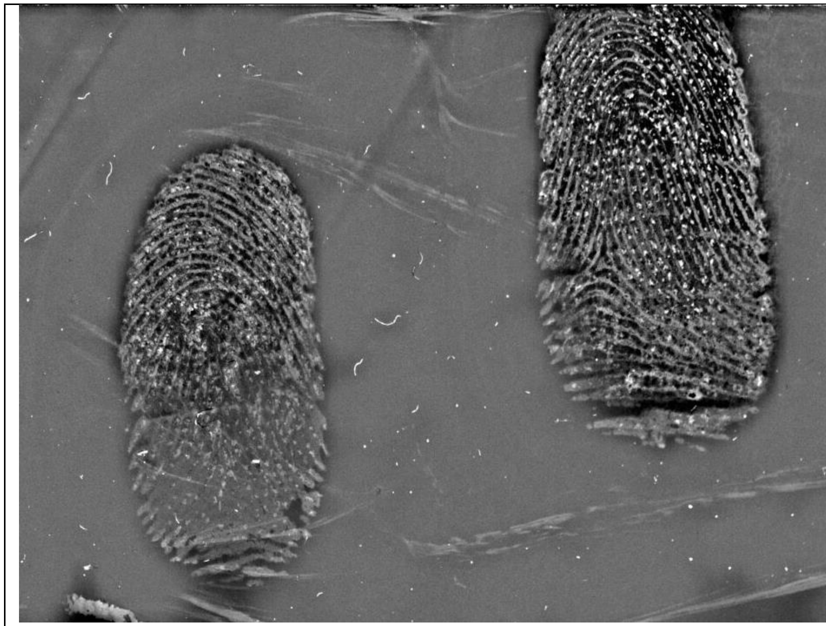
3rd Fingermark
PVC 7 days sooting; Mikrosil sample 3; DSC5

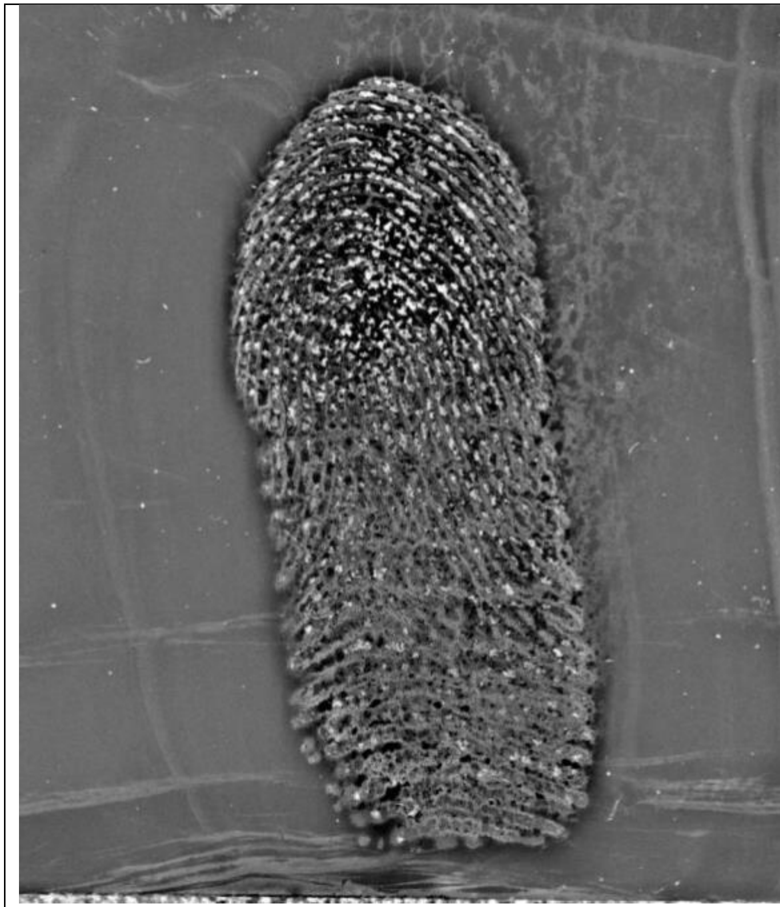


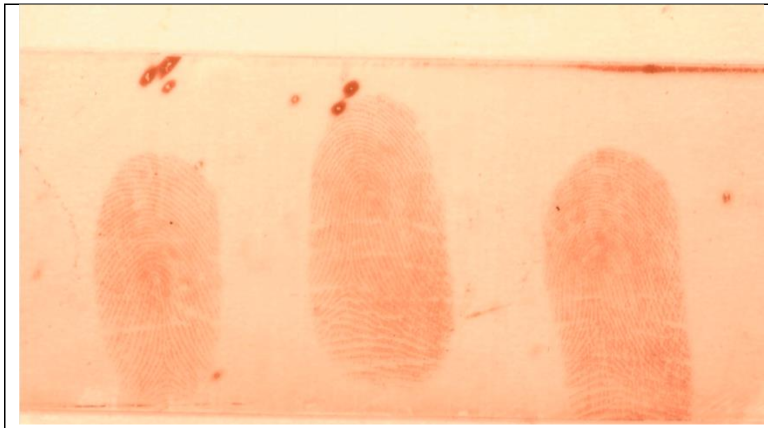
Glass immediate sooting No cleaning sample 3

CLEANED	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	2	3	2	12
2nd print-middle finger	5	4	4	3	16
3rd print-ring finger	5	4	4	3	16

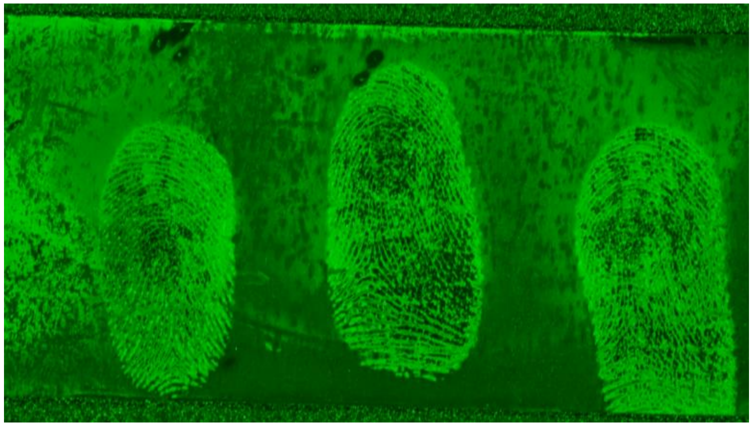
BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	3	3	5	16
2nd print-middle finger	5	5	4	5	19
3rd print-ring finger	5	5	3	5	18

 Glass immediate sooting No cleaning sample 3; DSC5; Fingermark 1 and 2	NO DIFFERENCE IN GRADING

 Glass immediate sooting No cleaning sample 3; DSC5; Fingermark 3	



Glass 2 days sooting Tape-lift sample 1

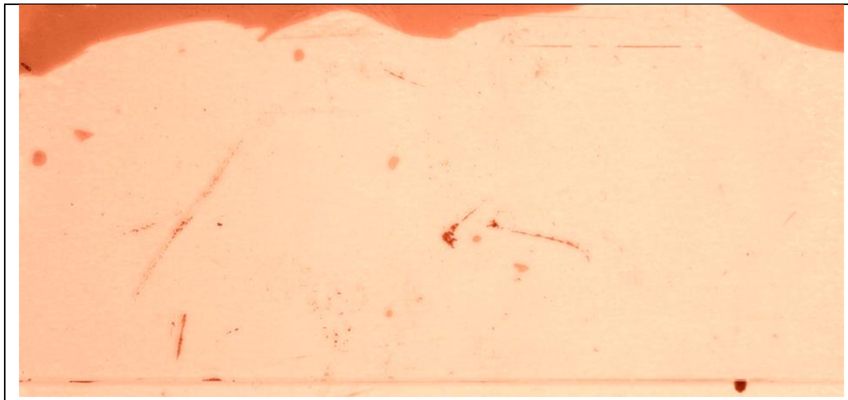


Glass 2 days sooting Tape-lift sample 1; DSC5

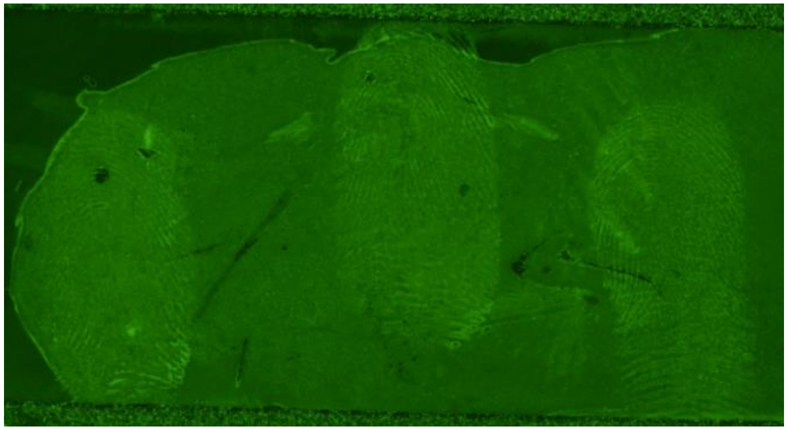
	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	5	5	5	20
2nd print-middle finger	5	5	5	5	20
3rd print-ring finger	5	5	5	5	20

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total	
1st print-pointer finger	5	5	4	5	19	
2nd print-middle finger	5	5	4	5	19	
3rd print-ring finger	5	5	4	5	19	

