DECODE: DEvelopment of a multi-analytical strategy for the bioCOdicological study of parchment DEgradation

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Background

- Parchment served as main writing support from the 2nd century BC until the end of Medieval times [1].
- Produced from animal skins, mainly of sheep, calves and goats.
- Deterioration induced by e. g. moisture, high temperature, atmospheric pollutants and UV radiation is closely related to the physical-chemical degradation of its major component collagen (Fig. 1) [2, 3].
- Degradation causes damage and loss of precious cultural objects.

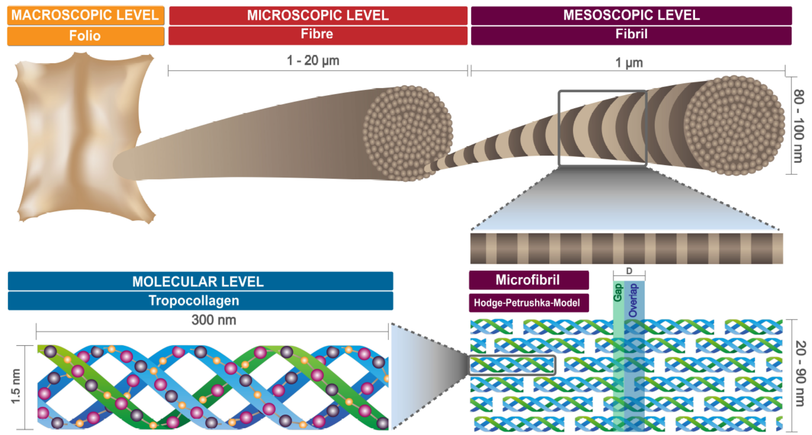

Fig. 1 Hierarchical levels of collagen in parchment and the structural components. Tropocollagen has a right-handed coiling of three polypeptide chains with $(Gly\text{-}Xaa\text{-}Yaa)_n$ as main repeating sequence; *Xaa* and *Yaa* are often proline and hydroxyproline.

Aim of the Study

- In depth proteome analysis (by matrix assisted laser desorption/ionization mass spectrometry (MALDI MS)) in addition to spectroscopic techniques for a more detailed study of degradation products
- Profound insight in degradation phenomena by studying upper surface and deeper parchment layers by point and spatially resolved analyses

References

[1] Fuchs, R., et a.. *Pergament: Geschichte, Material, Konservierung, Restaurierung,* Karger Gazette 67 (2001), 13-16.

[2] Florian, M. L., *Collagen structure.* In Florian, M. L.: Protein facts—Fibrous proteins in cultural and natural history artifacts, Archetype Publications Ltd. (2007), 79-85.

[3] Shoulders, M. D. and Raines, R. T. *Collagen structure and stability.* Annual review of biochemistry 78 (2009), 929-958.

Methodology

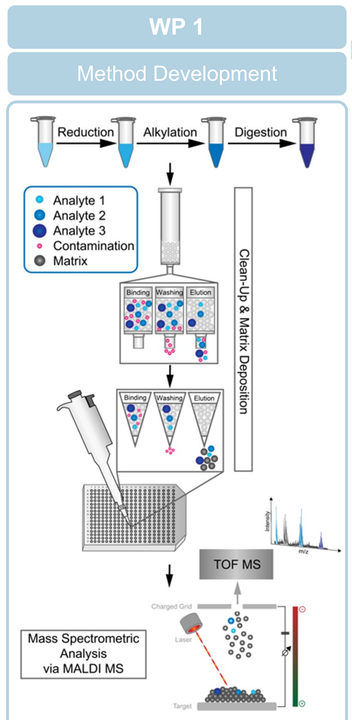

Fig. 2 Main steps of the proteomic workflow: peptides are purified after enzymatic digestion and analyzed with MALDI MS in reflectron mode.

