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A preliminary investigation into the use of FTIR microscopy as a probe for the identification of bullet entrance holes and the distance of firing

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ABSTRACT

FTIR spectroscopy has been found to be a valuable probe for the analysis of the distribution of organic components such as nitroglycerine in gunshot residues deposited on and around the bullet entrance hole of the clothing of the victim in short range firearm discharges. The method can be utilised for the detection and estimation of organic gunshot residues (OGSR) on the hands and clothing of the shooter. The method is specific and sensitive and is likely to be free from interference from, for example, environmental pollution. The method shows potential to be utilised as a suitable alternative to the widely used SEM-EDX analysis of the total contents of lead, barium and antimony present in the gunshot deposits around the bullet entrance hole. The method was tested in the laboratory and the results were validated by Gas Chromatography-Mass Spectrometry (GC-MS).

1. Introduction

The most common method of investigation involving incidents involving discharge of gunshots is the examination of gunshot residues (GSR) based on the detection and estimation of primer [1] (consisting of a blend of lead styphnate, barium nitrate and antimony sulfide). Various techniques exist and are commonly used for the analysis of GSR [1,2]. Usually samples of gunshot residues were collected from the hands and clothing of the shooter using cotton swabs and aluminum stubs with black carbon adhesive tabs which are subsequently subjected to examination for elemental composition and morphology of any particle present. The methods commonly used include inductively coupled mass spectrometry (ICP-MS) neutron activation analysis (NAA), atomic absorption spectroscopy (AAS), multi component analysis employing X-ray fluorescence (XRF) [1,3,4].

SEM-EDX is widely recognised as the most specific method [5–8]. Sen et al. [9] emphasised the use of PIXE (proton induced X-ray emission technique) for the analysis of gunshot residues. The GSR residues were analyzed for total content of antimony (Sb), barium (Ba) and lead (Pb). High amounts of these elements are considered to be characteristic of gunshot residues which also have a distinct morphology. According to Wallace and McQuillan [10] particles of Pb, Ba and Sb or Ba and Sb can be considered to be indicative of GSR but can also be indicative of any discharge residue of any primer based on

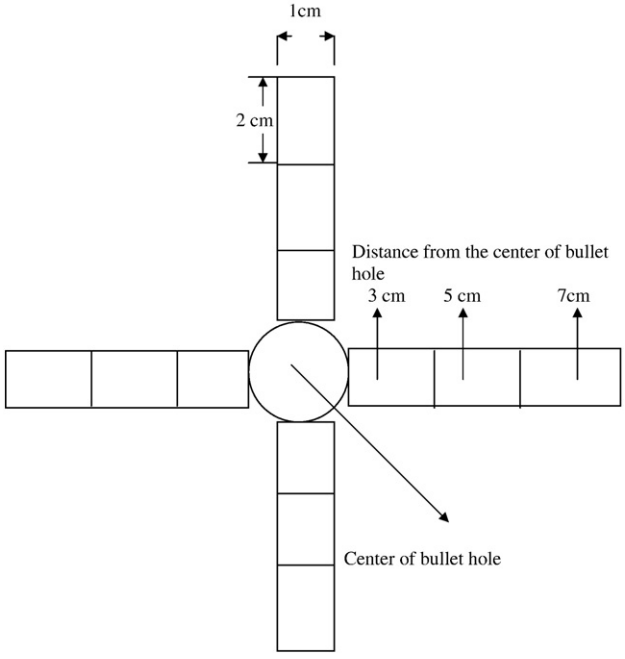

Fig. 1. Diagram for sample collection procedure around the bullet hole.

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a mixture of Pb, Ba and Sb compounds. Romolo and Margot [11] strongly advocated the use of SEM-EDX for the analysis of GSR which they considered very specific.

However, Torre et al. [12] suggested the occurrence of particles with similar compositions to GSR also existed within the environment, in particular in the analysis of brake linings and their wear products which were also found to contain lead, barium and antimony (showing GSR-like elemental profiles). The presence of occupational environmental particles similar in composition to GSR particles suggests the compositions are not necessarily specific to GSR. According to Torre [12] cartridge operated industrial tools and fireworks can produce particles with composition similar to GSR. Industrial smoothing and grinding of brake lining surfaces release microscopic residues of lead sulphide, antimony sulphide and barium sulphate in different combinations and the particles may spread through traffic due to brake lining wear. The detection of Pb–Sb–Ba aggregates from non fireworks sources is also observed according to tests performed on brake-pad and automobile workers [13]. Information on particles taken from cartridge cases show the relative weak importance of the morphology in distinguishing gunshot residues [12].