NO DIFFERENCE IN GRADING



Glass 3 days sooting; Mikrosil sample 1

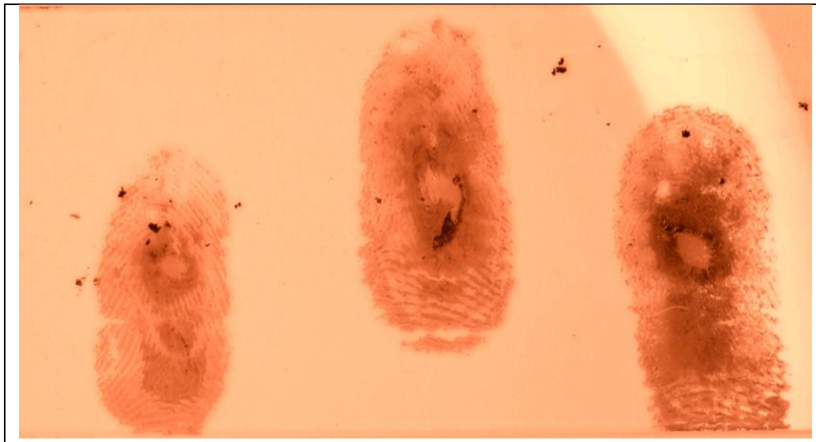


Glass 3 days sooting; Mikrosil sample 1; DSC5

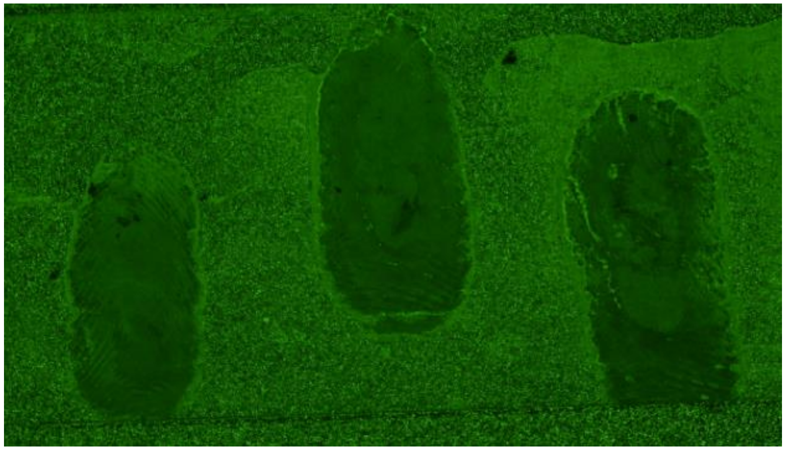
	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	0	0	0	0	0
2nd print-middle finger	0	0	0	0	0
3rd print-ring finger	0	0	0	0	0

BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1st print-pointer finger	5	5	5	5	20
2nd print-middle finger	5	5	5	5	20
3rd print-ring finger	5	5	5	5	20

NO DIFFERENCE IN GRADINGS



Glass 7 days sooting: Ultra-pure deionised water wash sample 2



Glass 7 days sooting: Ultra-pure deionised water wash sample 2; DSC5

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total	
1st print- pointer finger	5	5	5	4	19	0
2nd print- middle finger	5	3	5	4	17	0
3rd print- ring finger	5	4	3	4	16	0
BY40	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total	
1st print- pointer finger	5	4	3	3	15	
2nd print- middle finger	5	1	3	3	12	
3rd print- ring finger	5	1	3	3	11	

No differences in H_2O/C.

DIFFERENCES IN
1st fingermark- original 16= differences=1
2nd fingermark- original 13 differences=1
3rd fingermark- original 12 differences=1

Appendix F:

This document contains the statistical data for this research.

Statistical data

GLASS Test for normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
NO CLEAN; Cleaned	.284	36	<.001	.706	36	<.001
NO CLEAN; CNA	.156	36	.027	.914	36	.009
TAPE-LIFT; cleaned	.343	36	<.001	.627	36	<.001
TAPE-LIFT; CNA	.294	36	<.001	.687	36	<.001
H20; Cleaned	.205	36	<.001	.813	36	<.001
H20; CNA	.192	36	.002	.895	36	.002
MIKROSIL; Cleaned	.	36	.	.	36	.
MIKROSIL; CNA	.282	36	<.001	.782	36	<.001

a. Lilliefors Significance Correction

	NO CLEAN; Cleaned	NO CLEAN; CNA	TAPE-LIFT; cleane	TAPE-LIFT; CNA	H20; Clear	H20; CNA	MIKROSIL;	MIKROSIL; CNA
Glass; IMMEDIATE; FM1	16	12	3	18	15	15	0	10
Glass; IMMEDIATE; FM2	17	15	3	17	17	14	0	7
Glass;IMMEDIATE; FM3	15	15	3	16	9	10	0	10
Glass;IMMEDIATE; FM4	15	17	9	16	20	15	0	8
Glass;IMMEDIATE; FM5	16	15	3	15	18	12	0	13
Glass;IMMEDIATE; FM6	13	17	4	14	18	11	0	16
Glass;IMMEDIATE; FM7	12	16	20	20	8	10	0	7
Glass;IMMEDIATE; FM8	16	19	20	18	13	6	0	8
Glass;IMMEDIATE; FM9	16	18	19	10	9	10	0	15
Glass; 2 days; FM1	17	16	20	19	18	18	0	18
Glass; 2 days; FM2	17	16	20	19	19	19	0	18
Glass; 2 days; FM3	17	16	20	19	19	19	0	18
Glass; 2 days; FM4	16	12	19	19	19	19	0	18
Glass; 2 days; FM5	16	12	19	19	19	20	0	13
Glass; 2 days; FM6	16	12	19	19	18	19	0	16
Glass; 2 days; FM7	17	18	20	20	19	20	0	17
Glass; 2 days; FM8	17	16	20	19	19	20	0	18
Glass; 2 days; FM9	17	15	20	19	20	19	0	18
Glass; 3 days; FM1	16	18	19	20	19	20	0	20
Glass; 3 days; FM2	16	18	15	20	19	20	0	20
Glass; 3 days; FM3	14	18	15	20	18	20	0	20
Glass; 3 days; FM4	16	18	18	20	19	17	0	18
Glass; 3 days; FM5	17	18	19	20	18	19	0	19
Glass; 3 days; FM6	15	16	19	20	18	19	0	18
Glass; 3 days; FM7	17	20	19	20	16	19	0	20
Glass; 3 days; FM8	17	20	16	20	14	18	0	20
Glass; 3 days; FM9	17	20	16	20	10	17	0	20
Glass; 7 days; FM1	16	19	19	20	15	16	0	20
Glass; 7 days; FM2	13	17	19	20	16	12	0	20
Glass; 7 days; FM3	12	16	19	20	16	15	0	20
Glass; 7 days; FM4	17	18	18	20	19	16	0	19
Glass; 7 days; FM5	14	18	18	20	17	13	0	19
Glass; 7 days; FM6	14	17	19	20	16	12	0	19
Glass; 7 days; FM7	7	17	18	17	17	10	0	19
Glass; 7 days; FM8	7	18	19	18	16	13	0	19
Glass; 7 days; FM9	7	14	19	19	15	13	0	15

GLASS Friedman test

Ranks

	Mean Rank
NO CLEAN; CNA	4.54
TAPE-LIFT; CNA	6.76
H20; CNA	4.63
MIKROSIL; CNA	5.21
NO CLEAN; Cleaned	3.56
TAPE-LIFT; cleaned	5.43
H20; Cleaned	4.88
MIKROSIL; Cleaned	1.00

Test Statistics[a]

N	36
Chi-Square	123.155
df	7
Asymp. Sig.	<.001

a. Friedman Test

Wilcoxon Descriptive

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
NO CLEAN; Cleaned	36	14.94	2.828	7	17	14.00	16.00	17.00
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
NO CLEAN; CNA	36	16.58	2.209	12	20	15.25	17.00	18.00
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

GLASS Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
NO CLEAN; Cleaned	36	14.94	2.828	7	17	14.00	16.00	17.00
NO CLEAN; CNA	36	16.58	2.209	12	20	15.25	17.00	18.00
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

All NO CLEAN- 7 pairs

Ranks

		N	Mean Rank	Sum of Ranks
NO CLEAN; CNA - NO CLEAN; Cleaned	Negative Ranks	11[a]	14.64	161.00
	Positive Ranks	24[b]	19.54	469.00
	Ties	1[c]		
	Total	36		
TAPE-LIFT; cleaned - NO CLEAN; Cleaned	Negative Ranks	9[d]	22.28	200.50
	Positive Ranks	27[e]	17.24	465.50
	Ties	0[f]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; Cleaned	Negative Ranks	2[g]	15.00	30.00
	Positive Ranks	33[h]	18.18	600.00
	Ties	1[i]		
	Total	36		
H20; Cleaned - NO CLEAN; Cleaned	Negative Ranks	9[j]	18.44	166.00
	Positive Ranks	26[k]	17.85	464.00
	Ties	1[l]		
	Total	36		
H20; CNA - NO CLEAN; Cleaned	Negative Ranks	12[m]	15.50	186.00
	Positive Ranks	21[n]	17.86	375.00
	Ties	3[o]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; Cleaned	Negative Ranks	36[p]	18.50	666.00
	Positive Ranks	0[q]	.00	.00
	Ties	0[r]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; Cleaned	Negative Ranks	9[s]	21.28	191.50
	Positive Ranks	25[t]	16.14	403.50
	Ties	2[u]		
	Total	36		

a. NO CLEAN; CNA < NO CLEAN; Cleaned
b. NO CLEAN; CNA > NO CLEAN; Cleaned
c. NO CLEAN; CNA = NO CLEAN; Cleaned
d. TAPE-LIFT; cleaned < NO CLEAN; Cleaned
e. TAPE-LIFT; cleaned > NO CLEAN; Cleaned
f. TAPE-LIFT; cleaned = NO CLEAN; Cleaned
g. TAPE-LIFT; CNA < NO CLEAN; Cleaned
h. TAPE-LIFT; CNA > NO CLEAN; Cleaned
i. TAPE-LIFT; CNA = NO CLEAN; Cleaned
j. H20; Cleaned < NO CLEAN; Cleaned
k. H20; Cleaned > NO CLEAN; Cleaned
l. H20; Cleaned = NO CLEAN; Cleaned
m. H20; CNA < NO CLEAN; Cleaned
n. H20; CNA > NO CLEAN; Cleaned
o. H20; CNA = NO CLEAN; Cleaned
p. MIKROSIL; Cleaned < NO CLEAN; Cleaned
q. MIKROSIL; Cleaned > NO CLEAN; Cleaned
r. MIKROSIL; Cleaned = NO CLEAN; Cleaned
s. MIKROSIL; CNA < NO CLEAN; Cleaned
t. MIKROSIL; CNA > NO CLEAN; Cleaned
u. MIKROSIL; CNA = NO CLEAN; Cleaned

