



## **An integrated approach for the detection of body fluids and fingerprints**

Kevin J. Farrugia, Abertay University

February, 2019

### *Introduction*

It is important to maximise the recovery of evidence during a scene of crime examination and from items received into the forensic laboratory. Issues arise when multiple types of evidence are found in combination on the same substrate, such as latent marks, body fluids and inks. A sequential order for treating multiple types of evidence should be established to maximise the evidence recovery. If a biological stain is not visible, speculative swabbing may be detrimental to any latent marks present. Enhancement techniques may diminish the amount of DNA recovered; however, a recent study reported that cyanoacrylate fuming of latent marks on cables resulted in a larger amount of DNA when compared to latent marks that had not been treated suggesting that the enhancement process provides a target area for swabbing that can result in a higher yield of DNA recovery. Abertay University has conducted a number of studies investigating the effects of various mark enhancement techniques on the presumptive and confirmatory tests for body fluids including semen/sperm, saliva and blood.

### *Semen/sperm*

Seven fingerprint and blood enhancement techniques were employed followed by the subsequent detection of semen/spermatozoa using a depletion series as well as varying substrates and ageing periods of up to 28 days. The effect these techniques had on the subsequent detection of semen was assessed by visual and fluorescence examination followed by presumptive and confirmatory testing for semen and spermatozoa. The results found that protein stains (acid violet 17 and acid yellow 7) caused a loss in presumptive AP test reactivity; however, sperm heads were still observed using microscopic examination after extraction and staining. The use of black magnetic powder, Bluestar Forensic Magnum (BFM) luminol, Lumicyano 4% and cyanoacrylate fuming followed by basic yellow 40 staining did not hinder subsequent presumptive and confirmatory tests for semen and sperm heads. Iron-oxide powder suspensions caused a loss in both presumptive test reactivity and sperm heads from the substrate. In general, the enhancement techniques resulted in the improved visualisation of the semen stains under white and violet/blue light.

### *Saliva*

Saliva detection was performed by means of a presumptive test (Phadebas®) in addition to analysis by a rapid stain identification (RSID) kit test and confirmatory DNA testing. Additional variables included a saliva depletion series and a number of different substrates with varying

porosities as well as different ageing periods. All enhancement techniques (except BFM luminol) employed in this study resulted in an improved visualisation of the saliva stains, although the inherent fluorescence of saliva was sometimes blocked after chemical treatment. The use of protein stains was, in general, detrimental to the detection of saliva. Positive results were less pronounced after the use of black iron-oxide powder suspension, cyanoacrylate fuming followed by BY40 and ninhydrin when compared to the respective positive controls. The application of BFM luminol and black magnetic powder proved to be the least detrimental, with no significant difference between the test results and the positive controls. The use of non-destructive fluorescence examination provided good visualisation; however, only the first few marks in the depletion were observed. Of the samples selected for DNA analysis only depletion 1 samples contained sufficient DNA quantity for further processing using standard methodology. The 28-day delay between sample deposition and collection resulted in a 5-fold reduction in the amount of useable DNA. When sufficient DNA quantities were recovered, enhancement techniques did not have a detrimental effect on the ability to generate DNA profiles.

### *Blood*

A number of enhancement techniques were tested on human blood, using a depletion series of 30 marks and varying ageing periods and substrates, to evaluate their potential effects on subsequent presumptive and confirmatory tests. Acid violet 17 and BFM luminol provided the best enhancement and fully enhanced all depletions in the series. The sensitivity of the Kastle-Meyer (KM) (presumptive), Takayama and RSID-Blood tests (confirmatory) was initially investigated to determine the range of detectable depletions. The KM test detected all depletions, whereas the Takayama test only detected up to depletion 6 and RSID-Blood detected up to depletion 20 (paper), 10 (envelope), 15 (tile) and 9 (lino). The abilities of these tests to detect blood after enhancement were then observed. A number of techniques resulted in little to no effect on any of the blood tests, whereas adverse effects were observed for others. Ninhydrin and CA fuming caused weak but instantaneous positive KM results whereas methanol-based protein stains delayed the reaction by as much as 1 min. The Takayama test was not very sensitive, therefore, its performance was easily affected by enhancement and negative results were often observed. RSID-Blood tests were largely unaffected by chemical enhancement although a drop in positive results was observed for some of the techniques when compared to positive controls. Using a standard procedure for DNA extraction, all the tested blood samples (before and after enhancement) gave a detectable quantity of DNA and were successfully profiled. Out of the 45 samples processed for DNA profiling, 41 gave full profiles, while the remaining showed allele drop out in one or two loci.

