Ft-Ir Spectroscopy and Microspectroscopy of Ancient Egyptian Embalmed Heads from the Museum of Anthropology and Ethnography of the University of Turin

M.G. Bridelli[1], A. Dell'Anna[1], C. Stani[1], A. Baraldi[1], R. Boano[2], S. De Iasio[3]

[1] Department of Physics, University of Parma, Italy. E-mail: mariagrazia.bridelli@unipr.it
[2] Department of Animal and Human Biology, University of Turin, Italy.
[3] Department of Human and Animal Biology, University of Parma, Italy

KEY WORDS: Dynastic mummy, predynastic mummy, skin, FTIR spectroscopy, Amidel band.

Introduction

The Museum of Anthropology and Ethnography of University of Turin is involved in the study and conservation of ancient human remains as described by Boano *et al.*(2011), and, in particular, of Egyptian mummies belonging to the prof. G. Marro collection (80 embalmed heads, 15 Dynastic mummies and 5 Predynastic mummies). In the present work Fourier Transform Infrared (FTIR) Spectroscopy and microspectroscopy were applied in order to assess the preservation state of the skin of such remains by applying minimally destructive preparation of the samples. Changes in the conformation of the skin proteins of the ancient investigated tissues, with respect to the modern skin were correlated with ageing processes of the tissues and studied by monitoring the modification of the infrared Amide I band. Other non-skin-derived features in the IR spectra of embalmed skin were distinguished and identified.

Material and Methods

Small fragments of skin (~1 mm^2) were taken from a predynastic mummy and from a dynastic head. A "modern skin" reference sample was a small piece of skin taken from the hand of one of us. Modern and natural mummy skin were studied in transmission mode by Jasco 420 spectrophotometer (4000 – 600 cm^{-1}, 128 scans, spectral resolution 2 cm^{-1}) prepared as KBr pellets (~1 mg in 100 mg of KBr). An embalmed skin sample, without any preparation, was studied by BOMEM DA8 FT spectrophotometer (1000 scans, spectral resolution 1 cm^{-1}) coupled with IR PLAN microscope focusing the beam light in small areas (0.4x0.4 mm^2).
The Amide I band Gaussian fitting was performed by means of Origin 8.0 program.
The identification of the embalming substances was carried out by matching the measured IR spectra against the Library of Diagnostic Markers (General and Inorganic Chemistry Department, University of Parma).

Results and Discussion

As shown in Fig. 1, the IR spectrum both of modern and naturally mummified skin are dominated by the protein

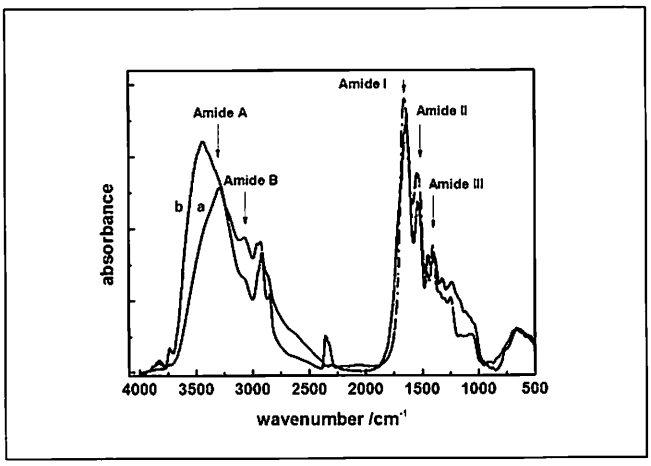

Fig. 1. *FTIR spectrum of modern (a) and Predynastic mummy (b) skin.*

Amide bands. Amide I band ($\nu \approx 1600$-1700 cm^{-1}, due to the peptide backbone C=O stretching vibrations), as shown by Torii and Tasumi (1996) is particularly sensitive to the protein conformation. From the peak position and area of the component bands obtained by means of the deconvolution procedure, the main secondary structure frequency and percentage amount might be detected. In Fig. 2 the Amide I band deconvolution of the modern (A) skin and the predynastic mummy's (B) one are compared. Modern skin proteins, collagen and keratins, are mainly composed of α- and triple- helices, while in the mummified sample the band enlargement to the side of high wavenumber due to the α helix amount decrease and