Test Statistics[a]

	NO CLEAN; CNA - NO CLEAN; Cleaned	TAPE-LIFT; cleaned - NO CLEAN; Cleaned	TAPE-LIFT; CNA - NO CLEAN; Cleaned	H20; Cleaned - NO CLEAN; Cleaned	H20; CNA - NO CLEAN; Cleaned	MIKROSIL; Cleaned - NO CLEAN; Cleaned	MIKROSIL; CNA - NO CLEAN; Cleaned
Z	-2.538[b]	-2.092[b]	-4.684[b]	-2.454[b]	-1.696[b]	-5.274[c]	-1.816[b]
Asymp. Sig. (2-tailed)	.011	.036	<.001	.014	.090	<.001	.069

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

Ranks

		N	Mean Rank	Sum of Ranks
NO CLEAN; CNA - NO CLEAN; Cleaned	Negative Ranks	11[a]	14.64	161.00
	Positive Ranks	24[b]	19.54	469.00
	Ties	1[c]		
	Total	36		
TAPE-LIFT; CNA - TAPE-LIFT; cleaned	Negative Ranks	9[d]	10.94	98.50
	Positive Ranks	21[e]	17.45	366.50
	Ties	6[f]		
	Total	36		
H20; CNA - H20; Cleaned	Negative Ranks	15[g]	21.03	315.50
	Positive Ranks	16[h]	11.28	180.50
	Ties	5[i]		
	Total	36		
MIKROSIL; CNA - MIKROSIL; Cleaned	Negative Ranks	0[j]	.00	.00
	Positive Ranks	36[k]	18.50	666.00
	Ties	0[l]		
	Total	36		

a. NO CLEAN; CNA < NO CLEAN; Cleaned

b. NO CLEAN; CNA > NO CLEAN; Cleaned

c. NO CLEAN; CNA = NO CLEAN; Cleaned

d. TAPE-LIFT; CNA < TAPE-LIFT; cleaned

e. TAPE-LIFT; CNA > TAPE-LIFT; cleaned

f. TAPE-LIFT; CNA = TAPE-LIFT; cleaned

g. H20; CNA < H20; Cleaned

h. H20; CNA > H20; Cleaned

i. H20; CNA = H20; Cleaned

j. MIKROSIL; CNA < MIKROSIL; Cleaned

k. MIKROSIL; CNA > MIKROSIL; Cleaned

l. MIKROSIL; CNA = MIKROSIL; Cleaned

Test Statistics[a]

	NO CLEAN; CNA - NO CLEAN; Cleaned	TAPE-LIFT; CNA - TAPE-LIFT; cleaned	H20; CNA - H20; Cleaned	MIKROSIL; CNA - MIKROSIL; Cleaned
Z	-2.538[b]	-2.799[b]	-1.336[c]	-5.252[b]
Asymp. Sig. (2-tailed)	.011	.005	.182	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

NO CLEAN CNA ALL 6 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
NO CLEAN; CNA	36	16.58	2.209	12	20	15.25	17.00	18.00
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; cleaned - NO CLEAN; CNA	Negative Ranks	11[a]	22.00	242.00
	Positive Ranks	21[b]	13.62	286.00
	Ties	4[c]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; CNA	Negative Ranks	4[d]	13.00	52.00
	Positive Ranks	26[e]	15.88	413.00
	Ties	6[f]		
	Total	36		
H20; Cleaned - NO CLEAN; CNA	Negative Ranks	12[g]	20.13	241.50
	Positive Ranks	20[h]	14.33	286.50
	Ties	4[i]		
	Total	36		
H20; CNA - NO CLEAN; CNA	Negative Ranks	21[j]	18.79	394.50
	Positive Ranks	15[k]	18.10	271.50
	Ties	0[l]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; CNA	Negative Ranks	36[m]	18.50	666.00
	Positive Ranks	0[n]	.00	.00
	Ties	0[o]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; CNA	Negative Ranks	10[p]	21.30	213.00
	Positive Ranks	22[q]	14.32	315.00
	Ties	4[r]		
	Total	36		

a. TAPE-LIFT; cleaned < NO CLEAN; CNA
b. TAPE-LIFT; cleaned > NO CLEAN; CNA
c. TAPE-LIFT; cleaned = NO CLEAN; CNA
d. TAPE-LIFT; CNA < NO CLEAN; CNA
e. TAPE-LIFT; CNA > NO CLEAN; CNA
f. TAPE-LIFT; CNA = NO CLEAN; CNA
g. H20; Cleaned < NO CLEAN; CNA
h. H20; Cleaned > NO CLEAN; CNA
i. H20; Cleaned = NO CLEAN; CNA
j. H20; CNA < NO CLEAN; CNA
k. H20; CNA > NO CLEAN; CNA
l. H20; CNA = NO CLEAN; CNA
m. MIKROSIL; Cleaned < NO CLEAN; CNA
n. MIKROSIL; Cleaned > NO CLEAN; CNA
o. MIKROSIL; Cleaned = NO CLEAN; CNA
p. MIKROSIL; CNA < NO CLEAN; CNA
q. MIKROSIL; CNA > NO CLEAN; CNA
r. MIKROSIL; CNA = NO CLEAN; CNA

Test Statistics[a]

	TAPE-LIFT; cleaned - NO CLEAN; CNA	TAPE-LIFT; CNA - NO CLEAN; CNA	H20; Cleaned - NO CLEAN; CNA	H20; CNA - NO CLEAN; CNA	MIKROSIL; Cleaned - NO CLEAN; CNA	MIKROSIL; CNA - NO CLEAN; CNA
Z	-.413[b]	-3.732[b]	-.423[b]	-.969[c]	-5.253[c]	-.962[b]
Asymp. Sig. (2-tailed)	.680	<.001	.672	.332	<.001	.336

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

ALL tape-cleaned- 5 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; CNA - TAPE-LIFT; cleaned	Negative Ranks	9[a]	10.94	98.50
	Positive Ranks	21[b]	17.45	366.50
	Ties	6[c]		
	Total	36		
H20; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	22[d]	13.93	306.50
	Positive Ranks	10[e]	22.15	221.50
	Ties	4[f]		
	Total	36		
H20; CNA - TAPE-LIFT; cleaned	Negative Ranks	17[g]	14.62	248.50
	Positive Ranks	12[h]	15.54	186.50
	Ties	7[i]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	36[j]	18.50	666.00
	Positive Ranks	0[k]	.00	.00
	Ties	0[l]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; cleaned	Negative Ranks	15[m]	16.90	253.50
	Positive Ranks	17[n]	16.15	274.50
	Ties	4[o]		
	Total	36		

a. TAPE-LIFT; CNA < TAPE-LIFT; cleaned
b. TAPE-LIFT; CNA > TAPE-LIFT; cleaned
c. TAPE-LIFT; CNA = TAPE-LIFT; cleaned
d. H20; Cleaned < TAPE-LIFT; cleaned
e. H20; Cleaned > TAPE-LIFT; cleaned
f. H20; Cleaned = TAPE-LIFT; cleaned
g. H20; CNA < TAPE-LIFT; cleaned
h. H20; CNA > TAPE-LIFT; cleaned
i. H20; CNA = TAPE-LIFT; cleaned
j. MIKROSIL; Cleaned < TAPE-LIFT; cleaned
k. MIKROSIL; Cleaned > TAPE-LIFT; cleaned
l. MIKROSIL; Cleaned = TAPE-LIFT; cleaned
m. MIKROSIL; CNA < TAPE-LIFT; cleaned
n. MIKROSIL; CNA > TAPE-LIFT; cleaned
o. MIKROSIL; CNA = TAPE-LIFT; cleaned

Test Statistics[a]

	TAPE-LIFT; CNA - TAPE-LIFT; cleaned	H20; Cleaned - TAPE-LIFT; cleaned	H20; CNA - TAPE-LIFT; cleaned	MIKROSIL; Cleaned - TAPE-LIFT; cleaned	MIKROSIL; CNA - TAPE-LIFT; cleaned
Z	-2.799[b]	-.799[c]	-.672[c]	-5.277[c]	-.197[b]
Asymp. Sig. (2-tailed)	.005	.424	.502	<.001	.843

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

ALL TAPE LIFT CNA – 4 pairs (tape lift CNA and cleaned repeated above)