## Summary

Tables 1-3 provide a summary for the effects of various enhancement techniques on the detection of various body fluids. The ability to recover DNA from these body fluid stains after treatment with various enhancement techniques does not imply that DNA may be recoverable from a normal enhanced latent fingerprint since a body fluid stain contains a much larger amount of cellular material. This study provides information that allows strategic decisions for an integrated approach to maximise the evidence recovery when fingerprints and body fluids may be present. The opposite sequence as to the effect that body fluid detection techniques have on subsequent finger and footwear mark enhancement may be considered; however, since such marks are fragile, a loss of the fine detail may occur. The visualisation of stains by latent enhancement techniques provides a target area for swabbing for subsequent presumptive, confirmative and DNA tests. If the stains are not visualised in the first instance, then speculative swabbing may be detrimental to the fine detail of latent marks.

**Table 1 - Semen/spermatozoa**

Method	Improved visual examination	Positive AP test	Confirmatory test
AV17 (water based)	✓	X	✓
AY7 (water based)	✓	X	✓
Methanol (preliminary)	X	✓	✓
Bluestar® Forensic Luminol	✓	✓	✓
Lumicyano™ 4%	✓	✓	✓
Cyanoacrylate/BY40	✓	✓	✓
Black magnetic powder	✓	✓	✓
Iron-oxide powder suspension	✓	X	X

**Table 2 - Saliva**

Method	Improved Visual Examination	Phadebas® Testing	RSID™-Saliva Testing	DNA Analysis
Cyanoacrylate /BY40	✓	✓	✓	✓
Iron-oxide PS	✓	✓	✓	✓
Ninhydrin	✓	✓	✓	Limited
Acid Violet 17	✓	X	X	✓
Bluestar® Forensic Magnum	Limited	✓	✓	✓
Black Magnetic Powder	✓	✓	✓	✓

**Table 3 - Blood**

<b>Enhancement Technique</b>	<b>Improved Visual Examination</b>	<b>KM Testing</b>	<b>Takayama</b>	<b>RSID™- Blood</b>	<b>DNA Analysis</b>
Black Magnetic Powder	X	✓	✓	✓	✓
Iron-oxide PS	✓	✓	Reduced	✓	✓
Cyanoacrylate Fuming/ BY40	X	✓	✓	✓	✓
Acid Violet 17 (WEAA)	✓	✓	Reduced	✓	✓
Acid Violet 17 (MeOH)	✓	Reduced	Reduced	✓	✓
Acid Yellow 7 (WEAA)	✓	✓	✓	✓	✓
Acid Yellow 7 (MeOH)	✓	Reduced	X	✓	✓
Ninhydrin	✓	✓	✓	Reduced	✓
DFO	✓	✓	Reduced	✓	✓
Bluestar® Forensic Magnum	✓	✓	✓	✓	✓

**Abertay peer-reviewed publications investigating alternative solvents**

- [1] R. Simmons, P. Deacon, D.J. Phillips, K. Farrugia, The effect of mark enhancement techniques on the subsequent detection of semen/spermatozoa, *Forensic Sci. Int.* 244 (2014) 231–246.
- [2] P. McAllister, E. Graham, P. Deacon, K.J. Farrugia, The effect of mark enhancement techniques on the subsequent detection of saliva, *Sci. Justice.* 56 (2016) 305–320.
- [3] V. Stewart, P. Deacon, N. Zahra, M.L. Uchimoto, K.J. Farrugia, The effect of mark enhancement techniques on the presumptive and confirmatory tests for blood, *Sci. Justice.* (2018).