The Effects of Dyes on the Near-Infrared Detection of Bloodstains on Dyed Apparel Fabrics

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ABSTRACT This research has thus far revealed that there are several factors that influence the visibility of a bloodstain on a fabric when using NIR cameras. The degree of fuzziness, roughness, smoothness and wickability, etc. of a fabric will all influence how blood behaves, spreads and dries either on, in, or through a fabric. This results in an inconstant ability to visualise bloodstains on certain fabrics in both the visible and near-infrared regions. The true underlying issues that inhibit the visualisation of a bloodstain using specialised NIR cameras is hard to define as the substratum found at crime scenes can vary immensely. Each item encountered will potentially have a chemical composition that could interfere with the optical and differential capabilities of a NIR camera. Even limiting this to apparel textiles, the potential variability is still vast. In order to aid the current knowledge and improve the NIR blood-screening methodology on fabrics, further studies are warranted. These should specifically target the broad range of factors that affect the NIR detection of bloodstains on dyed apparel fabrics.

KEY WORDS near-infrared detection, dyes, apparel fabrics, bloodstain pattern analysis, forensic science

INTRODUCTION

Forensic science encompasses an ever-expanding, powerful group of disciplines many of which can aid crime scene reconstruction and are constantly refining their methodologies. Bloodstain Pattern Analysis (BPA) in particular, provides a wealth of information that can deliver diverse insights into the events of a crime. BPA relies on known, reproducible characteristics of bloodstains to interpret and define mechanisms that created bloodstains left at a crime scene or found on the clothing worn by people involved in a bloodletting event [1].

Locating and interpreting bloodstain evidence on dyed apparel fabrics can be deceptive and laborious, with dark and/or patterned apparel fabrics being particularly unaccommodating when trying to visualise blood [2, 3]. Restricting the examination of clothing to the visual spectral region seen by the human eye will not always reveal the existing bloodstain evidence. Where bloodstain evidence is suspected but cannot be seen with the naked eye, the use of near-infrared (NIR) cameras has gained popularity as a screening tool as they are easy to use and non-destructive [4, 2].

NIR cameras rely on the different NIR absorption properties of haemoglobin in blood and the substrate the bloodstain is deposited on. The different absorption properties can increase the contrast between the bloodstain and a dark substrate, allowing for stain visualisation and analysis [5, 6]. Bloodstains absorb near infrared and appear dark coloured and substrates commonly reflect near infrared and appear pale coloured [5]. However, these cameras sometimes do not visualise the bloodstain evidence on certain dyed apparel fabrics [5]. The reason for the lack of visibility of a bloodstain on some dyed apparel fabrics is not known and is, so far, unexplained.

The reliability of NIR as a blood-screening tool for textiles, in particular apparel fabrics, lies in the molecular interaction of the NIR electromagnetic waves and the fabric substrate being screened [7]. The visual contrast created between fabrics viewed in the NIR region relies on the chemistry of a substrate and the differing vibrations of the electrons associated with the atoms within that substrate [8]. If the frequency generated by electrons of the atoms does not match the frequency of the irradiating light, the light waves will not be absorbed, but instead are reflected [7]. Fabrics that absorb NIR radiation do so with unique vibrations of NIR