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
H20; Cleaned - TAPE-LIFT; CNA	Negative Ranks	25[a]	15.00	375.00
	Positive Ranks	4[b]	15.00	60.00
	Ties	7[c]		
	Total	36		
H20; CNA - TAPE-LIFT; CNA	Negative Ranks	24[d]	14.29	343.00
	Positive Ranks	2[e]	4.00	8.00
	Ties	10[f]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; CNA	Negative Ranks	36[g]	18.50	666.00
	Positive Ranks	0[h]	.00	.00
	Ties	0[i]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; CNA	Negative Ranks	23[j]	14.09	324.00
	Positive Ranks	4[k]	13.50	54.00
	Ties	9[l]		
	Total	36		
TAPE-LIFT; CNA - TAPE-LIFT; cleaned	Negative Ranks	9[m]	10.94	98.50
	Positive Ranks	21[n]	17.45	366.50
	Ties	6[o]		
	Total	36		

a. H20; Cleaned < TAPE-LIFT; CNA
b. H20; Cleaned > TAPE-LIFT; CNA
c. H20; Cleaned = TAPE-LIFT; CNA
d. H20; CNA < TAPE-LIFT; CNA
e. H20; CNA > TAPE-LIFT; CNA
f. H20; CNA = TAPE-LIFT; CNA
g. MIKROSIL; Cleaned < TAPE-LIFT; CNA
h. MIKROSIL; Cleaned > TAPE-LIFT; CNA
i. MIKROSIL; Cleaned = TAPE-LIFT; CNA
j. MIKROSIL; CNA < TAPE-LIFT; CNA
k. MIKROSIL; CNA > TAPE-LIFT; CNA
l. MIKROSIL; CNA = TAPE-LIFT; CNA
m. TAPE-LIFT; CNA < TAPE-LIFT; cleaned
n. TAPE-LIFT; CNA > TAPE-LIFT; cleaned
o. TAPE-LIFT; CNA = TAPE-LIFT; cleaned

Test Statistics[a]

	H20; Cleaned - TAPE-LIFT; CNA	H20; CNA - TAPE-LIFT; CNA	MIKROSIL; Cleaned - TAPE-LIFT; CNA	MIKROSIL; CNA - TAPE-LIFT; CNA	TAPE-LIFT; CNA - TAPE-LIFT; cleaned
Z	-3.425[b]	-4.271[b]	-5.309[b]	-3.272[b]	-2.799[c]
Asymp. Sig. (2-tailed)	<.001	<.001	<.001	.001	.005

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

ALL H2O CLEANED- 3 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
H20; CNA - H20; Cleaned	Negative Ranks	15[a]	21.03	315.50
	Positive Ranks	16[b]	11.28	180.50
	Ties	5[c]		
	Total	36		
MIKROSIL; Cleaned - H20; Cleaned	Negative Ranks	36[d]	18.50	666.00
	Positive Ranks	0[e]	.00	.00
	Ties	0[f]		
	Total	36		
MIKROSIL; CNA - H20; Cleaned	Negative Ranks	16[g]	15.81	253.00
	Positive Ranks	16[h]	17.19	275.00
	Ties	4[i]		
	Total	36		

a. H20; CNA < H20; Cleaned
b. H20; CNA > H20; Cleaned
c. H20; CNA = H20; Cleaned
d. MIKROSIL; Cleaned < H20; Cleaned
e. MIKROSIL; Cleaned > H20; Cleaned
f. MIKROSIL; Cleaned = H20; Cleaned
g. MIKROSIL; CNA < H20; Cleaned
h. MIKROSIL; CNA > H20; Cleaned
i. MIKROSIL; CNA = H20; Cleaned

Test Statistics[a]

	H20; CNA - H20; Cleaned	MIKROSIL; Cleaned - H20; Cleaned	MIKROSIL; CNA - H20; Cleaned
Z	-1.336[b]	-5.252[b]	-.207[c]
Asymp. Sig. (2-tailed)	.182	<.001	.836

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.

ALL H2O CNA 2 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; Cleaned - H20; CNA	Negative Ranks	36[a]	18.50	666.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	36		
MIKROSIL; CNA - H20; CNA	Negative Ranks	13[d]	13.69	178.00
	Positive Ranks	17[e]	16.88	287.00
	Ties	6[f]		
	Total	36		

a. MIKROSIL; Cleaned < H20; CNA

b. MIKROSIL; Cleaned > H20; CNA

c. MIKROSIL; Cleaned = H20; CNA

d. MIKROSIL; CNA < H20; CNA

e. MIKROSIL; CNA > H20; CNA

f. MIKROSIL; CNA = H20; CNA

Test Statistics[a]

	MIKROSIL; Cleaned - H20; CNA	MIKROSIL; CNA - H20; CNA
Z	-5.243[b]	-1.125[c]
Asymp. Sig. (2-tailed)	<.001	.261

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

MIKROSIL CLEANED – 1 pair

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; CNA - MIKROSIL; Cleaned	Negative Ranks	0[a]	.00	.00
	Positive Ranks	36[b]	18.50	666.00
	Ties	0[c]		
	Total	36		

a. MIKROSIL; CNA < MIKROSIL; Cleaned

b. MIKROSIL; CNA > MIKROSIL; Cleaned

c. MIKROSIL; CNA = MIKROSIL; Cleaned

Test Statistics[a]

	MIKROSIL; CNA - MIKROSIL; Cleaned
Z	-5.252[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of NO CLEAN; Cleaned is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
2	The distribution of NO CLEAN; CNA is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
3	The distribution of TAPE-LIFT; cleaned is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
4	The distribution of TAPE-LIFT; CNA is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
5	The distribution of H20; Cleaned is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
6	The distribution of H20; CNA is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.
7	The distribution of MIKROSIL; Cleaned is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	1.000	Retain the null hypothesis.
8	The distribution of MIKROSIL; CNA is the same across categories of V1.	Independent-Samples Kruskal-Wallis Test	.468	Retain the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

Aluminium surface

	NO CLEAN; Cleaned	NO CLEAN; CNA	TAPE-LIFT; cleaned	TAPE-LIFT; CNA	H20; Cleaned	H20; CNA	MIKROSIL; Cleaned	MIKROSIL; CNA
Aluminium; IMMEDIATE; FM1	0	18	5	7	18	19	0	20
Aluminium; IMMEDIATE; FM2	0	18	7	6	20	20	0	20
Aluminium;IMMEDIATE; FM3	0	16	5	8	19	19	0	16
Aluminium;IMMEDIATE; FM4	18	19	6	17	17	18	0	0
Aluminium;IMMEDIATE; FM5	18	19	12	18	19	19	0	0
Aluminium;IMMEDIATE; FM6	18	17	17	16	20	14	0	0
Aluminium;IMMEDIATE; FM7	17	18	20	20	20	19	0	19
Aluminium;IMMEDIATE; FM8	17	15	17	19	20	20	0	19
Aluminium;IMMEDIATE; FM9	17	13	14	16	20	19	0	17
Aluminium; 2 days; FM1	19	20	18	18	17	18	0	0
Aluminium; 2 days; FM2	19	20	17	18	18	17	0	11
Aluminium; 2 days; FM3	19	20	16	17	18	17	0	9
Aluminium; 2 days; FM4	16	17	19	20	19	17	0	17
Aluminium; 2 days; FM5	13	15	18	19	19	18	0	17
Aluminium; 2 days; FM6	15	15	20	20	19	17	0	7
Aluminium; 2 days; FM7	16	20	20	20	15	15	0	17
Aluminium; 2 days; FM8	16	19	20	20	20	17	0	17
Aluminium; 2 days; FM9	8	17	20	20	18	14	0	10
Aluminium; 3 days; FM1	0	16	16	13	19	19	0	4
Aluminium; 3 days; FM2	0	16	15	11	19	19	0	0
Aluminium; 3 days; FM3	0	14	6	6	19	19	0	0
Aluminium; 3 days; FM4	17	19	11	11	15	16	0	0
Aluminium; 3 days; FM5	16	19	9	9	19	20	0	0
Aluminium; 3 days; FM6	15	19	7	7	19	18	0	0
Aluminium; 3 days; FM7	7	18	18	19	19	20	0	0
Aluminium; 3 days; FM8	9	18	19	20	19	20	0	6
Aluminium; 3 days; FM9	7	18	18	20	19	20	0	5
Aluminium; 7 days; FM1	0	16	19	20	19	14	6	18
Aluminium; 7 days; FM2	0	15	19	19	18	14	6	17
Aluminium; 7 days; FM3	0	13	18	17	19	18	6	18
Aluminium; 7 days; FM4	20	18	19	18	19	14	0	20
Aluminium; 7 days; FM5	15	18	18	16	20	14	0	19
Aluminium; 7 days; FM6	0	20	16	16	20	16	0	20
Aluminium; 7 days; FM7	0	9	8	10	20	20	15	16
Aluminium; 7 days; FM8	0	8	6	4	20	17	12	20
Aluminium; 7 days; FM9	5	18	12	5	20	16	16	19

ALUMINIUM Test for normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
NO CLEAN; Cleaned	.239	36	<.001	.804	36	<.001
NO CLEAN; CNA	.207	36	<.001	.853	36	<.001
TAPE-LIFT; cleaned	.218	36	<.001	.836	36	<.001
TAPE-LIFT; CNA	.241	36	<.001	.828	36	<.001
H20; Cleaned	.303	36	<.001	.772	36	<.001
H20; CNA	.177	36	.006	.882	36	.001
MIKROSIL; Cleaned	.489	36	<.001	.459	36	<.001
MIKROSIL; CNA	.254	36	<.001	.803	36	<.001

a. Lilliefors Significance Correction

Test for normality aluminium- not normally distributed

ALUMINIUM Friedman test

Descriptive Statistics

	N	Percentiles		
		25th	50th (Median)	75th
NO CLEAN; Cleaned	36	.00	14.00	17.00
NO CLEAN; CNA	36	15.25	18.00	19.00
TAPE-LIFT; cleaned	36	9.50	17.00	19.00
TAPE-LIFT; CNA	36	10.25	17.00	19.75
H20; Cleaned	36	18.25	19.00	20.00
H20; CNA	36	16.00	18.00	19.00
MIKROSIL; Cleaned	36	.00	.00	.00
MIKROSIL; CNA	36	.00	16.00	18.75

