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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 fingermarks 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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\[ 510 - \frac{485 + 535}{2} \]
\[ e) \quad \text{Eu} = \frac{2 \times 615}{605 + 625}, \quad \text{Panacryl} = \frac{2 \times 510}{485 + 535}; \quad f) \quad \text{Eu} = \frac{2 \times 615}{605 + 625}, \quad \text{Panacryl} = \frac{2 \times 510}{475 + 545} \]

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\[
\text{Eu} = 615 \text{ nm}, \quad \text{Panacryl} = 510 \text{ nm}, \quad d) \quad \text{Eu} = 615 - \frac{605 + 625}{2}, \quad \text{Panacryl} = \frac{510}{485 + 535},
\]

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\[ \text{Rhodamine 6G} = 560 \text{ nm}, \quad c) \quad \text{Eu} = 615 - \frac{605 + 625}{2}, \quad \text{Rhodamine 6G} = 560 - 590, \quad d) \quad \text{Eu} = \frac{2 \times 615}{605 + 625}, \quad \text{Rhodamine 6G} = 560/590. \]

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