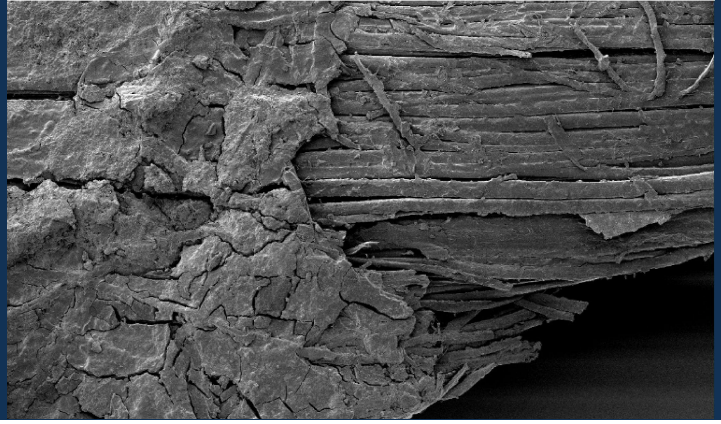

© Anthony MAGUERESSE and Alessia MELELLI - FLinen threads from a painting covered with layers of different materials (glue, plaster, paint, etc.) viewed under a scanning electron microscope.

Old fibres from art objects can be used to design sustainable ecomaterials for the future

Read more

Melelli A. *et al.*

Lessons on textile history and fibre durability from a 4,000-year-old Egyptian flax yarn

Nature Plants . 2021

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Partnerships

- Henri Dupuy de Lôme Research Institute (IRDL, CNRS/ENSTA Bretagne/Université Bretagne Occidentale/Université Bretagne-Sud)
- School of Science and Technology (SST) of the University of Camerino (Italy)
- 'Capitani-Segre' magnetic resonance laboratory of the Italian National Research Council (CNR, Italy)
- Mechanical and Civil Engineering Laboratory (LMGC, CNRS/University of Montpellier)
- Synchrotron facility SOLEIL
- UR BIA

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Context

Organic materials such as flax fibres, composed of renewable biogenic carbon, are often considered to have a short lifespan, but they can last for centuries or millennia by accommodating structural and biochemical changes. Flax can be sustainable, both in terms of the environment and as a material. To better understand the secrets of its durability and its limits, a study was conducted on linen threads extracted from four paintings dated between the 17th and 18th centuries. To further complete our study of these hundreds-year-old samples, we also looked at mortuary linen fibres from Egypt, dated to 4,000 years ago. These two complementary studies pinpoint how the environment, in addition to the extraction process of natural fibres, creates defects in the structures and plays a key role in their preservation and performance. This research brought to light ways to create the most sustainable ecomaterials possible to meet today's challenges.

Results

Our results show – counter-intuitively – that the fibres extracted from the paintings dated a few hundred years ago have undergone more marked changes than the thousands-year-old fibres from Egypt. A general stiffening was found in almost all of the ancient fibres compared to a modern reference linen thread, but the threads in the paintings also showed structural changes not only in the structural defects already identified as weak points by the study of Egyptian threads but also due to other issues. These include oxidation and hydrolysis, which break up the fibres into small pieces, or fungal attacks, which more than any other factor contributes to degradation, through the formation of 'tunnels' and fractures in the fibres.

Despite the effects of ageing, two-photon microscopy showed good stability in the organisation of cellulose (flax is 80 % cellulose). Solid-state NMR and infrared spectroscopy provided additional information on changes in the biochemistry and structure of the fibres. The interdisciplinary team identified the major role of water penetrating and damaging these materials through their structural defects.

Future outlook

These findings provide insights on the ageing of modern flax fibres, which are used, for example, in the design of composite materials for the automotive, nautical and aeronautical industries. Based on the strength of these results that could impact various disciplines, a new ANUBIS project has been launched, financed by the French National Research Agency (ANR, topic Bioeconomy).