Ranks

	Mean Rank
NO CLEAN; Cleaned	3.33
NO CLEAN; CNA	5.21
TAPE-LIFT; cleaned	4.74
TAPE-LIFT; CNA	5.08
H20; Cleaned	6.54
H20; CNA	5.50
MIKROSIL; Cleaned	1.64
MIKROSIL; CNA	3.96

Test Statistics[a]

N	36
Chi-Square	99.043
df	7
Asymp. Sig.	<.001

a. Friedman Test

ALUMINIUM Wilcoxon Signed Ranks Test

1st 7 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
NO CLEAN; Cleaned	36	9.92	7.940	0	20	.00	14.00	17.00
NO CLEAN; CNA	36	16.89	2.846	8	20	15.25	18.00	19.00
TAPE-LIFT; cleaned	36	14.58	5.234	5	20	9.50	17.00	19.00
TAPE-LIFT; CNA	36	15.00	5.340	4	20	10.25	17.00	19.75
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Ranks

		N	Mean Rank	Sum of Ranks
NO CLEAN; CNA - NO CLEAN; Cleaned	Negative Ranks	4[a]	10.63	42.50
	Positive Ranks	31[b]	18.95	587.50
	Ties	1[c]		
	Total	36		
TAPE-LIFT; cleaned - NO CLEAN; Cleaned	Negative Ranks	11[d]	12.00	132.00
	Positive Ranks	24[e]	20.75	498.00
	Ties	1[f]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; Cleaned	Negative Ranks	10[g]	9.50	95.00
	Positive Ranks	24[h]	20.83	500.00
	Ties	2[i]		
	Total	36		
H20; Cleaned - NO CLEAN; Cleaned	Negative Ranks	7[j]	4.79	33.50
	Positive Ranks	29[k]	21.81	632.50
	Ties	0[l]		
	Total	36		
H20; CNA - NO CLEAN; Cleaned	Negative Ranks	8[m]	8.75	70.00
	Positive Ranks	27[n]	20.74	560.00
	Ties	1[o]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; Cleaned	Negative Ranks	23[p]	17.37	399.50
	Positive Ranks	6[q]	5.92	35.50
	Ties	7[r]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; Cleaned	Negative Ranks	13[s]	17.54	228.00
	Positive Ranks	19[t]	15.79	300.00
	Ties	4[u]		
	Total	36		

a. NO CLEAN; CNA < NO CLEAN; Cleaned
b. NO CLEAN; CNA > NO CLEAN; Cleaned
c. NO CLEAN; CNA = NO CLEAN; Cleaned
d. TAPE-LIFT; cleaned < NO CLEAN; Cleaned
e. TAPE-LIFT; cleaned > NO CLEAN; Cleaned
f. TAPE-LIFT; cleaned = NO CLEAN; Cleaned
g. TAPE-LIFT; CNA < NO CLEAN; Cleaned
h. TAPE-LIFT; CNA > NO CLEAN; Cleaned
i. TAPE-LIFT; CNA = NO CLEAN; Cleaned
j. H20; Cleaned < NO CLEAN; Cleaned
k. H20; Cleaned > NO CLEAN; Cleaned
l. H20; Cleaned = NO CLEAN; Cleaned
m. H20; CNA < NO CLEAN; Cleaned
n. H20; CNA > NO CLEAN; Cleaned
o. H20; CNA = NO CLEAN; Cleaned
p. MIKROSIL; Cleaned < NO CLEAN; Cleaned
q. MIKROSIL; Cleaned > NO CLEAN; Cleaned
r. MIKROSIL; Cleaned = NO CLEAN; Cleaned
s. MIKROSIL; CNA < NO CLEAN; Cleaned
t. MIKROSIL; CNA > NO CLEAN; Cleaned
u. MIKROSIL; CNA = NO CLEAN; Cleaned

Test Statistics[a]

	NO CLEAN; CNA - NO CLEAN; Cleaned	TAPE-LIFT; cleaned - NO CLEAN; Cleaned	TAPE-LIFT; CNA - NO CLEAN; Cleaned	H20; Cleaned - NO CLEAN; Cleaned	H20; CNA - NO CLEAN; Cleaned	MIKROSIL; Cleaned - NO CLEAN; Cleaned	MIKROSIL; CNA - NO CLEAN; Cleaned
Z	-4.472[b]	-3.000[b]	-3.466[b]	-4.713[b]	-4.020[b]	-3.940[c]	-.674[b]
Asymp. Sig. (2-tailed)	<.001	.003	<.001	<.001	<.001	<.001	.500

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

2nd 6 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
NO CLEAN; CNA	36	16.89	2.846	8	20	15.25	18.00	19.00
TAPE-LIFT; cleaned	36	14.58	5.234	5	20	9.50	17.00	19.00
TAPE-LIFT; CNA	36	15.00	5.340	4	20	10.25	17.00	19.75
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; cleaned - NO CLEAN; CNA	Negative Ranks	17[a]	19.26	327.50
	Positive Ranks	13[b]	10.58	137.50
	Ties	6[c]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; CNA	Negative Ranks	19[d]	20.18	383.50
	Positive Ranks	15[e]	14.10	211.50
	Ties	2[f]		
	Total	36		
H20; Cleaned - NO CLEAN; CNA	Negative Ranks	6[g]	16.42	98.50
	Positive Ranks	25[h]	15.90	397.50
	Ties	5[i]		
	Total	36		
H20; CNA - NO CLEAN; CNA	Negative Ranks	16[j]	16.38	262.00
	Positive Ranks	18[k]	18.50	333.00
	Ties	2[l]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; CNA	Negative Ranks	34[m]	19.44	661.00
	Positive Ranks	2[n]	2.50	5.00
	Ties	0[o]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; CNA	Negative Ranks	19[p]	23.03	437.50
	Positive Ranks	14[q]	8.82	123.50
	Ties	3[r]		
	Total	36		

a. TAPE-LIFT; cleaned < NO CLEAN; CNA
b. TAPE-LIFT; cleaned > NO CLEAN; CNA
c. TAPE-LIFT; cleaned = NO CLEAN; CNA
d. TAPE-LIFT; CNA < NO CLEAN; CNA
e. TAPE-LIFT; CNA > NO CLEAN; CNA
f. TAPE-LIFT; CNA = NO CLEAN; CNA
g. H20; Cleaned < NO CLEAN; CNA
h. H20; Cleaned > NO CLEAN; CNA
i. H20; Cleaned = NO CLEAN; CNA
j. H20; CNA < NO CLEAN; CNA
k. H20; CNA > NO CLEAN; CNA
l. H20; CNA = NO CLEAN; CNA
m. MIKROSIL; Cleaned < NO CLEAN; CNA
n. MIKROSIL; Cleaned > NO CLEAN; CNA
o. MIKROSIL; Cleaned = NO CLEAN; CNA
p. MIKROSIL; CNA < NO CLEAN; CNA
q. MIKROSIL; CNA > NO CLEAN; CNA
r. MIKROSIL; CNA = NO CLEAN; CNA

Test Statistics[a]

	TAPE-LIFT; cleaned - NO CLEAN; CNA	TAPE-LIFT; CNA - NO CLEAN; CNA	H20; Cleaned - NO CLEAN; CNA	H20; CNA - NO CLEAN; CNA	MIKROSIL; Cleaned - NO CLEAN; CNA	MIKROSIL; CNA - NO CLEAN; CNA
Z	-1.958[b]	-1.475[b]	-2.943[c]	-.610[c]	-5.165[b]	-2.810[b]
Asymp. Sig. (2-tailed)	.050	.140	.003	.542	<.001	.005

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

3rd 5 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
TAPE-LIFT; cleaned	36	14.58	5.234	5	20	9.50	17.00	19.00
TAPE-LIFT; CNA	36	15.00	5.340	4	20	10.25	17.00	19.75
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; CNA - TAPE-LIFT; cleaned	Negative Ranks	9[a]	13.06	117.50
	Positive Ranks	15[b]	12.17	182.50
	Ties	12[c]		
	Total	36		
H20; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	5[d]	8.30	41.50
	Positive Ranks	25[e]	16.94	423.50
	Ties	6[f]		
	Total	36		
H20; CNA - TAPE-LIFT; cleaned	Negative Ranks	11[g]	12.55	138.00
	Positive Ranks	20[h]	17.90	358.00
	Ties	5[i]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	33[j]	19.76	652.00
	Positive Ranks	3[k]	4.67	14.00
	Ties	0[l]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; cleaned	Negative Ranks	24[m]	18.65	447.50
	Positive Ranks	11[n]	16.59	182.50
	Ties	1[o]		
	Total	36		

a. TAPE-LIFT; CNA < TAPE-LIFT; cleaned

b. TAPE-LIFT; CNA > TAPE-LIFT; cleaned

c. TAPE-LIFT; CNA = TAPE-LIFT; cleaned

d. H20; Cleaned < TAPE-LIFT; cleaned

e. H20; Cleaned > TAPE-LIFT; cleaned

f. H20; Cleaned = TAPE-LIFT; cleaned

g. H20; CNA < TAPE-LIFT; cleaned

h. H20; CNA > TAPE-LIFT; cleaned

i. H20; CNA = TAPE-LIFT; cleaned

j. MIKROSIL; Cleaned < TAPE-LIFT; cleaned

k. MIKROSIL; Cleaned > TAPE-LIFT; cleaned

l. MIKROSIL; Cleaned = TAPE-LIFT; cleaned

m. MIKROSIL; CNA < TAPE-LIFT; cleaned

n. MIKROSIL; CNA > TAPE-LIFT; cleaned

o. MIKROSIL; CNA = TAPE-LIFT; cleaned

Test Statistics[a]

