Mummified tissues and ancient cosmetic recipes analysed by infrared and X-ray micro-spectroscopies

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Some organic materials may present an exceptional resistance to degradation even after many centuries. Among them, pieces of human tissues from mummies as well as cosmetics are sometimes discovered in tombs. They are very precious samples and may provide a lot of information about the way of life contemporaneous of the funeral, as well as the chemical long time evolutions that may occur.

We will present two types of examples: mummified tissues and ancient cosmetics. Infrared (IR) and X-ray spectroscopies are well-suited methods to study such samples, which are often composed of a mixture of organic and inorganic materials. The chemical probing of these two techniques is completely different due to the two distinct wave-number domains used. IR micro-spectroscopy offers images of the molecular groups, whereas X-ray analyses reveal the atomic composition. Hence, the complementarity of these two methods is helpful. For the two techniques, the synchrotron radiation provides a good trade-off between duration, spatial resolution and spectral quality of the acquisitions.
Concerning the mummified tissues, some samples are in an amazing conservation state. The main constituents (lipids and proteins) as well as the protein secondary structure present a similar distribution to the one observed on modern samples. A beginning of degradation seems to appear in the middle of the hair, the medulla. X-ray fluorescence, IR and XANES spectroscopies converge on the same result: the identification of a calcium phosphate which could be formed via long term reactions.
The analysis of some ancient cosmetics revealed the presence of some lead soaps. IR spectroscopy can sometimes be used to identify the precise nature of these soaps and their distribution may be indicative of the process of the cosmetics. These lead compounds are considered, nowadays, as potentially toxic. We have reconstructed ancient recipes to study the interactions between these pharmaceutical preparations and skin. X-ray fluorescence enables to follow the diffusion of lead inside transversal cross-sections of skin, treated by different mixtures and analyse the resistance of *stratum corneum* to the penetration of exogenous substances. IR micro-spectroscopy is less sensitive, and may not detect so low concentrations, but, conversely, it can give information about the supramolecular organisation of the molecules.
These two examples demonstrate the usefulness of combining IR and X-ray spectroscopies to better understand the short and long term interactions between organic materials and minerals.