ISIS@MACH ITALIA

Science and Technology Facilities Council
ISIS Neutron and Muon Source

Experiment Proposal

Experiment number GP2023002

Principal investigator	Mrs Valentina Turina, Museo Egizo, ITALY
Co-investigator (*)	Dr Giovanni Romanelli, University of Rome Tor Vergata, ITALY
Co-investigator	Dr Joseph Bevitt, Australian Nuclear Science and Technology Organisation, AUSTRALIA
Co-investigator	Dr Robert Robinson, University of Wollongong, AUSTRALIA
Co-investigator	Professor Salima Ikram, American University in Cairo, EGYPT
Co-investigator	Dr Lucy Skinner, University of Northampton and the British Museum, UNITED_KINGDOM
Co-investigator	Dr André J Veldmeijer, American University in Cairo, NETHERLANDS
Co-investigator	Professor Marco Laurati, CSGI, ITALY
Co-investigator	Dr Triestino Minniti, University of Rome Tor Vergata, ITALY
Experiment title	SAXS characterization of leather artefacts from Museo Egizio

MRF Instrument	**SAXS Xenocs Xeuss**	**Days requested:** 2
Access Route	Direct Access	**Previous GP Number:** GP2021001
Science Areas	Cultural Heritage	**DOI:** -
Sponsored Grant	None	**Sponsor:** -
Grant Title	-	**Grant Number:** -
Start Date	-	**Finish Date:** -
Similar Submission?	-	
Industrial Links	Fondazione Museo Egizio	

Non-Technical Abstract

Within the Museo Egizio collection there are 200 precious and unique leather artifacts belonging to different historical periods including the Old Kingdom, New Kingdom, Roman and Byzantine eras. Here we propose to study the structure, dynamics and elemental composition of leather artefacts spanning from the Old Kingdom to the Byzantine Period and including samples from the intact tomb of Kha (around 1400 BC) that document an extensive crystallization phenomenon. We propose to perform a SAXS experiment using the Xenocs XEUSS (SAXS_USAXS_GISAXS_WAXD). In particular, we want to assess the degree of assembly of the collagen fibrils of the samples previously investigated and compare the results with similar-size modern leather samples as well as from results from the literature.

Publications

G. Romanelli, et al., “Neutron-Enhanced Information on the Laboratory Characterization of Ancient Egyptian Leathers...”, Information, 2022, 13, 467

ANSTO Reactor — **IM@IT E-platform:** Yes - ANSTO Reactor

Brief abstract

The measurements will be complemented through a follow-up separate proposal at the ANSTO Reactor (Australia). This other proposal aims at performing a 3D neutron imaging/ tomography experiment on the Dingo neutron beamline for collecting additional information on the homogeneity and texture of the same Egyptian leather samples. For the neutron experiment we envisage a request for 2 days of beam time on Dingo.

Sample record sheet

Principal contact	Dr Giovanni Romanelli, University of Rome Tor Vergata, ITALY		
MRF Instrument	**SAXS Xenocs Xeuss**	**Days Requested:** 2	
Special requirements:			

SAMPLE

Material	Leather	-	-
Formula	collagen	-	-
Forms	Solid		
Volume	1 cc		
Weight	1 mg		
Container or substrate	Al	-	-
Storage Requirements	-	-	-

SAMPLE ENVIROMENT

Temperature Range	300 - 300 K	-	-
Pressure Range	0.1 - 0.1 MPa	-	-
Magnetic field range	- T	-	-
Standard equipment	None	-	-
Special equipment	-	-	-

SAFETY

Prep lab needed	Yes	-	-
Sample Prep Hazards	-	-	-
Special equip. reqs	-	-	-
Sensitivity to air	No	-	-
Sensitivity to vapour	No	-	-
Experiment Hazards	-	-	-
Equipment Hazards	-	-	-
Biological hazards	-	-	-
Radioactive Hazards	-	-	-
Additional Hazards	-	-	-
Additional Details	-	-	-
Sample will be	Disposed of by instrument scientist	-	-

SCIENTIFIC BACKGROUND

The collection of the Museo Egizio (Turin) houses over 200 leather artifacts belonging to different historical periods, including the Old Kingdom, New Kingdom, Roman and Byzantine eras. Leather is the main material and the only common element of these objects. Leather was used throughout the entire society, from low to high status and often subject to a variety of uses, from decorative to intense use. As with any organic material, due to their vulnerable structure, leather is prone to deterioration and its fragility if preserved and stored in collections forces special care. In order to meet the requirements for proper storage, knowledge on the condition and the reason and mechanism of is current state is paramount.
Here we propose to study the structure, dynamics and elemental composition of some of them, including samples from the intact tomb of Kha (around 1400 BC) that document an extensive crystallization phenomenon (Fig. 1).
Through the constant conservative monitoring of the artifacts, the archeologists and conservators were able to identify different types of degradation and, above all, a correspondence between their dating and the type of documented deterioration. Indeed, the different types of degradation are probably related to the way the skins were prepared and made durable.