the β sheet motif increase, indicates degradation in the skin. The burial in the aerobic sandstones and the environmental high temperatures could have produced the protein conformational changes and the collagen fibrils crosslinking, preventing the subsequent tissue deterioration.
The embalmed skin specimen, stained with red and black spots, as shown in the inset in Fig. 3, was mapped by means of the IR microspectroscopy in the different locations, the skin (a, Fig. 3, inset) and the colored spots (b and c), with a twofold aim: to study the preservation degree of the embalmed skin and to identify the embalming substances. Fig. 3 displays the stack plots of the spectra recorded on the three areas a, b, c. The high α-helix amount in the Amide I band (Fig. 2 C) in the spectrum of the skin region (Fig. 3, spectrum a) is indicative of a quite good preservation state of the embalmed skin. The presence of embalming agents is pointed out by a relevant ester C=O component at ν~1722 cm^{-1}. The comparison of the spectrum collected on the red region (Fig. 3, spectrum b) with the reference spectra suggests that it could represent traces of resins from *pistacia* or conifer trees, as studied by Buckley and Evershed (2001). Finally, the correspondence of the fingerprint bands of the spectrum (c), recorded on the black spots, with the IR bands of some fungi, leads to the suspicion that the sample could be affected by a fungal colonization. In conclusion, FTIR spectroscopy is a very powerful and versatile technique to investigate biological remains of mummies enabling to gain information about the ageing progress of the ancient human remains and to detect tracks of extraneous biochemical components, such as balms or fungi.

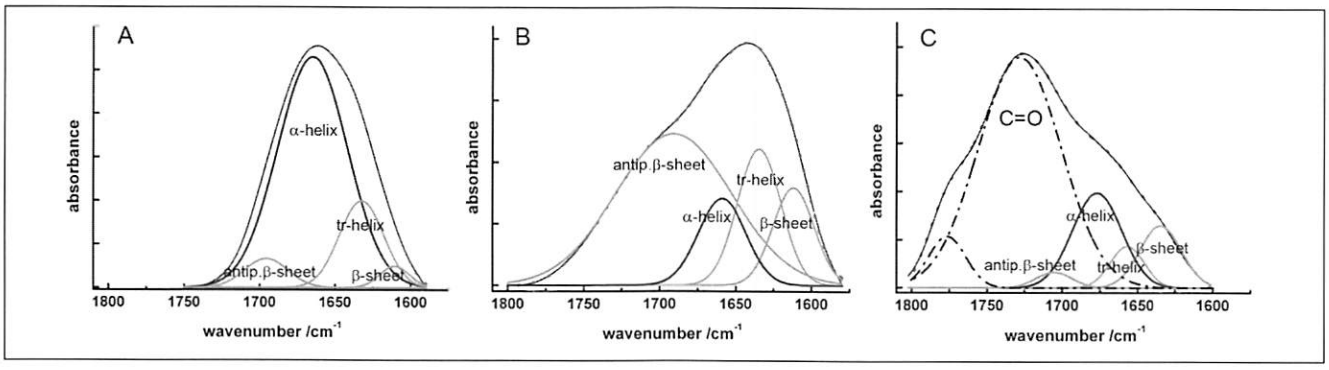

Fig. 2. *Amide I band deconvolution in Gaussian components for modern (A), Predynastic mummy (B) and embalmed head (C) skin.*

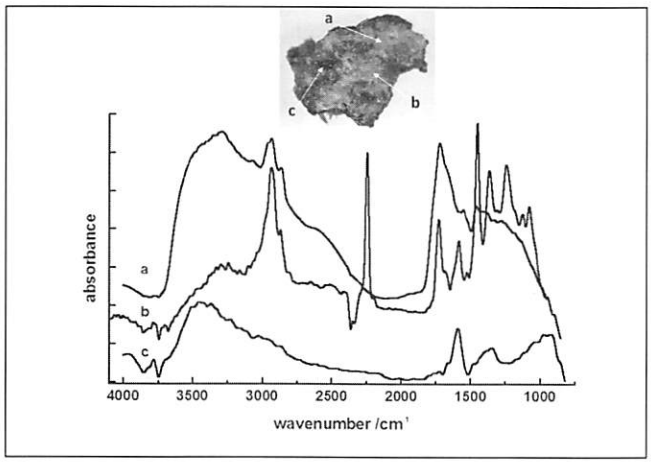

Fig. 3. *Embalmed head FTIR microspectra of skin(a), red area (b) and black spot (c). Inset: image of the sample. The arrows indicate the three locations analyzed.*

References

Boano R., Meaglia D., Dutto G., Costa E., Rabino MassaE. 2011. The biological archive of the Museum of Anthropology and Ethnography of Turin: microscopic analysis to assess the preservation of ancient human hair, In: *Yearbook of Mummy Study*, Vol. 1, H. Gill-Frerking, Rosendahl W. & Zink A. and Piombino Mascali D., eds.: 29-32.

Buckley S.A., Evershed R.P. 2001. Organic chemistry of embalming agents in Pharaonic and Graeco-Roman mummies. *Nature*, 413: 837-841.

Torii H., Tasumi M. 1996. Theoretical analyses of the Amide I infrared bands of globular proteins. In: Mantsch H.H., Chapman D. (eds.), *Infrared Spectroscopy of Biomolecules*, Wiley J. & sons, inc. NY: 1-18.