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Applications of UV-visible spectral imaging in forensic science

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Abstract

This study investigated the use of UV-visible spectral imaging for the location and enhancement of substances of forensic interest using targeted approaches based on the spectrum of the substance.

Spectral enhancement procedures were developed for blood with and without chemical enhancement, and for latent fingerprints after chemical enhancement. Focus was on substances whose spectrum exhibited a steep change in absorbance or fluorescence over a small wavelength range. Substances with such spectral features were able to be enhanced using arithmetic combinations of two or three spectral images taken at wavelengths near the steep spectral feature.

Some enhancement reagents do not react to produce a product with a steep spectral feature suitable for photographic enhancement. In such cases reagents that compliment spectral imaging can be developed. A tridentate ligand for iron(II), BBIDMAPP, which forms a complex with a narrow intense charge-transfer band, was synthesised and was used to visualise muddy shoemarks.

UV-visible spectral imaging systems based on a liquid crystal filter or a filter wheel were constructed to facilitate the acquisition of the spectral images and to perform the enhancement operations. A thorough characterisation of the imaging systems determined their limitations and sources of artefacts which could lead to complications in interpreting the enhanced images.

The spectral imaging procedure used to visualise blood was incorporated into a near-real-time, hand-held imaging system for the location of blood staining. This prototype imaging system is capable of acquiring two spectral images simultaneously, perform the enhancement procedure, and display the enhanced image within 5 s, which would make it suitable as a non-chemical presumptive screening test for blood at crime scenes.

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List of Abbreviations

ABA	Auckland Boxing Association
ADU	Analogue to Digital Unit
ASCLD/LAB	American Society of Crime Laboratory Directors- Laboratory Accreditation Board
BBIDMAPP	2,6-Bis [1-(3,5-dimethoxybenzyl) benzimidazol-2-yl]-4- [4'-(dimethylamino) phenyl]pyridine
CCD	Charge Coupled Device
Cd-RP(benzo(f)nin)	Cadmium complex of Ruhemann's purple (derived from benzo(f)ninhydrin)
CJS	Criminal Justice System
CMOS	Complementary Metal Oxide Semiconductor
DFYADF	9-(1,8-diazafluoren-9-ylidene)amino-1,8-diazafluorene
DDQ	2,3-dichloro-5,6-dicyano-1,4 benzoquinone
DFO	1,9-Diazafluorene-9-one
DLL	Dynamic Linked Library
DNA	Deoxyribonucleic acid
ESR	Environmental and Scientific Research Ltd
FBI	Federal Bureau of Investigation
FPN	Fixed Pattern Noise
FWHM	Full Width at Half Maximum
GUI	Graphical User Interface
ISO	International Standards Organisation
JPEG	Joint Photographic Experts Group
LCTF	Liquid Crystal Tuneable Filter
LCV	Leuco Crystal Violet
LED	Light Emitting Diode
LMG	Leuco Malachite Green
OD	Optical Density
RP(benzo(f)nin)	Ruhemann's purple (derived from benzo(f)ninhydrin)
RP(nin)	Ruhemann's purple (derived from ninhydrin)
PTC	Photon Transfer Curve
PRNU	Photo Response Non-Uniformity
SOP	Standard Operating Procedures
SWGIT	Scientific Working Group on Imaging Technologies
TIFF	Tagged Image File Format
XML	Extensible Markup Language
Zn-RP(nin)	Zinc complex of Ruhemann's purple (derived from ninhydrin)