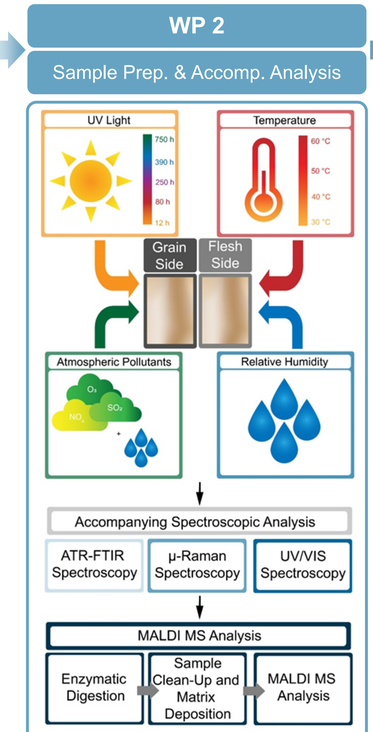

Fig. 3 Bulk analysis is performed on unaged and artificially aged samples by MALDI MS and ATR-FTIR, µ-Raman and UV/VIS analyses.

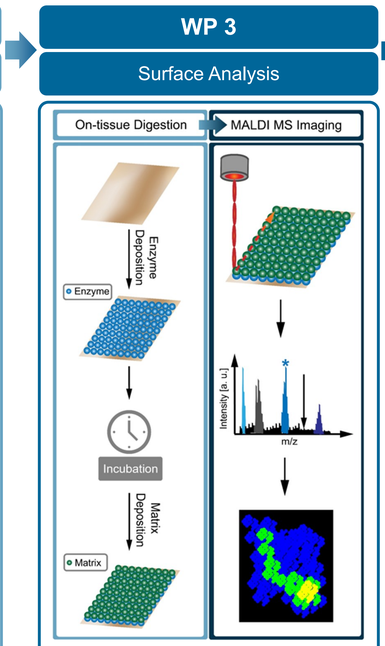

Fig. 4 Stepwise transfer of the in-solution digestion protocol to an on-tissue digestion protocol and method development of the subsequent lateral analysis by MALDI MS imaging (MALDI MSI).

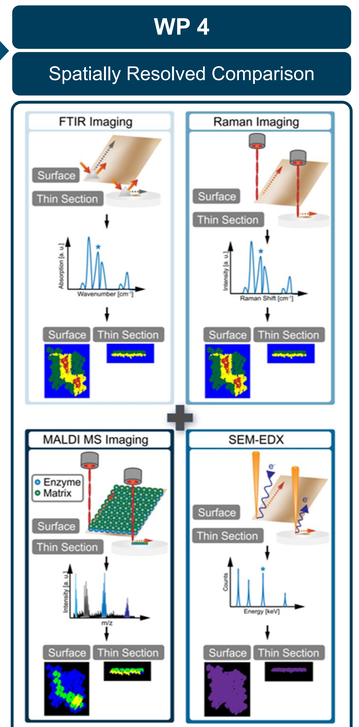

Fig. 5 Combination of complementing imaging techniques (FTIR, Raman, MALDI MS imaging and SEM-EDX).

- WP1: Development of the proteomic workflow for in-solution digestion and subsequent analysis by MALDI MS analysis using collagen type I from calf skin
- WP2: Artificial aging of parchment samples (grain and flesh side) obtained from sheep skin; bulk analysis of unaged and artificially aged samples by ATR-FTIR, Raman and UV/VIS spectroscopy and MALDI MS
- WP3: Direct analysis of the sample surface by MALDI MS after enzymatic on-tissue digestion
- WP4: Spatially resolved analysis of sample surface and parchment thin sections by complementing imaging techniques; correlation of the results

Future Perspective

- Further analysis of the impact of common de-structive writing and painting materials, e. g. iron gall inks or Fe/Cu containing pigments on parchment degradation

Acknowledgements

The PhD project is funded by the DOC Fellowship Program of the Austrian Academy of Sciences (ÖAW). Samples of sheep parchment were kindly provided by Jiří Vnoucek (Kongelige Bibliotek, Kopenhagen).

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