Cardineti et al. [13] suggested an X-ray mapping technique where the spatial distribution of the emission energy of each element differentiates GSR samples from some other environmental occupational aggregates. According to this study, the concentrations of Pb–Sb–Ba aggregates in GSR would be expected to be higher (at least three times higher than those present in the environment). It is also suggested [14] that depending on the cartridge capsule the elemental distribution of GSR may not contain Pb, Ba, Sb but other elemental clusters including [Ba Sb], [Pb Sb], [Pb Ba], [Pb Sn], [Sn Ba (Pb)], [BaCa Si], [Pb], [Ba], [TiZn], [Hg]. Non GSR elements observed included Cu, Zn, K, Cl, S, Fe, Ni, Al, Ca, Si.

Pb, Ba and Sb are ubiquitous in the environment with a natural abundance of (in g kg^{-1}), Sb—0.0002, Pb—0.0125, Ba—0.425 [15]. The concentrations of these elements (particularly of lead) are also expected to be high in the third world countries as environmental awareness and pollution control measurements are not well advanced. Pb pollution in the environment can arise from multiple

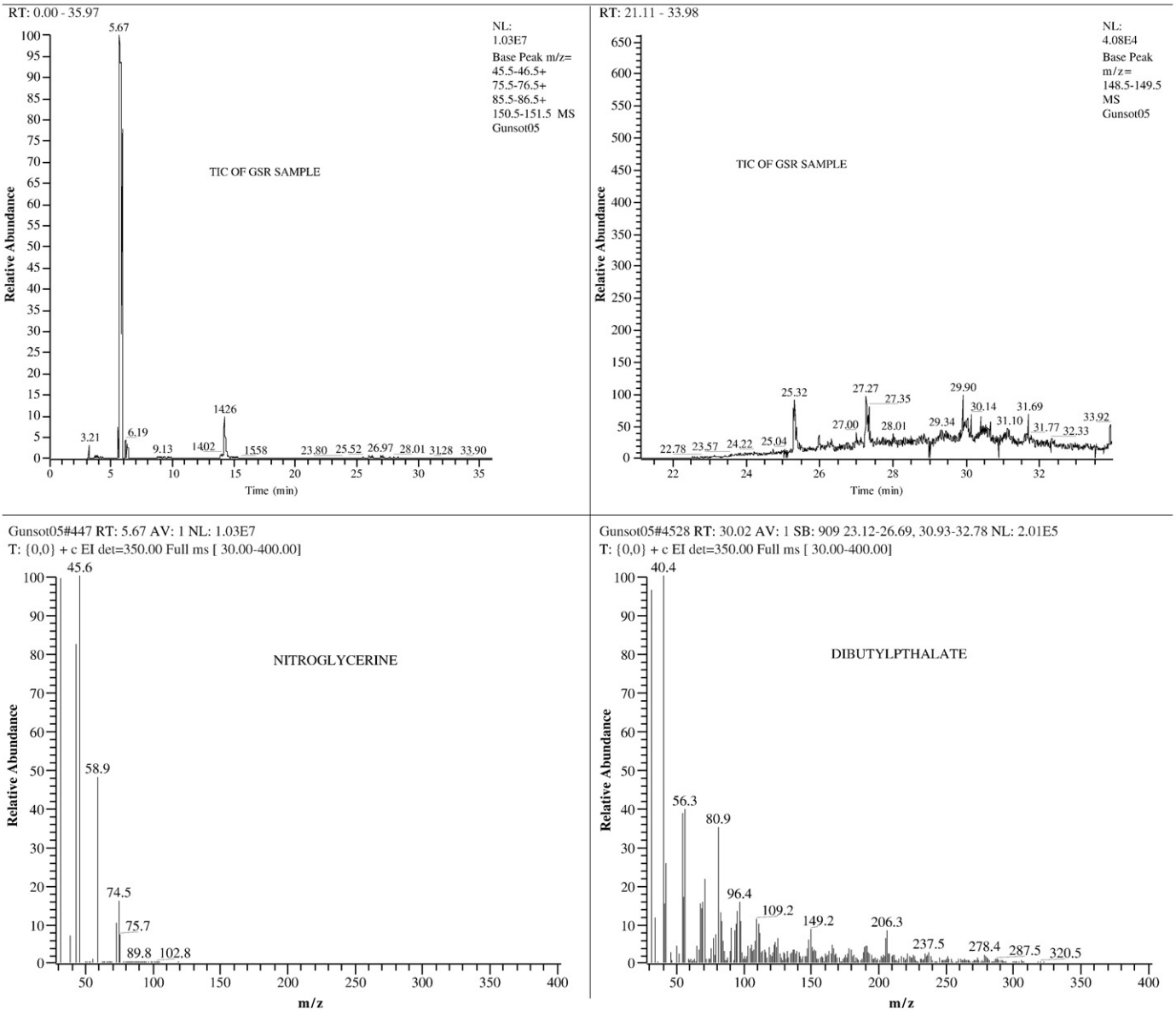

Fig. 2. GC-MS spectra: TIC and MS of GSR sample.