	TAPE-LIFT; CNA - TAPE-LIFT; cleaned	H20; Cleaned - TAPE-LIFT; cleaned	H20; CNA - TAPE-LIFT; cleaned	MIKROSIL; Cleaned - TAPE-LIFT; cleaned	MIKROSIL; CNA - TAPE-LIFT; cleaned
Z	-.942[b]	-3.939[b]	-2.159[b]	-5.017[c]	-2.172[c]
Asymp. Sig. (2-tailed)	.346	<.001	.031	<.001	.030

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

4th 4 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
TAPE-LIFT; CNA	36	15.00	5.340	4	20	10.25	17.00	19.75
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
H20; Cleaned - TAPE-LIFT; CNA	Negative Ranks	9[a]	8.17	73.50
	Positive Ranks	21[b]	18.64	391.50
	Ties	6[c]		
	Total	36		
H20; CNA - TAPE-LIFT; CNA	Negative Ranks	13[d]	12.23	159.00
	Positive Ranks	18[e]	18.72	337.00
	Ties	5[f]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; CNA	Negative Ranks	33[g]	19.64	648.00
	Positive Ranks	3[h]	6.00	18.00
	Ties	0[i]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; CNA	Negative Ranks	24[j]	19.13	459.00
	Positive Ranks	11[k]	15.55	171.00
	Ties	1[l]		
	Total	36		

a. H20; Cleaned < TAPE-LIFT; CNA

b. H20; Cleaned > TAPE-LIFT; CNA

c. H20; Cleaned = TAPE-LIFT; CNA

d. H20; CNA < TAPE-LIFT; CNA

e. H20; CNA > TAPE-LIFT; CNA

f. H20; CNA = TAPE-LIFT; CNA

g. MIKROSIL; Cleaned < TAPE-LIFT; CNA

h. MIKROSIL; Cleaned > TAPE-LIFT; CNA

i. MIKROSIL; Cleaned = TAPE-LIFT; CNA

j. MIKROSIL; CNA < TAPE-LIFT; CNA

k. MIKROSIL; CNA > TAPE-LIFT; CNA

l. MIKROSIL; CNA = TAPE-LIFT; CNA

Test Statistics[a]

	H20; Cleaned - TAPE-LIFT; CNA	H20; CNA - TAPE-LIFT; CNA	MIKROSIL; Cleaned - TAPE-LIFT; CNA	MIKROSIL; CNA - TAPE-LIFT; CNA
Z	-3.292[b]	-1.749[b]	-4.958[c]	-2.360[c]
Asymp. Sig. (2-tailed)	<.001	.080	<.001	.018

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

5th 3pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
H20; CNA - H20; Cleaned	Negative Ranks	19[a]	16.53	314.00
	Positive Ranks	8[b]	8.00	64.00
	Ties	9[c]		
	Total	36		
MIKROSIL; Cleaned - H20; Cleaned	Negative Ranks	36[d]	18.50	666.00
	Positive Ranks	0[e]	.00	.00
	Ties	0[f]		
	Total	36		
MIKROSIL; CNA - H20; Cleaned	Negative Ranks	30[g]	17.85	535.50
	Positive Ranks	3[h]	8.50	25.50
	Ties	3[i]		
	Total	36		

a. H20; CNA < H20; Cleaned

b. H20; CNA > H20; Cleaned

c. H20; CNA = H20; Cleaned

d. MIKROSIL; Cleaned < H20; Cleaned

e. MIKROSIL; Cleaned > H20; Cleaned

f. MIKROSIL; Cleaned = H20; Cleaned

g. MIKROSIL; CNA < H20; Cleaned

h. MIKROSIL; CNA > H20; Cleaned

i. MIKROSIL; CNA = H20; Cleaned

Test Statistics[a]

	H20; CNA - H20; Cleaned	MIKROSIL; Cleaned - H20; Cleaned	MIKROSIL; CNA - H20; Cleaned
Z	-3.067[b]	-5.277[b]	-4.569[b]
Asymp. Sig. (2-tailed)	.002	<.001	<.001

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

2[nd] PAIR

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; Cleaned - H20; CNA	Negative Ranks	35[a]	18.00	630.00
	Positive Ranks	0[b]	.00	.00
	Ties	1[c]		
	Total	36		
MIKROSIL; CNA - H20; CNA	Negative Ranks	22[d]	18.84	414.50
	Positive Ranks	9[e]	9.06	81.50
	Ties	5[f]		
	Total	36		

a. MIKROSIL; Cleaned < H20; CNA

b. MIKROSIL; Cleaned > H20; CNA

c. MIKROSIL; Cleaned = H20; CNA

d. MIKROSIL; CNA < H20; CNA

e. MIKROSIL; CNA > H20; CNA

f. MIKROSIL; CNA = H20; CNA

Test Statistics[a]

	MIKROSIL; Cleaned - H20; CNA	MIKROSIL; CNA - H20; CNA
Z	-5.174[b]	-3.266[b]
Asymp. Sig. (2-tailed)	<.001	.001

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

1 pair

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; CNA - MIKROSIL; Cleaned	Negative Ranks	0[a]	.00	.00
	Positive Ranks	26[b]	13.50	351.00
	Ties	10[c]		
	Total	36		

a. MIKROSIL; CNA < MIKROSIL; Cleaned

b. MIKROSIL; CNA > MIKROSIL; Cleaned

c. MIKROSIL; CNA = MIKROSIL; Cleaned

Test Statistics[a]

	MIKROSIL; CNA - MIKROSIL; Cleaned
Z	-4.464[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

PVC Test for normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
NO CLEAN; Cleaned	.514	36	<.001	.425	36	<.001
NO CLEAN; CNA	.211	36	<.001	.855	36	<.001
TAPE-LIFT; cleaned	.538	36	<.001	.158	36	<.001
TAPE-LIFT; CNA	.211	36	<.001	.859	36	<.001
H20; Cleaned	.539	36	<.001	.246	36	<.001
H20; CNA	.316	36	<.001	.754	36	<.001
MIKROSIL; Cleaned	.525	36	<.001	.212	36	<.001
MIKROSIL; CNA	.388	36	<.001	.661	36	<.001

a. Lilliefors Significance Correction

	NO CLEAN; Cleaned	NO CLEAN; CNA	TAPE-LIFT; cleaned	TAPE-LIFT; CNA	H20; Cleaned	H20; CNA	MIKROSIL; Cleaned	MIKROSIL; CNA
PVC; IMMEDIATE; FM1	17	13	0	9	7	13	0	13
PVC; IMMEDIATE; FM2	17	13	0	9	0	15	0	15
PVC;IMMEDIATE; FM3	17	12	0	5	0	15	0	15
PVC;IMMEDIATE; FM4	14	12	0	9	0	8	0	14
PVC;IMMEDIATE; FM5	12	10	4	9	0	9	0	14
PVC;IMMEDIATE; FM6	0	9	0	9	0	13	0	14
PVC;IMMEDIATE; FM7	0	8	0	9	0	0	16	15
PVC;IMMEDIATE; FM8	0	8	0	8	0	0	4	15
PVC;IMMEDIATE; FM9	0	0	0	8	0	0	0	13
PVC; 2 days; FM1	0	10	0	13	0	0	0	20
PVC; 2 days; FM2	0	11	0	13	0	0	0	20
PVC; 2 days; FM3	0	10	0	13	0	0	0	20
PVC; 2 days; FM4	0	0	0	17	0	0	0	20
PVC; 2 days; FM5	0	0	0	17	0	0	0	20
PVC; 2 days; FM6	0	0	0	17	0	0	0	20
PVC; 2 days; FM7	0	0	0	12	0	0	0	20
PVC; 2 days; FM8	0	0	0	12	0	0	0	20
PVC; 2 days; FM9	0	0	0	15	0	0	0	20
PVC; 3 days; FM1	0	18	0	20	7	17	0	20
PVC; 3 days; FM2	0	16	0	20	0	16	0	20
PVC; 3 days; FM3	0	0	0	20	0	17	0	20
PVC; 3 days; FM4	0	18	0	20	0	18	0	20
PVC; 3 days; FM5	0	18	0	20	0	18	0	20
PVC; 3 days; FM6	0	18	0	20	0	18	0	20
PVC; 3 days; FM7	0	0	0	19	0	17	0	20
PVC; 3 days; FM8	0	0	0	19	0	5	0	20
PVC; 3 days; FM9	0	0	0	20	0	5	0	20
PVC; 7 days; FM1	0	19	0	19	0	0	0	20
PVC; 7 days; FM2	0	19	0	19	0	0	0	16
PVC; 7 days; FM3	0	19	0	18	0	0	0	14
PVC; 7 days; FM4	0	14	0	19	0	0	0	20
PVC; 7 days; FM5	0	10	0	19	0	0	0	20
PVC; 7 days; FM6	0	9	0	17	0	0	0	19
PVC; 7 days; FM7	0	20	0	19	0	19	0	20
PVC; 7 days; FM8	0	19	0	17	0	19	0	20
PVC; 7 days; FM9	0	19	0	16	0	19	0	19

PVC Friedman test

Test Statistics[a]

N	36
Chi-Square	172.930
df	7
Asymp. Sig.	<.001

a. Friedman Test

PVC Wilcoxon Signed Ranks Test

7 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
NO CLEAN; Cleaned	36	2.14	5.457	0	17	.00	.00	.00
NO CLEAN; CNA	36	9.78	7.461	0	20	.00	10.00	18.00
TAPE-LIFT; cleaned	36	.11	.667	0	4	.00	.00	.00
TAPE-LIFT; CNA	36	15.14	4.661	5	20	9.75	17.00	19.00
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Ranks

