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Money Talks - fingerprint enhancement on polymer banknotes

Since the late 19th century, fingerprints have been a valuable source of identification in forensic investigations. They are valuable because they can be individualised, remaining unchanged throughout life and only being disfigured as a result of deep scarring. In any criminal investigation, a suspect can be linked to an object and/or place by the presence of their fingerprints. A common example of this would be fingerprints recovered from banknotes used in criminal activity. The recovery of fingerprints from banknotes has changed considerably over the last 30 years, as a result of the introduction of polymer notes.

Australia introduced the first polymer banknotes in 1988, and they have been released in many countries during the three decades following this. Polymer banknotes are now in circulation in more than 30 countries, and the composition and processes used to produce polymer banknotes vary between them. In the UK, Clydesdale Bank (CB), the Royal Bank of Scotland (RBS) and the Bank of Scotland all released a £5 polymer banknote in Scotland in 2016, followed by a £10 polymer banknote in 2017. The Bank of England (BoE) also released their £5 and £10 polymer banknotes in England within the same timeframe.

This change in material from the old cotton notes was implemented for a number of reasons, the most important being to increase counterfeit resilience and durability. Polymer materials allow for more enhanced security features – for example a clear window within the note and more complex background patterns – which are harder to copy. The quality and sturdiness of these note types is also superior, increasing their life expectancy – approximately 2.5 times that of a cotton note – as they are less likely to tear and are more resistant to dirt and moisture. This longer life expectancy also benefits the environment, and the Carbon Trust have stated that the carbon footprint of polymer notes is 16% lower than that of cotton notes. The detection and enhancement of latent (i.e. invisible) fingerprints is an important tool in the identification of any individuals involved in the handling of evidence. Understanding the best techniques for the recovery of latent prints on polymer banknotes is therefore crucial in criminal investigations.

Cotton vs Polymer

Each individual has a series of tiny pores located along their fingerprint ridges. The sweat excreted from these pores combined with sebum picked up by the fingers (from other areas of the body, such as the face) forms an outline of the ridges present. When an individual comes into contact with an object/surface this sweat is deposited in a mirror image of the skin ridges forming a characteristic print. As sweat is colourless/latent, so are the fingerprints deposited, therefore chemical or physical treatments may be required to visualize the fingerprint.

Unfortunately, conventional mark enhancement techniques that are recommended for use on old cotton banknotes are not effective on new polymer notes. This is due to the non-porous nature of these polymer notes in comparison to porous cotton paper notes. Porous surfaces – i.e. cotton notes, paper – will quickly absorb the deposited latent fingerprint and over time any water present evaporates, leaving a mixture of in-soluble components. As the deposited fingerprint has been absorbed into the substrate, this means it cannot be removed or wiped away, making forensic examination easier as the notes can be easily handled and treated without disrupting any fingerprints. This also allows the notes to be stacked for easier storage. The Scottish Police Authority (SPA) Forensic Services can receive hundreds of thousands or even millions of pounds in a single case, and the porous nature of cotton notes allowed efficiency of processing.

Non-porous surfaces – i.e. polymer notes, glass, plastic – are smooth and do not absorb any components of a deposited fingerprint. The components of fingerprints deposited on a non-porous substrate will remain on the surface indefinitely, however, various water-based constituents will still evaporate over time. This makes the fingerprints fragile and at increased risk of exposure to environmental conditions and damage through handling. Furthermore, it is common for offenders to attempt to destroy pieces of evidence, for example they may try to remove any fingerprints present, which could also damage any deposits sitting on the surface. The fragile nature of these prints means that extra care must be taken when handling, counting and treating evidential polymer banknotes, which can significantly increase the processing time. Each bank uses different

printing methods when producing their banknotes which adds to the complexity of the backgrounds making fingerprints harder to enhance and visualise.

