Museum of London and UCL Institute for Sustainable Heritage

The use of Solid-Phase Microextraction Gas Chromatography Mass Spectrometry (SPME-GC/MS) for analysis of plastic materials in historic collections:

A case study of handbags at the Museum of London

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Introduction

The identification of plastic materials in heritage collections is challenging due to the limitations of visual identification techniques and the wide range of plastic formulations often found in museum collections. However, accurate material identification is becoming increasingly important as plastic objects are entering collections at an ever increasing rate, and historic objects exhibiting signs of advanced degradation are being observed. This is particularly true for social history, costume, and modern art and design collections.

Solid-phase Microextraction Gas Chromatography Mass Spectrometry (SPME-GC/MS) involves the non-invasive detection of volatile organic compound (VOC) emissions from materials, using fibres with an absorbent coating. This can provide information about material composition, in addition to identifying the products of ongoing degradation reactions. Unambiguous identification of additives such as plasticisers is possible, along with characteristic markers of particular plastic types. Advantageously, the fibres can be used to accurately and non-invasively analyse difficult to reach parts of an object, as well as objects with complex surface textures.

SPME-GC/MS has been used to analyse plastic materials from a variety of 20th century handbags from the Museum of London's costume collection, demonstrating the practical application of the technique to real, naturally aged museum objects. It has been shown that for some objects SPME-GC/MS can be used to accurately identify plastic materials and provide information on composition. It is possible that other emissions relate to the former use or storage of the handbag. For example, an emission of naphthalene suggests handbag 89.338/8 has previously been exposed to mothballs, and an emission of isoamyl acetate (banana or pear oil) suggests handbag 74.47 may once have contained flavoured cosmetics or confectionary.

In other cases the results from SPME-GC/MS were inconclusive, and more established techniques such as FTIR may be a more straightforward approach to polymer identification.

Figure 6. Right: Contactless FTIR external reflectance analysis of the exterior of 85.559/4. The spectrum shows a strong match for phthalate plasticised PVC. SPME-GC/MS analysis corroborated this result, however FTIR external reflectance analysis proved faster and equally successful.

Results

Figure 1. 20th Century handbags and purses from the Museum of London's costume collection.

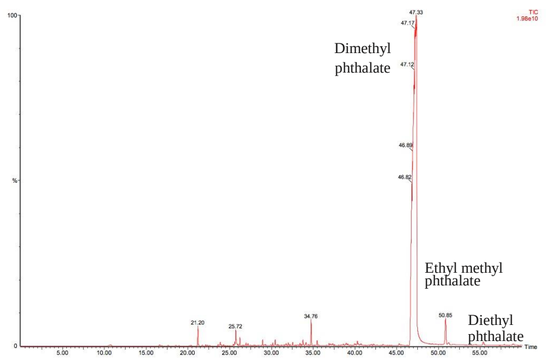
Handbag ID Number	SPME-GC/MS polymer identification	FTIR external reflectance polymer identification
97.6/10	Polystyrene	Not possible due to uneven surface texture
85.145/27	Polyurethane	Polyurethane
62.149/4	Inconclusive	Casein formaldehyde
85.559/4	PVC	PVC
2002.70/3	Inconclusive	Not possible due to uneven surface texture
90.340/3	PVC	PVC
74.47	Inconclusive	Not possible due to uneven surface texture
89.338/8	PVC	Not possible due to inaccessible surface

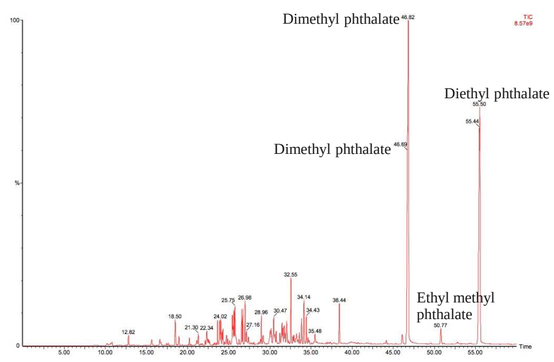
Figure 3. Summary of results from SPME-GC/MS and FTIR external reflectance analysis.

