Alternative solvent to HFE7100 and Triton X100 for fingermark formulations

Kevin J. Farrugia, February, 2019

Introduction

A number of techniques for the development of latent fingermarks use chemicals or solvents (e.g. HFE-7100) that may be harmful to the environment. The EU and UK are considering a ban on some of these fluorinated chemicals (EU Regulation 517/2014 and House of Commons HC469). The carrier solvent for amino acid reagent formulations has changed many times since the first reported use of ninhydrin as a fingerprint reagent in 1954. Such changes were applied to improve the safety of the reagent (e.g. non-flammable ninhydrin), the performance of the reagent (addition of acetic acid to ninhydrin formulation) and environmental regulations (replacement of CFC-113). In the UK, CFC-113 was the main solvent carrier from 1974 up to the late 1990s until it was banned under the Montreal Protocols of 1987. The Home Office CAST (now part of DSTL) embarked on a research project to find an alternative for CFC-113 formulations that was non-flammable, non-toxic, volatile and relatively non-polar to minimise the diffusion of ink. Ideally, the alternative solvent should also provide equivalent, or superior, performance in the detection of latent fingermarks on porous surfaces. CAST identified hydrofluoroethers (HFE) as potential replacements to CFC-113, recommending HFE-7100 for ninhydrin and HFE-7100/HFE-71DE for DFO. Around 2009, in an effort to reduce costs to police forces, CAST investigated an alternative solvent for ninhydrin formulations, Asahiklin AE-3000. Initial price estimates were quoted as 30% cheaper than HFE7100; however, further estimates from the supplier indicated that there will be little, if any, cost saving.

The solvent industry moved from CFCs to HCFCs, HFCs and HFEs to limit ozone depletion; however, another problem with greenhouse gases and global warming potential (GWP) ensued. The solvent industry then moved to HFOs and HCFOs, which have a much shorter lifetime in the atmosphere as well as a very low GWP. The supply of HFE-7100 may be disrupted due to environmental regulations and an alternative is therefore required.

Solstice PF vs HFE7100

A suitable alternative solvent to HFE7100 should ideally be non-flammable, non-toxic, volatile, environmentally friendly and relatively non-polar to minimise the diffusion of ink. Solstice PF, (Honeywell), fulfils these criteria and when compared to HFE7100 has a lower toxicity and surface tension as well as a higher wetting index. The high wetting index indicates that the solvent can be absorbed easier by the substrate to reach amino acids ingrained in the pores of the porous substrate. Although a fluorinated solvent itself, Solstice PF has a very low GWP

rate of 1 and atmospheric lifetime of 26 days compared to a GWP of 320 and an atmospheric lifetime of 4.1 years for HFE7100. In addition to these environmental attributes Solstice PF has a lower cost of about a third on a single unit which increases to about a half cost-saving on bulk orders.

Recent work at Abertay involving laboratory trials using split depletions and a pseudo-operational trial of 1000 porous samples have shown that Solstice1 PF is a viable alternative to HFE7100 for the chemical formulations of ninhydrin and 1,2-indanedione (1,2-IND). Results from the pseudo-operational trial demonstrate that the number of marks detected by ninhydrin and 1,2-IND formulations for each carrier solvent was comparable. This study also provides a validation study that supports the potential replacement of DFO with 1,2-IND. This supports recent newsletter updates from CAST that indicate the replacement of DFO with 1,2-IND.

Triton X100 vs Tween 20

The black iron-oxide powder suspension as currently recommended in the Fingermark Visualisation Manual may be at risk because the Triton X100 surfactant belongs to the group of 4-(1,1,3,3-tetramethylbutyl)phenol ethoxylates residing on the Candidate List of Substances of Very High Concern as defined in article 57 of the REACH Regulation (European Commission). The concern is associated with the accumulation of these chemicals in the environment that may affect aquatic life. A recent Abertay study reported that the iron-oxide should have a particle size below 1 micron and recommended a new powder suspension formulation using 10% Tween 20 surfactant solution and a Sigma Aldrich iron oxide nanopowder (50–100 nm), in the ratio of 1:2 w/v, whereby development results improved by 27% over the 2015 Fisher formulation.

Summary

As the UK and EU are considering restricting some of the chemicals and solvents used in fingermark development techniques, such as HFE7100 and Triton X100, research into alternative chemicals and solvents is required. Solstice PF and Tween 20 appear to be suitable alternatives to HFE7100 and Triton X100 respectively. Further research by the forensic community to assess these alternatives is required in addition to full operational trials from police forces. Further work at Abertay will assess other solvents as well as possible solvent-free delivery of the main ingredients by means of vacuum, vapour and carrier gases as well as chemical-free treatments (e.g. use of heat alone).

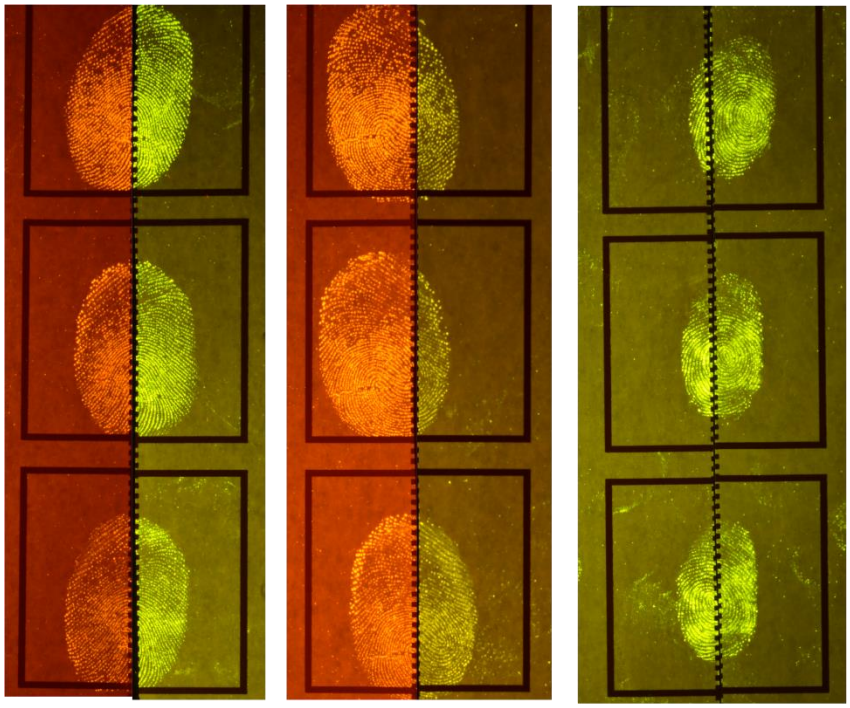

Figure 1 - Depletion series on paper by different donors as observed under fluorescence: (a) DFO (left) and 1,2-IND-HFE (right); (b) DFO (left) and 1,2-IND-Solstice PF (right); (c) 1,2-IND-HFE (left), 1,2-IND- Solstice1 PF (right).

Abertay peer-reviewed publications investigating alternative solvents

[1] I. Olszowska, P. Deacon, M. Lindsay, A. Leśniewski, J. Niedziółka-Jönsson, K. Farrugia, An alternative carrier solvent for fingermark enhancement reagents, Forensic Sci. Int. 284 (2018) 53–64.

[2] R.P. Downham, V.G. Sears, L. Hussey, B.-S. Chu, B.J. Jones, Fingermark visualisation with iron oxide powder suspension: The variable effectiveness of iron (II/III) oxide powders, and Tween® 20 as an alternative to Triton™ X-100, Forensic Sci. Int. 292 (2018) 190–203.