Enhancement techniques

Previously, a chemical called Ninhydrin was used to enhance latent fingerprints on cotton notes. This chemical is most effective at developing fingerprints on porous surfaces as it reacts with the components of proteins in fingerprints, which are absorbed into the porous surface, turning them purple. This chemical allowed the processing of cotton notes to be both effective and efficient. The bank notes could be submerged in the liquid solution and stacked together in a wire rack, which was then put into a specialised oven to speed up the chemical reaction. Any fingerprints that were developed could not be wiped off or disturbed, allowing notes to be easily handled and stored in bundles. Unfortunately, this technique does not work on polymer banknotes.

Due to the introduction of polymer banknotes in Scotland, a joint study was carried out by researchers at the University of Strathclyde and SPA Forensic Services to determine the most effective enhancement treatments on RBS and CB £5 and £10 polymer bank notes. This study concluded that the two most effective processing sequences were (1) superglue fuming (using PolyCyano UV) followed by black magnetic powder and (2) black powder suspension, visualised using infrared light.

Polycyano UV is a solid polymer form of cyanoacrylate (superglue). When heated in a specialised chamber the cyanoacrylate vaporises. These vapours undergo polymerisation when the fumes come into contact with any moisture present in the fingerprints, causing a hard white polymer, known as polycyanoacrylate, to be deposited. This type of process is highly effective on fingerprints present on non-porous surfaces, as the constituents of the fingerprint that react with the glue will remain on the surface. Porous surfaces do not contain any surface moisture, making this process ineffective. As the white polymer formed hardens, this makes the fingerprints more robust, allowing easier handling for examiners. This also allows the notes to be stacked for storage, similar to cotton notes. The downside to using this process is that if an item has been wet – i.e. an item found outside or one commonly found within a kitchen – this white polymer will coat the entire surface instead of only targeting the fingerprint. PolyCano UV contains ultraviolet (UV) properties, which cause it to fluoresce under UV light. This property is beneficial on most surfaces as it improves the visibility of fingerprints, however all polymer banknotes also contain UV security features. The addition of black magnetic powder changes the fingerprint colour from white to black, which removes the need for UV light and allows visualisation of any prints under white light – although further work found Infrared light to be the most effective light source for visualisation as this eradicated the background pattern.

Black powder suspension is another enhancement treatment which is effective for developing fingerprints present on non-porous surfaces. This product consists of a black metal in a detergent solution. Powder suspension is applied to a surface using a soft brush, similar to painting. The lipophilic components of the fingerprint residue adhere to the hydrophobic tail of the surfactant, while the hydrophilic head of the surfactant binds to the metal particles, meaning that the particles within the powder suspension adhere to the residues within fingerprints. Black powder suspension contains iron oxide or carbon – iron oxide powder suspension works best on light coloured surfaces, due to the contrast produced. Once applied to a surface, this treatment is then washed from the surface using water and if any fingerprints are present the powder suspension remains attached. The advantage of using this process over superglue fuming is that it can be used on items that have been subjected to moisture, because unlike superglue it does not react with any water present. Similar to superglue fuming, powder suspension can be visualised under white light however, visualisation under infrared light was more effective.

Application

A pseudo-operational trial was carried out in order to test the two most effective sequences from the study on a set of banknotes that would be typical of a real criminal investigation. This trial concluded that both superglue fuming followed by black magnetic powder, and black powder suspension, were both successful in recovering latent fingerprints on RBS and CB £5 and £10 polymer banknotes. The treatments used were selected based on resources available to all criminal justice partners in the United Kingdom (UK). The purpose of this study was to find the best enhancement treatment that could be used operationally; therefore, all treatments and technologies used had to be common to all police forces in the UK without the need to outsource for special equipment. Alternative processes such as Vacuum metal deposition (VMD) have been successful in recovering fingerprints on Canadian and Australian polymer banknotes, however, not all forces own this type of equipment due to its size and cost. The most effective techniques demonstrated by this study are now being implemented for use with these note types in Scotland by the SPA Forensic Services.