		N	Mean Rank	Sum of Ranks
NO CLEAN; CNA - NO CLEAN; Cleaned	Negative Ranks	5[a]	3.00	15.00
	Positive Ranks	20[b]	15.50	310.00
	Ties	11[c]		
	Total	36		
TAPE-LIFT; cleaned - NO CLEAN; Cleaned	Negative Ranks	5[d]	3.00	15.00
	Positive Ranks	0[e]	.00	.00
	Ties	31[f]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; Cleaned	Negative Ranks	5[g]	4.40	22.00
	Positive Ranks	31[h]	20.77	644.00
	Ties	0[i]		
	Total	36		
H20; Cleaned - NO CLEAN; Cleaned	Negative Ranks	5[j]	4.00	20.00
	Positive Ranks	1[k]	1.00	1.00
	Ties	30[l]		
	Total	36		
H20; CNA - NO CLEAN; Cleaned	Negative Ranks	5[m]	3.40	17.00
	Positive Ranks	13[n]	11.85	154.00
	Ties	18[o]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; Cleaned	Negative Ranks	5[p]	4.60	23.00
	Positive Ranks	2[q]	2.50	5.00
	Ties	29[r]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; Cleaned	Negative Ranks	3[s]	2.67	8.00
	Positive Ranks	32[t]	19.44	622.00
	Ties	1[u]		
	Total	36		

a. NO CLEAN; CNA < NO CLEAN; Cleaned
b. NO CLEAN; CNA > NO CLEAN; Cleaned
c. NO CLEAN; CNA = NO CLEAN; Cleaned
d. TAPE-LIFT; cleaned < NO CLEAN; Cleaned
e. TAPE-LIFT; cleaned > NO CLEAN; Cleaned
f. TAPE-LIFT; cleaned = NO CLEAN; Cleaned
g. TAPE-LIFT; CNA < NO CLEAN; Cleaned
h. TAPE-LIFT; CNA > NO CLEAN; Cleaned
i. TAPE-LIFT; CNA = NO CLEAN; Cleaned
j. H20; Cleaned < NO CLEAN; Cleaned
k. H20; Cleaned > NO CLEAN; Cleaned
l. H20; Cleaned = NO CLEAN; Cleaned
m. H20; CNA < NO CLEAN; Cleaned
n. H20; CNA > NO CLEAN; Cleaned
o. H20; CNA = NO CLEAN; Cleaned
p. MIKROSIL; Cleaned < NO CLEAN; Cleaned
q. MIKROSIL; Cleaned > NO CLEAN; Cleaned
r. MIKROSIL; Cleaned = NO CLEAN; Cleaned
s. MIKROSIL; CNA < NO CLEAN; Cleaned
t. MIKROSIL; CNA > NO CLEAN; Cleaned
u. MIKROSIL; CNA = NO CLEAN; Cleaned

Test Statistics[a]

	NO CLEAN; CNA - NO CLEAN; Cleaned	TAPE-LIFT; cleaned - NO CLEAN; Cleaned	TAPE-LIFT; CNA - NO CLEAN; Cleaned	H20; Cleaned - NO CLEAN; Cleaned	H20; CNA - NO CLEAN; Cleaned	MIKROSIL; Cleaned - NO CLEAN; Cleaned	MIKROSIL; CNA - NO CLEAN; Cleaned
Z	-3.976[b]	-2.060[c]	-4.897[b]	-1.997[c]	-2.988[b]	-1.532[c]	-5.209[b]
Asymp. Sig. (2-tailed)	<.001	.039	<.001	.046	.003	.125	<.001

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

6 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
NO CLEAN; CNA	36	9.78	7.461	0	20	.00	10.00	18.00
TAPE-LIFT; cleaned	36	.11	.667	0	4	.00	.00	.00
TAPE-LIFT; CNA	36	15.14	4.661	5	20	9.75	17.00	19.00
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; cleaned - NO CLEAN; CNA	Negative Ranks	25[a]	13.00	325.00
	Positive Ranks	0[b]	.00	.00
	Ties	11[c]		
	Total	36		
TAPE-LIFT; CNA - NO CLEAN; CNA	Negative Ranks	9[d]	10.11	91.00
	Positive Ranks	23[e]	19.00	437.00
	Ties	4[f]		
	Total	36		
H20; Cleaned - NO CLEAN; CNA	Negative Ranks	25[g]	13.00	325.00
	Positive Ranks	0[h]	.00	.00
	Ties	11[i]		
	Total	36		
H20; CNA - NO CLEAN; CNA	Negative Ranks	15[j]	12.23	183.50
	Positive Ranks	7[k]	9.93	69.50
	Ties	14[l]		
	Total	36		
MIKROSIL; Cleaned - NO CLEAN; CNA	Negative Ranks	24[m]	13.46	323.00
	Positive Ranks	1[n]	2.00	2.00
	Ties	11[o]		
	Total	36		
MIKROSIL; CNA - NO CLEAN; CNA	Negative Ranks	2[p]	11.50	23.00
	Positive Ranks	31[q]	17.35	538.00
	Ties	3[r]		
	Total	36		

a. TAPE-LIFT; cleaned < NO CLEAN; CNA
b. TAPE-LIFT; cleaned > NO CLEAN; CNA
c. TAPE-LIFT; cleaned = NO CLEAN; CNA
d. TAPE-LIFT; CNA < NO CLEAN; CNA
e. TAPE-LIFT; CNA > NO CLEAN; CNA
f. TAPE-LIFT; CNA = NO CLEAN; CNA
g. H20; Cleaned < NO CLEAN; CNA
h. H20; Cleaned > NO CLEAN; CNA
i. H20; Cleaned = NO CLEAN; CNA
j. H20; CNA < NO CLEAN; CNA
k. H20; CNA > NO CLEAN; CNA
l. H20; CNA = NO CLEAN; CNA
m. MIKROSIL; Cleaned < NO CLEAN; CNA
n. MIKROSIL; Cleaned > NO CLEAN; CNA
o. MIKROSIL; Cleaned = NO CLEAN; CNA
p. MIKROSIL; CNA < NO CLEAN; CNA
q. MIKROSIL; CNA > NO CLEAN; CNA
r. MIKROSIL; CNA = NO CLEAN; CNA

Test Statistics[a]

	TAPE-LIFT; cleaned - NO CLEAN; CNA	TAPE-LIFT; CNA - NO CLEAN; CNA	H20; Cleaned - NO CLEAN; CNA	H20; CNA - NO CLEAN; CNA	MIKROSIL; Cleaned - NO CLEAN; CNA	MIKROSIL; CNA - NO CLEAN; CNA
Z	-4.380[b]	-3.240[c]	-4.380[b]	-1.852[b]	-4.327[b]	-4.621[c]
Asymp. Sig. (2-tailed)	<.001	.001	<.001	.064	<.001	<.001

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.

5 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
TAPE-LIFT; cleaned	36	.11	.667	0	4	.00	.00	.00
TAPE-LIFT; CNA	36	15.14	4.661	5	20	9.75	17.00	19.00
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
TAPE-LIFT; CNA - TAPE-LIFT; cleaned	Negative Ranks	0[a]	.00	.00
	Positive Ranks	36[b]	18.50	666.00
	Ties	0[c]		
	Total	36		
H20; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	1[d]	1.00	1.00
	Positive Ranks	2[e]	2.50	5.00
	Ties	33[f]		
	Total	36		
H20; CNA - TAPE-LIFT; cleaned	Negative Ranks	0[g]	.00	.00
	Positive Ranks	18[h]	9.50	171.00
	Ties	18[i]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; cleaned	Negative Ranks	1[j]	1.50	1.50
	Positive Ranks	2[k]	2.25	4.50
	Ties	33[l]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; cleaned	Negative Ranks	0[m]	.00	.00
	Positive Ranks	36[n]	18.50	666.00
	Ties	0[o]		
	Total	36		

a. TAPE-LIFT; CNA < TAPE-LIFT; cleaned
b. TAPE-LIFT; CNA > TAPE-LIFT; cleaned
c. TAPE-LIFT; CNA = TAPE-LIFT; cleaned
d. H20; Cleaned < TAPE-LIFT; cleaned
e. H20; Cleaned > TAPE-LIFT; cleaned
f. H20; Cleaned = TAPE-LIFT; cleaned
g. H20; CNA < TAPE-LIFT; cleaned
h. H20; CNA > TAPE-LIFT; cleaned
i. H20; CNA = TAPE-LIFT; cleaned
j. MIKROSIL; Cleaned < TAPE-LIFT; cleaned
k. MIKROSIL; Cleaned > TAPE-LIFT; cleaned
l. MIKROSIL; Cleaned = TAPE-LIFT; cleaned
m. MIKROSIL; CNA < TAPE-LIFT; cleaned
n. MIKROSIL; CNA > TAPE-LIFT; cleaned
o. MIKROSIL; CNA = TAPE-LIFT; cleaned

Test Statistics[a]

	TAPE-LIFT; CNA - TAPE-LIFT; cleaned	H20; Cleaned - TAPE-LIFT; cleaned	H20; CNA - TAPE-LIFT; cleaned	MIKROSIL; Cleaned - TAPE-LIFT; cleaned	MIKROSIL; CNA - TAPE-LIFT; cleaned
Z	-5.245[b]	-1.089[b]	-3.732[b]	-.816[b]	-5.404[b]
Asymp. Sig. (2-tailed)	<.001	.276	<.001	.414	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

