An Investigation of Synthetic Body Covering Materials in Soil Burials for Forensic Application

by

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Certificate of authorship and originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text. I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abbreviations

AFM – Atomic Force Microscopy

ATR – Attenuated Total Reflectance

DSC – Differential Scanning Calorimetry

DEHP- Bis(2-ethylhexyl) phthalate

DTG – Derivative Thermogravimetry

FTIR – Fourier Transform Infrared

HFW – Horizontal Field Width

HDPE – High Density Polyethylene

LDPE – Low Density Polyethylene

LLDPE – Linear Low Density Polyethylene

PCA – Principal Component Analysis

PCR – Principal Component Regression

PE – Polyethylene

PET – Poly(ethylene terephthalate)

PLS-R – Partial Least Squares Regression

PP – Polypropylene

PVC – Poly Vinyl Chloride

SEM – Scanning Electron Microscopy

STD Error – Standard Error

TGA – Thermogravimetric Analysis

UTS – University of Technology Sydney

UV-VIS – Ultraviolet - Visible

Abstract

During the forensic investigation of grave sites artefacts are often located and have the potential to provide valuable information about the victim or the perpetrator. Such artefacts may include body coverings used by the perpetrator to interfere with the crime scene. Polymer materials are now frequently encountered at crime scenes and given their use in bag and carpet manufacture, there was an increased likelihood that this class of materials will form part of a clandestine grave. Understanding the degradation of these materials in potential crime scene soils will provide insight into the age and nature of the burial. Previous forensic research on polymers at the crime scene has mostly focused on identifying polymer materials such as fibres and the studies that have investigated polymer degradation, examined the effect degradation had on identifying the polymer rather than the information the polymer can provide about the burial. This thesis provides a comprehensive examination of the degradation of five commonly encountered polymers with potential to be used as body coverings in a variety of soil t types. A comparison of the suitability of a range of analytical techniques to understand polymer degradation associated with burial has also been made in this thesis.

The five polymers -polyethylene (PE), polypropylene (PP), poly vinyl chloride (PVC), polyethylene terephthalate (PET) and nylon- in the form of films and carpets were buried in a series of laboratory controlled environments that varied by soil type, moisture content, soil pH and temperature for a burial period of 24 months. Scanning electron microscopy and atomic force microscopy were utilised for the examination of changes to the morphology of polymer surface. Spectroscopic analyses, including infrared, Raman and ultraviolet-visible spectroscopies, were

applied to monitor changes to the chemical structure of the polymers and their additives. Thermal analysis was also investigated as an approach to monitoring the subtle changes associated with the degradation processes. This study determined that certain soil environments enhanced the degradation of the polymers in soil, while other environments were shown to preserve the polymers. The degradation of these polymers often included the interaction of polymer additives with the soil environment. The factors that were shown to enhance polymer degradation included the availability of water and the ability of the soil environment to encourage microbial growth. In this thesis, a combination of morphological changes determined by scanning electron microscopy and the microstructural changes determined using infrared spectroscopy, and to a lesser extent, thermal changes monitored using thermogravimetric analysis, were determined to be the most powerful methods for monitoring degradation processes in the polymer systems investigated.

This thesis provides new knowledge about the impact different soil variations have on the degradation of polymers that are more and more likely to be found at clandestine grave sites.