Figure 1 – Leather artifacts, fragmentary and completely 'crystallized'

Ancient leather presents a heterogeneous composition of both organic and inorganic materials that show an evident reactivity, which varies as a function of the type of environmental exposure. Its proper preservation remains challenging as some aspects of its chemical composition, degradation and effectiveness of conservation treatments are still not fully understood. Of particular concern for the collection of Museo Egizio (Turin) is that the skin processing method (including any colouring treatments) and the substances used to make it more dura le are not known. Two types of processes are attested: vegetable tannin, which was introduced during the Ptolemaic of even Roman period, treating skins with lipids, which was the most used technique in Pharaonic Egypt. A third treatment is mentioned in literature, the treatment of skins and hides with alum and mineral treatments, although their use is uncertain and probably were used in the process of colouring skins rather than making them durable [2]. The substances that were used to treat the skin and the likely connection with the types of deterioration that are documented are closely linked to collagen, the most important fibrous protein. Collagen is the principal protein constituent of a wide variety of connective tissues in animals. Its structure has been investigated extensively by electron microscopy and by diffraction techniques using x-rays and neutrons [3-8]. Recently [9], a characterization of Egyptian leather samples was completed by combining non-destructive techniques, including surface probes (X-ray fluorescence, Raman scattering, and scanning electron microscopy enhanced by X-ray energy spectroscopy) and neutron-based bulk techniques (inelastic and deep-inelastic neutron scattering). Results showed partial dehydration of the samples, affecting the morphology of their surface, the presence of potassium alum, and iron oxides, as well as phosphates and hydroxides related to the tanning and curing procedures. While such characterization provided a wealth of information at the atomic and molecular lever on one side, and at the micrometre scale on the other side, we suggest bridging the gap between the two scales by looking at the structure at the nanometre scale.

PROPOSED EXPERIMENT

We propose to perform a Small Angle, Ultra Small Angle and Wide Angle X-ray Scattering (SAXS-USAXS-WAXD) experiment using the Xenocs XEUSS 3.0 system operating at the Medium Range Facility 1 (MRF1) of the CSGI-Unifi Unit of ISIS@MACH ITALIA. In particular, we want to assess the degree of assembly of the collagen fibrils of the samples previously investigated in Ref. [9] and compare the results with similar-size modern leather samples, ancient samples not showing any relevant deterioration, as well as results from the literature (see, e.g., Ref. [10]). Combination of SAXS and USAXS measurements will provide access to length scales from the nm up to a few hundred nm, allowing to characterize the fibrils and their assembly. Since a moderate quantity of metallic compounds is only present on the sample's surface, we expect that the bulk scattering from the samples will be dominated by fibrils. Moreover, we aim at assessing the degree of fibre orientation and the dispersion of the orientation for different samples and relate it to the hydration degree previously assessed. This will be analysed through the anisotropy of the diffraction pattern, in particular in the WAXD regime. For the proposed experiments we request two days of beamtime at the MRF1 Facility.

The whole set of data will help specialists in monitoring the leather conditions, and in improving the conservation and restoration processes of the artifacts.

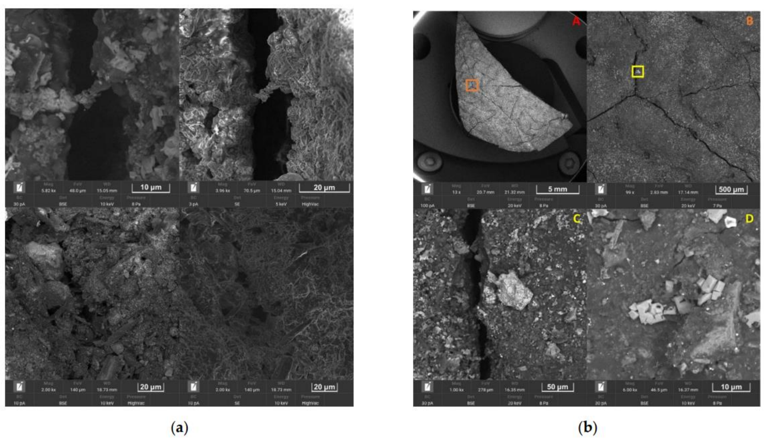

Figure 2 (a) SEM images of two samples (top and bottom) obtained from back scattering (left) and secondary electrons (right). (b) SEM images collected from the overall sample in (a, top) (A), using a magnification of the region delimited by the orange square (B) and two details in the region within the yellow square (C, D). Images adopted from Ref. [9]

References

[1] Schiaparelli, E. Relazione sui lavori Della Missione Archeologica Italiana in Egitto (anni 1903–1920), volume secondo: La Tomba Intatta dell'Architetto Cha Nella Necropoli di Tebe, Torino 1927 = The intact tomb of the architect Kha in the necropolis of Thebes (reprint with english translation). (AdArte, 2008).

[2] Driel-Murray, van, C. 2000. Leatherwork and Skin Products. In: Nicholson, P.T. & I. Shaw. Eds. 2000. Ancient Egyptian Materials and Technology. – Cambridge, Cambridge University Press: 299-319.

[3] Miller, A. *Philos. Trans. R. Soc. Lond. B.* **304** 455-477 (1984)

[4] Praser, R. D. B., T. P. MacRac, and A. Miller. *J. Mol. Biol.* **193** 115-125 (1987)

[5] Wess, T. J., A. Miller, and J. P. Bradshaw. *J. Mol. Biol.* **213**1-5, (1990)

[6] Karplus, M., and G. Petsko. *Nature (Lond.)* **347** 631-639 (1990)

[7] H. D. Middendorf, R. L. Hayward, S. F. Parker, J. Bradshaw and A. Miller, *Biophysical Journal* **69** 660-673 (1995)

[8] J. Li, *J. Chem. Phys.* **105** 6733-6755 (1996)

[9] G. Romanelli, C. Andreani, E. Ferraris, et al., "Neutron-Enhanced Information on the Laboratory Characterization of Ancient Egyptian Leathers: Hydration and Preservation Status", Information, 2022, 13, 467.

[10] M. M. Basil-Jones, R. L. Edmonds, T. F. Allsop, S. M. Cooper, G. Holmes, G. E. Norris, D. J. Cookson, N. Kirby, R. G. Haverkamp. J. Agric. Food Chem. 2010, 58, 5286–5291