Improved Methods for Microfibre Quantification and Characterisation: A Collaborative Approach with Forensic Fibre Analysis

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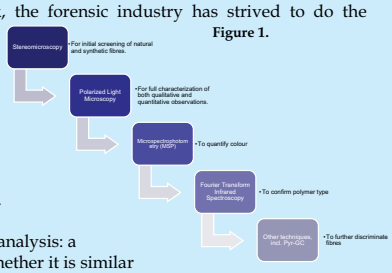
Forensic Fibre Examinations

Forensic fibre examination has been a fundamental part of criminal investigations for over 50 years [1]. The majority of fibres found at crime scenes are <5mm in length and include both natural and synthetic types. The nature of all court going evidence means that techniques for both analysis and interpretation must be robust. There are also drivers for technological advancement in analysis techniques; these include the need to improve both the evidential value of fibres evidence and their cost effectiveness. Since their initial use in casework, the forensic industry has strived to do the following [2];

- Improve discrimination between fibre types through improved analysis techniques,
- Increase throughput of samples,
- Improve interpretation through use of data and adaptive statistical approaches,
- Provide intelligence through use of provenance information and transfer and persistence knowledge.

Figure 1.



Forensic examination of fibres is mainly a comparative analysis: a sample of unknown origin is examined to determine whether it is similar to a sample from a known source. Alternatively, a fibre analyst may be requested to identify the source or possible end-use of the fibre which has been collected as evidence. Polarized light microscopy is arguably the most important technique employed for fibres examinations due to its ability to quickly and easily screen fibres into relevant groups, identify polymer type and provide other morphological and optical information, all of which aids source identification. The order of techniques generally used for fibres evidence can be seen in figure 1. Unlike in microplastic analysis, the emphasis is not upon FTIR but instead on utilising a series of observations to categorise the fibres. In forensic examinations, 'layers of information' are sought to try to identify source and quantify the prevalence of such fibres, given that not all fibres of that share polymer type are the same.

Proposed Collaborative Project

A project has been launched which aims to maximise the knowledge, research and technology employed in forensic fibres examinations for use in microplastic analysis. Underpinning this, is the adaptation of an extant project in the development of an automated intelligent system that identifies, characterises and quantifies fibres (T.R.A.C.E) for environmental microfibre analysis. The features of this system and how this will be transformed to be fit-for-purpose for microplastics can be seen in figure 3. The possible benefits to microplastic analysis are described in table 1.

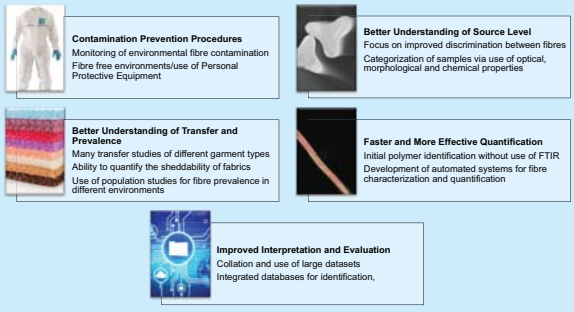
Table 1.

System Aim	Benefits to Microplastic Analysis
Automated detection and analysis of microfibres	Time saving and standardisation of analysis allowing more comparable research
Optical, chemical and morphological features to be simultaneously determined	Allows enhanced categorisation based on other features such as cross-sectional shape, width and the presence and absence of inclusions. These features allow fibres that fall within the same polymer type to be sub-categorised in order to fully understand the extent of possible sources of these fibres.
Surface area to be auto calculated along with microfibre/plastic count	Cross-sectional shape and fibre surface area could aid in the analysis of concentrated toxins on the fibres surface.
Generation of a database of microplastics	Allows collation of datasets from different studies, locations and samples improving interpretation and ease of comparison. Large dataset mining can provide probabilistic evaluations, e.g. use of Bayesian networks for determining the likelihood of finding certain microfibres in a given environment.

Crossover Between Forensic Fibres Examination and Microfibre Analysis from Environmental Samples

Many aspects of forensic fibre analysis and research overlap with microfibre analysis from environmental samples, such that techniques, protocols and developing technologies could be employed in microplastic work. Figure 2 outlines forensic fibre priorities which could benefit microplastic analysis, quantification and interpretation. Some of these have already been employed successfully, demonstrating the potential of a collaborative approach [3, 4].

Figure 2.



Development of a System for the Automated Identification and Characterisation of Microplastics

Figure 3.

T.R.A.C.E System

Trace Retrieval, and Automated Characterisation and Evaluation

- an optimised trace evidence retrieval system for use at crime scenes;
- an image capture and trace particulate evidence finding system (device and software).
- software for use in triage, tasking, and in the evaluation of the intelligence and evidential value of fibres and other traces.
- a secure and automatically populated database to enable the triage, tasking and evaluation referred to above.

Microfibre/Plastic System

- an optimised microfibre and plastic particulate retrieval system for use with environmental samples;
- an image capture and plastic particulate finding system (device and software) using image processing and machine learning.
- software for use in the automated identification and characterisation of microplastics providing additional quantification information, e.g. cross sectional shape and surface area.
- a secure and automatically populated database to enable microplastic research to be compared including the cross-comparison of locations, polymer type and microfibre morphology.

References

[1] Robertson J, Grieve M (1999), Forensic Examination of Fibres, Taylor and Francis.
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[3] Woodall LC, Gwinnett C, Packer M, Thompson RC, Robinson LF, Paterson GL (2015), Using a forensic science approach to minimize environmental contamination and to identify microfibres in marine sediments, Marine Pollution Bulletin, 95 (1): 40-6.
[4] Taylor ML, Gwinnett.C, Robinson LF, Woodall L (2016) Plastic microfibre ingestion by deep-sea organisms, Scientific Reports, online.

If you are interested in collaboration…

In order for this new analysis and evaluation system to be fit-for-purpose, collaboration is sought from those working in microplastic research. In addition to this, a funded PhD opportunity at Staffordshire University is now available in this area. If you are interested in collaborating in this area or in the PhD position, please contact Dr Claire Gwinnett, Associate Professor, Staffordshire University, Science Centre, Leek Road, Stoke-on-Trent, at c.gwinnett@staffs.ac.uk, 01782 295924.