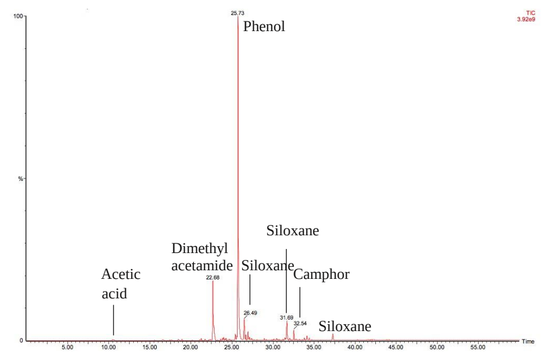
Figure 2. Two SPME sampling techniques were used:

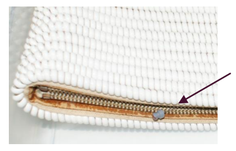
Above: The SPME fibre was placed in direct contact with the object's plastic component for 7 days. The object and fibre were enclosed in a new Stewart Sealfresh™ polyethylene box which had been off-gassed for 48hrs in an enclosed fume hood.

Below: The object was heat sealed in a nitrogen-flushed Tedlar® bag. The bag was filled with nitrogen gas and the SPME fibre was exposed to the headspace of the object for 1 hour via a syringe port.







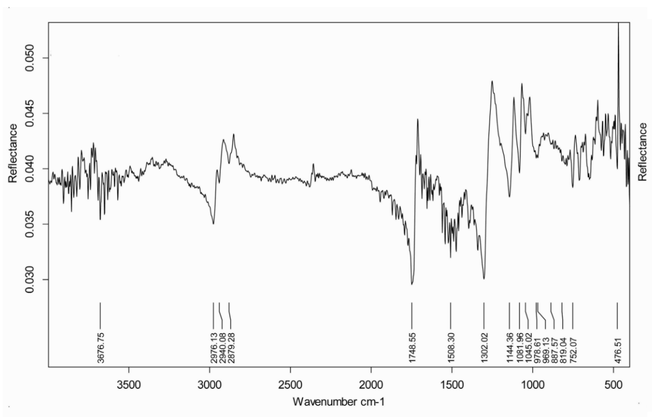


SPME fibre inserted in handbag 89.338/8.

Figure 4. Left: Chromatogram from SPME analysis of the internal lining of 89.338/8. Strong emissions of phthalates indicate a heavily plasticised material, likely PVC.

Figure 5. Left: Chromatogram from SPME analysis of the leaves of 90.340/3. Strong emissions of phthalates suggest PVC.

Figure 7. SPME-GC/MS analysis of 62.149/4 was inconclusive, containing emissions such as acetic acid and camphor which can come from a variety of different materials. However, FTIR external reflectance analysis showed a good match for casein formaldehyde (Figure 8).



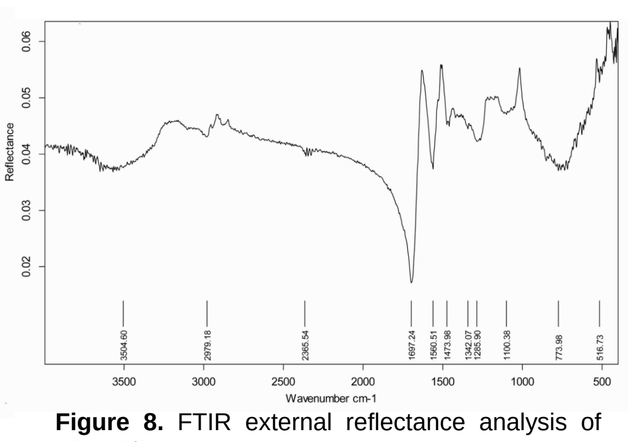


Figure 8. FTIR external reflectance analysis of 62.149/2

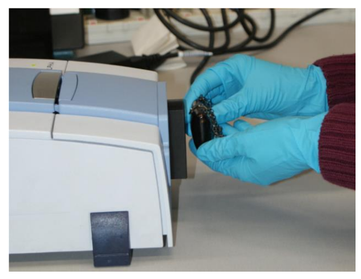


Figure 9. Contactless FTIR external reflectance analysis of 62.149/2