4 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
TAPE-LIFT; CNA	36	15.14	4.661	5	20	9.75	17.00	19.00
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
H20; Cleaned - TAPE-LIFT; CNA	Negative Ranks	36[a]	18.50	666.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	36		
H20; CNA - TAPE-LIFT; CNA	Negative Ranks	28[d]	18.96	531.00
	Positive Ranks	6[e]	10.67	64.00
	Ties	2[f]		
	Total	36		
MIKROSIL; Cleaned - TAPE-LIFT; CNA	Negative Ranks	35[g]	18.94	663.00
	Positive Ranks	1[h]	3.00	3.00
	Ties	0[i]		
	Total	36		
MIKROSIL; CNA - TAPE-LIFT; CNA	Negative Ranks	2[j]	12.50	25.00
	Positive Ranks	27[k]	15.19	410.00
	Ties	7[l]		
	Total	36		

a. H20; Cleaned < TAPE-LIFT; CNA

b. H20; Cleaned > TAPE-LIFT; CNA

c. H20; Cleaned = TAPE-LIFT; CNA

d. H20; CNA < TAPE-LIFT; CNA

e. H20; CNA > TAPE-LIFT; CNA

f. H20; CNA = TAPE-LIFT; CNA

g. MIKROSIL; Cleaned < TAPE-LIFT; CNA

h. MIKROSIL; Cleaned > TAPE-LIFT; CNA

i. MIKROSIL; Cleaned = TAPE-LIFT; CNA

j. MIKROSIL; CNA < TAPE-LIFT; CNA

k. MIKROSIL; CNA > TAPE-LIFT; CNA

l. MIKROSIL; CNA = TAPE-LIFT; CNA

Test Statistics[a]

	H20; Cleaned - TAPE-LIFT; CNA	H20; CNA - TAPE-LIFT; CNA	MIKROSIL; Cleaned - TAPE-LIFT; CNA	MIKROSIL; CNA - TAPE-LIFT; CNA
Z	-5.243[b]	-3.996[b]	-5.197[b]	-4.175[c]
Asymp. Sig. (2-tailed)	<.001	<.001	<.001	<.001

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

3 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
H20; CNA - H20; Cleaned	Negative Ranks	0[a]	.00	.00
	Positive Ranks	18[b]	9.50	171.00
	Ties	18[c]		
	Total	36		
MIKROSIL; Cleaned - H20; Cleaned	Negative Ranks	2[d]	2.50	5.00
	Positive Ranks	2[e]	2.50	5.00
	Ties	32[f]		
	Total	36		
MIKROSIL; CNA - H20; Cleaned	Negative Ranks	0[g]	.00	.00
	Positive Ranks	36[h]	18.50	666.00
	Ties	0[i]		
	Total	36		

a. H20; CNA < H20; Cleaned

b. H20; CNA > H20; Cleaned

c. H20; CNA = H20; Cleaned

d. MIKROSIL; Cleaned < H20; Cleaned

e. MIKROSIL; Cleaned > H20; Cleaned

f. MIKROSIL; Cleaned = H20; Cleaned

g. MIKROSIL; CNA < H20; Cleaned

h. MIKROSIL; CNA > H20; Cleaned

i. MIKROSIL; CNA = H20; Cleaned

Test Statistics[a]

	H20; CNA - H20; Cleaned	MIKROSIL; Cleaned - H20; Cleaned	MIKROSIL; CNA - H20; Cleaned
Z	-3.728[b]	.000[c]	-5.383[b]
Asymp. Sig. (2-tailed)	<.001	1.000	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. The sum of negative ranks equals the sum of positive ranks.

2 pairs

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; Cleaned - H20; CNA	Negative Ranks	18[a]	11.03	198.50
	Positive Ranks	2[b]	5.75	11.50
	Ties	16[c]		
	Total	36		
MIKROSIL; CNA - H20; CNA	Negative Ranks	0[d]	.00	.00
	Positive Ranks	32[e]	16.50	528.00
	Ties	4[f]		
	Total	36		

a. MIKROSIL; Cleaned < H20; CNA

b. MIKROSIL; Cleaned > H20; CNA

c. MIKROSIL; Cleaned = H20; CNA

d. MIKROSIL; CNA < H20; CNA

e. MIKROSIL; CNA > H20; CNA

f. MIKROSIL; CNA = H20; CNA

Test Statistics[a]

	MIKROSIL; Cleaned - H20; CNA	MIKROSIL; CNA - H20; CNA
Z	-3.495[b]	-4.970[c]
Asymp. Sig. (2-tailed)	<.001	<.001

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

1 pair

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
MIKROSIL; CNA - MIKROSIL; Cleaned	Negative Ranks	1[a]	1.00	1.00
	Positive Ranks	35[b]	19.00	665.00
	Ties	0[c]		
	Total	36		

a. MIKROSIL; CNA < MIKROSIL; Cleaned

b. MIKROSIL; CNA > MIKROSIL; Cleaned

c. MIKROSIL; CNA = MIKROSIL; Cleaned

Test Statistics[a]

	MIKROSIL; CNA - MIKROSIL; Cleaned
Z	-5.388[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

GLASS Friedman K-RELATED

Ranks

	Mean Rank
NO CLEAN; Cleaned	1.32
NO CLEAN; CNA	1.68

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
NO CLEAN; Cleaned	36	14.94	2.828	7	17	14.00	16.00	17.00
NO CLEAN; CNA	36	16.58	2.209	12	20	15.25	17.00	18.00

Test Statistics[a]

N	36
Chi-Square	4.829
df	1
Asymp. Sig.	.028

a. Friedman Test

Tape

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
TAPE-LIFT; cleaned	36	16.25	5.704	3	20	16.00	19.00	19.00
TAPE-LIFT; CNA	36	18.61	2.155	10	20	18.00	19.00	20.00

Friedman

Ranks

	Mean Rank
TAPE-LIFT; cleaned	1.33
TAPE-LIFT; CNA	1.67

Test Statistics[a]

N	36
Chi-Square	4.800
df	1
Asymp. Sig.	.028

a. Friedman Test

H20

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
H20; Cleaned	36	16.53	3.194	8	20	15.25	18.00	19.00
H20; CNA	36	15.69	3.875	6	20	12.25	16.50	19.00

Ranks

	Mean Rank
H20; Cleaned	1.49
H20; CNA	1.51

Test Statistics[a]

N	36
Chi-Square	.032
df	1
Asymp. Sig.	.857

a. Friedman Test

Mikrosil

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
MIKROSIL; Cleaned	36	.00	.000	0	0	.00	.00	.00
MIKROSIL; CNA	36	16.47	4.158	7	20	15.00	18.00	19.75

Ranks

	Mean Rank
MIKROSIL; Cleaned	1.00
MIKROSIL; CNA	2.00

Test Statistics[a]

N	36
Chi-Square	36.000
df	1
Asymp. Sig.	<.001

a. Friedman Test

PVC FRIEDMAN K-RELATED

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
NO CLEAN; Cleaned	36	2.14	5.457	0	17	.00	.00	.00
NO CLEAN; CNA	36	9.78	7.461	0	20	.00	10.00	18.00

Ranks

	Mean Rank
NO CLEAN; Cleaned	1.29
NO CLEAN; CNA	1.71

Friedman Test

Test Statistics[a]

N	36
Chi-Square	9.000
df	1
Asymp. Sig.	.003

a. Friedman Test

Tape

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
TAPE-LIFT; cleaned	36	.11	.667	0	4	.00	.00	.00
TAPE-LIFT; CNA	36	15.14	4.661	5	20	9.75	17.00	19.00

Ranks

	Mean Rank
TAPE-LIFT; cleaned	1.00
TAPE-LIFT; CNA	2.00

Friedman Test

Test Statistics[a]

N	36
Chi-Square	36.000
df	1
Asymp. Sig.	<.001

a. Friedman Test

H20

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
H20; Cleaned	36	.39	1.626	0	7	.00	.00	.00
H20; CNA	36	7.25	8.051	0	19	.00	2.50	16.75

Ranks

	Mean Rank
H20; Cleaned	1.25
H20; CNA	1.75

Friedman Test

Test Statistics[a]

N	36
Chi-Square	18.000
df	1
Asymp. Sig.	<.001

a. Friedman Test

Mikrosil

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
MIKROSIL; Cleaned	36	.56	2.730	0	16	.00	.00	.00
MIKROSIL; CNA	36	18.22	2.652	13	20	15.00	20.00	20.00

Ranks

	Mean Rank
MIKROSIL; Cleaned	1.03
MIKROSIL; CNA	1.97

Friedman Test

Test Statistics[a]

N	36
Chi-Square	32.111
df	1
Asymp. Sig.	<.001

a. Friedman Test

ALUMINIUM FRIEDMAN K-RELATED

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
NO CLEAN; Cleaned	36	9.92	7.940	0	20	.00	14.00	17.00
NO CLEAN; CNA	36	16.89	2.846	8	20	15.25	18.00	19.00

Ranks

	Mean Rank
NO CLEAN; Cleaned	1.13
NO CLEAN; CNA	1.88

Friedman Test

Test Statistics[a]

N	36
Chi-Square	20.829
df	1
Asymp. Sig.	<.001

a. Friedman Test

Tape

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
TAPE-LIFT; cleaned	36	14.58	5.234	5	20	9.50	17.00	19.00
TAPE-LIFT; CNA	36	15.00	5.340	4	20	10.25	17.00	19.75

Ranks

	Mean Rank
TAPE-LIFT; cleaned	1.42
TAPE-LIFT; CNA	1.58

Friedman Test

Test Statistics[a]

N	36
Chi-Square	1.500
df	1
Asymp. Sig.	.221

a. Friedman Test

H20

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
H20; Cleaned	36	18.83	1.254	15	20	18.25	19.00	20.00
H20; CNA	36	17.53	2.077	14	20	16.00	18.00	19.00

Ranks

	Mean Rank
H20; Cleaned	1.65
H20; CNA	1.35

Friedman Test

Test Statistics[a]

N	36
Chi-Square	4.481
df	1
Asymp. Sig.	.034

a. Friedman Test

Mikrosil

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
MIKROSIL; Cleaned	36	1.69	4.241	0	16	.00	.00	.00
MIKROSIL; CNA	36	11.06	8.222	0	20	.00	16.00	18.75

Ranks

	Mean Rank
MIKROSIL; Cleaned	1.14
MIKROSIL; CNA	1.86

Friedman Test

Test Statistics[a]

N	36
Chi-Square	26.000
df	1
Asymp. Sig.	<.001

a. Friedman Test