B28 Exploration of the Electrochemical Enhancement of Latent Fingerprints

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After attending this presentation, attendees will better understand the materials and processes involved in electrochemically depositing polymers onto latent fingerprints on metal surfaces to enhance their visibility. Deposition of intensely colored electrically conducting polymer in the valleys of the fingermarks is shown to result in a reverse image.

This presentation will impact the forensic science community by demonstrating the ability of select monomers, solvents, and electrochemical conditions to obtain excellent enhancement, including third-level detail of sweat pores, on a variety of metallic surfaces (doorknobs, spoons, coffee mugs, etc.). Exploratory studies also uncovered limitations of the method for base metals oxidized at potentials lower than the organic monomer.

While enhancement of latent fingerprints is well-established, significant challenges still exist. Among these is imaging prints on metallic surfaces including ammunition casings. Superglue fuming is widely used, partially due to the multiplicative effect of the polymerization reaction to produce a large amount of material from a smaller amount of fingerprint residue; however, cyanoacrylate is fairly clear in color and provides relatively poor contrast on metal surfaces. Several studies have suggested that oxidation of organic monomers to form intensely colored, electrically conducting polymers may be a viable approach to improving the poor success rate of enhancement on metal surfaces.[1-3] The present work was undertaken to systematically study the effect of the choice of organic monomer and solvent, as well as study controlled current and controlled potential systems. The controlled current studies were thought to allow the best repeatability of the amount of polymer deposited. The controlled potential system is most amenable to translation to a hand-held battery device for field use. Three electrode laboratory-based systems were used to understand important parameters including the oxidation of metal specimens and the effect of changing the monomer concentration. Two electrode systems were evaluated with an electrochemical potentiostat and the results used to design and test a portable battery-based system.

Initial screening results of five organic monomers (thiophene, 3-methyl thiophene, 3,4,Ethylenedieoxthiophene (EDOT), pyrrole, and aniline) showed that the best enhancement was obtained with EDOT. Screening of five solvents of various polarities showed that better enhancement was obtained in more polar solvents, presumably since non-polar solvents dissolve the sebaceous fingerprint residue (fatty acids, wax esters, squalene, cholesterol, etc.) to a greater extent. Controlled current studies showed that charge densities in the range of 275-375 coulombs per square centimeter applied over a period of 20 seconds generally resulted in sufficient polymer to enhance the image so that it was judged suitable for identification; that is, either a three or four on the Bandy scale.[4] The average thickness of the polymer is estimated as 0.23-0.30 micrometers based on 50% area coverage and 2.7 electrons per monomer unit polymerized. Additional controlled current studies (chronopotentiometry) demonstrated that progressively lower potentials were reached as the concentration of EDOT monomer was increased. Lower potentials reduce the amount of undesired side-reactions (oxidation of the metal substrate and oxidation of the solvent). At an EDOT concentration of 177mM, the potential generally remained below approximately 1.4 volts (vs. Ag/AgCl) at the optimal charge densities previously noted. In a two-electrode system, the optimal charge densities resulted in a voltage drop close to 3.4 volts across the cell.

Two electrode cells were constructed using 8mm-thick ethyl vinyl acetate foam from a craft shop sealed with silicon and applied over the latent fingerprint using double-sided duct tape and a stainless steel plate as a counter electrode. Various sizes of foam were easily constructed to conform to irregular shaped objects (doorknobs, spoons, coffee mugs). A typical cell with an area of 5.4 cm^2 required 4.2mL of EDOT solution. When the print was overdeveloped by deposition of excess polymer, application of tape was successful in improving the Brady score. Photography of the print on irregular metal objects was difficult, so various tapes were evaluated to identify if they could lift the polymer. In an evaluation of 12 brands of tape, D-SQUAME® performed the best.

In conclusion, significant fundamental work has been performed to identify materials and conditions for the formation of intensely colored conducting polymers to enhance latent fingerprints on metal. Good third-level detail prints have been obtained using short treatments with an easily constructed hand-held battery device.

References:

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Fingerprint, Tape Lift, Latent Fingerprint