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Investigations into Hair Analysis by ToF-SIMS

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A dramatic increase in the potential applications of hair analysis has occurred over recent years. Perhaps the most frequently reported being applied to the analysis for drug and pharmaceutical ingestion. Use as a biomonitor is receiving a greater number of publications, and interest also exists in the personal care industry in the development of hair care products.

This research has applied Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) to a variety of investigations for studying hair. Hair grows in such a manner as to incorporate any xenobiotics existing in the blood stream into the actively growing segment. As the hair continues to grow (at a rate of approximately 1 cm per month) a histological profile is produced along the strand representing drug use, dietary habits, exposure to pollutants and toxins and also cosmetic treatments.

A longitudinal sectioning technique[1] was utilised for the preparation of hair samples (**figure 1**). Due to the surface sensitive nature of ToF-SIMS, this enabled acquisition of internal and external, longitudinal and transverse distributions. Elemental ions and other molecular fragments were imaged on the surface of the hair and their sections to locate the particular location of the accumulations (**figure 2**). Various elements were observed to increase in concentration moving distally on a hair sample. Calcium for example was found to inhabit the gaps between the cuticle scales and is a common ingredient in cosmetic products and is also abundant in the tap water of the donor. A variety of species, both elemental and molecular, were observed to vary longitudinally on the surface of the hair samples (**Figure 3**). However, the internal distributions were often quite independent or not even detected.

Concentrations were also monitored across hair sections. Typical transverse distributions are given in **figure 4**. Such scans can be used to investigate the ability of species to migrate into or out of the hair structure.

While studying elemental concentrations, difficulty and loss in credibility occurs when exogenous contamination can't be distinguished from endogenous uptake. An ability to measure the internal concentrations independently to the surface concentrations will assist in the discrimination of biogenic and digenetic mechanisms of uptake.

Potential was also found for the use of ToF-SIMS to detect parent ions of high dose drugs in hair. Combining the sectioning method and drug detection by ToF-SIMS would enable the histological profiling of drug use of an individual with a resolution of days.

Reference:

[1] I.M. Kempson et al, Journal of Forensic Sciences, 47 (2002) 889.

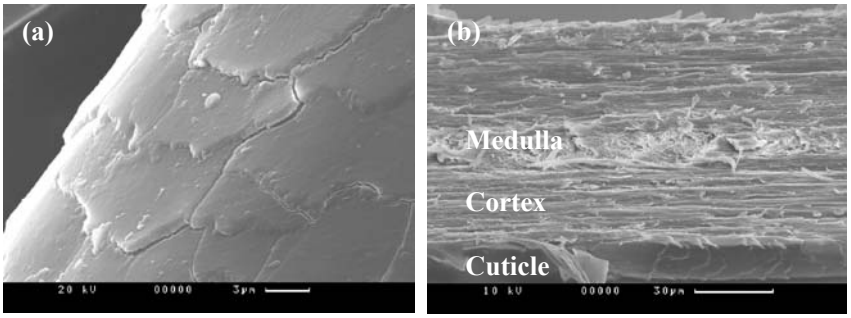

Figure 1: The surface of an un-sectioned hair (a), and a sectioned hair (b) clearly demonstrating the three layers.

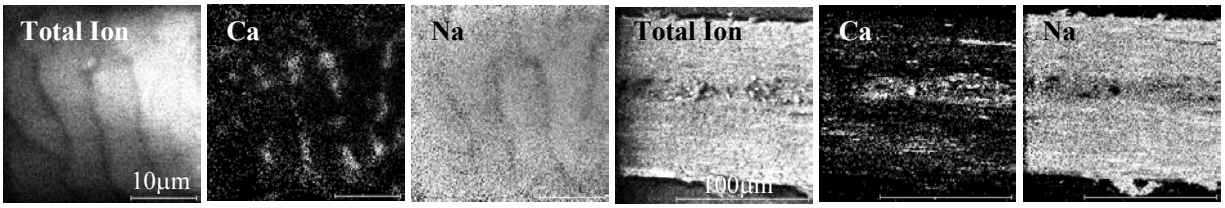

Figure 2: A selection of ToF-SIMS images of a hair surface (left) and a sectioned sample (right). Calcium has accumulated in the gaps of the cuticle scale and also in the medulla while sodium is concentrated on the flat areas of the scales and concentrated in the cortex.

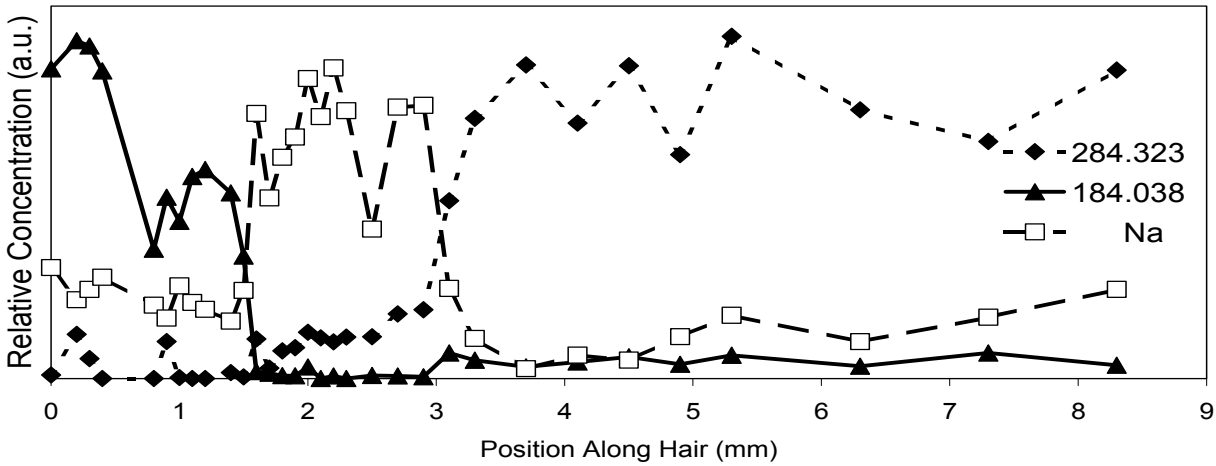

Figure 3: Elemental and molecular species vary along the surface of the hair. In the example given, the scalp level was at a position of 1.5 mm along the hair. A molecular fragment of 184 amu has been washed from the hair, while the 284 amu fragment has accumulated presumably through washing. Sodium indicates the transition from the unexposed and environmentally exposed region.

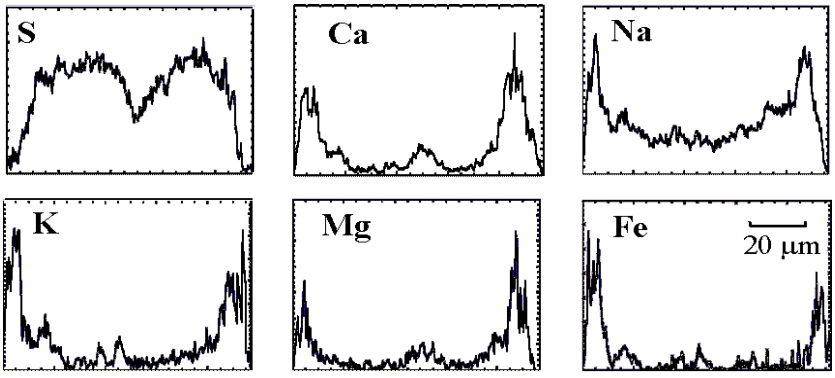

Figure 4: A selection of transverse linescans produced from ToF-SIMS images of a longitudinally sectioned hair.

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