

Investigating the degradation effects of a compartment fire protocol on wall-paintings



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Introduction

The main purpose of this study is to examine the possibility of detecting organic binders as a function of the maximum developed temperature. This is important in the case of wall paintings, as the presence or absence of organics is one of the criteria for the determination of the applied painting technique.

Materials and Methods

Preparation of wall painting mock-ups. Plaster: Ca(OH)₂, Chem-Lab NV, Distilled water. Pigments: Yellow Ochre JTCLES (Kremer)Cinnabar (Sigma-Aldrich). Binders: Distilled water, egg yolk, linseed oil, gum Arabic, casein.

Painting. After their preparation, the specimens were left to "naturally age" for 9 months:

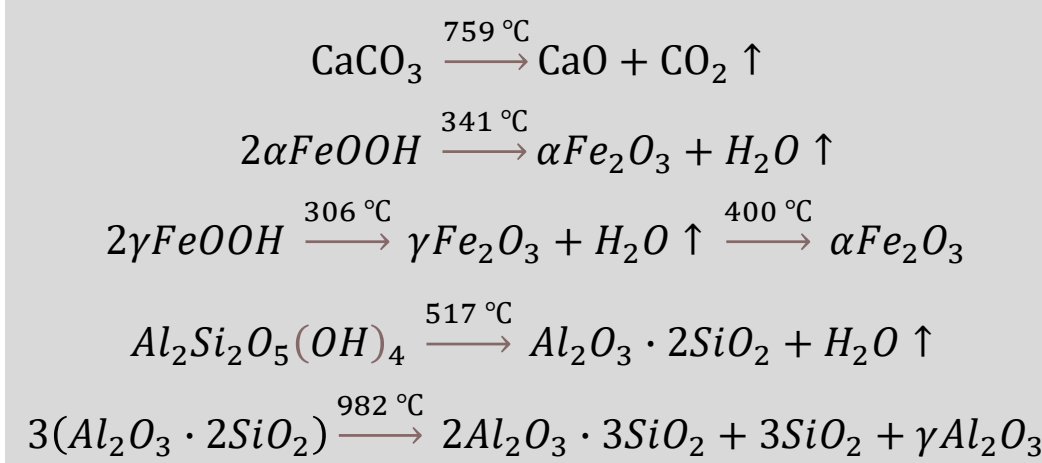
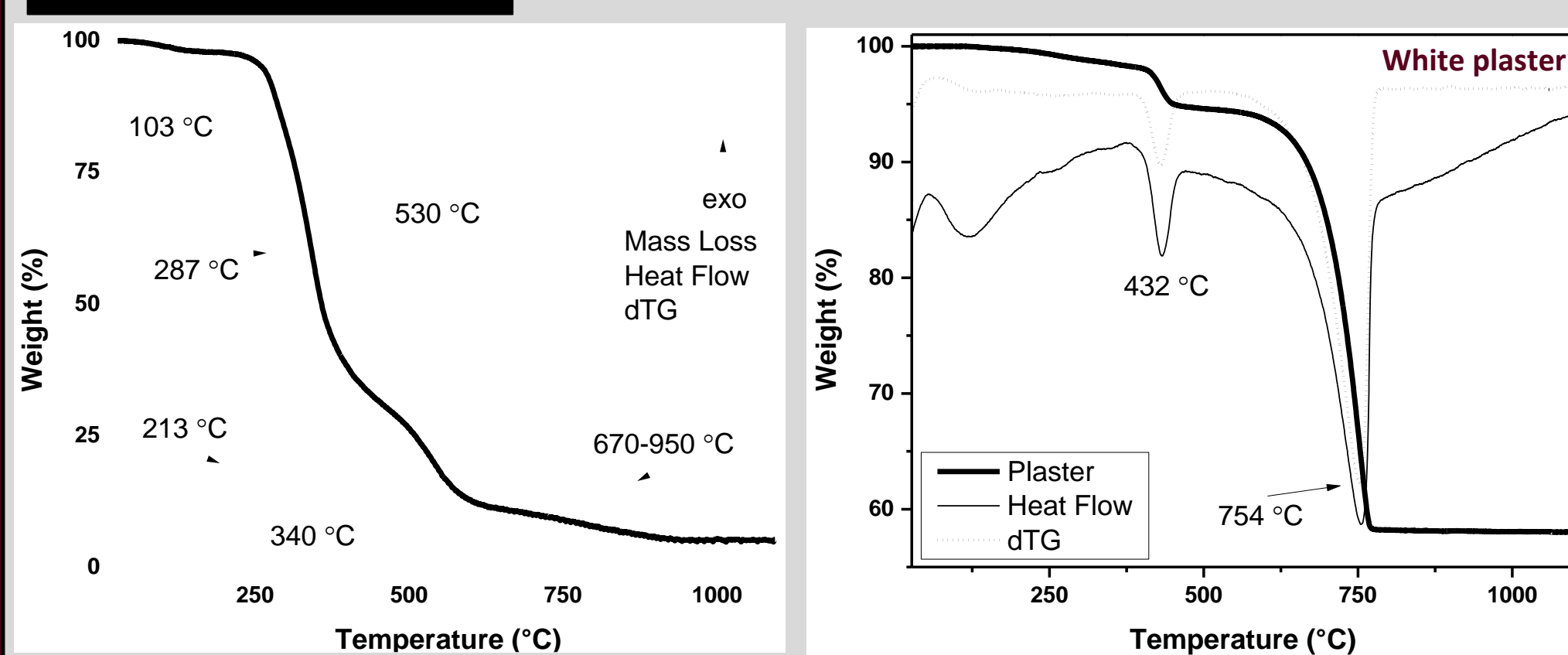
fresco → Application of painting layer after 2 h, *secco* → Application of painting layer after 48 h of plaster preparation

Annealing Protocol. *Step 1.* Heating T_{max}/h, *Step 2.* Stay at T_{max} for 6 h, *Step 3.* Left to cool down in the oven (T_{max}: 100-700 °C)

Characterization Techniques. Micro Fourier transform infrared (μ-FTIR) spectroscopy: i-Series FTIR microscope and Spectrum 1000 FTIR spectroscope (Perkin Elmer). Thermogravimetry (TGA): SETSYS TG-DTA 16/18 (SETARAM). UV-Vis Spectrophotometry: Lambda18 spectroscope (Perkin Elmer). X-ray Diffraction (XRD): Ultima Plus (Rigaku). X-ray Photoelectron spectroscopy (XPS): Kratos Analytical Axis Ultra^{DL} (Shimadzu).

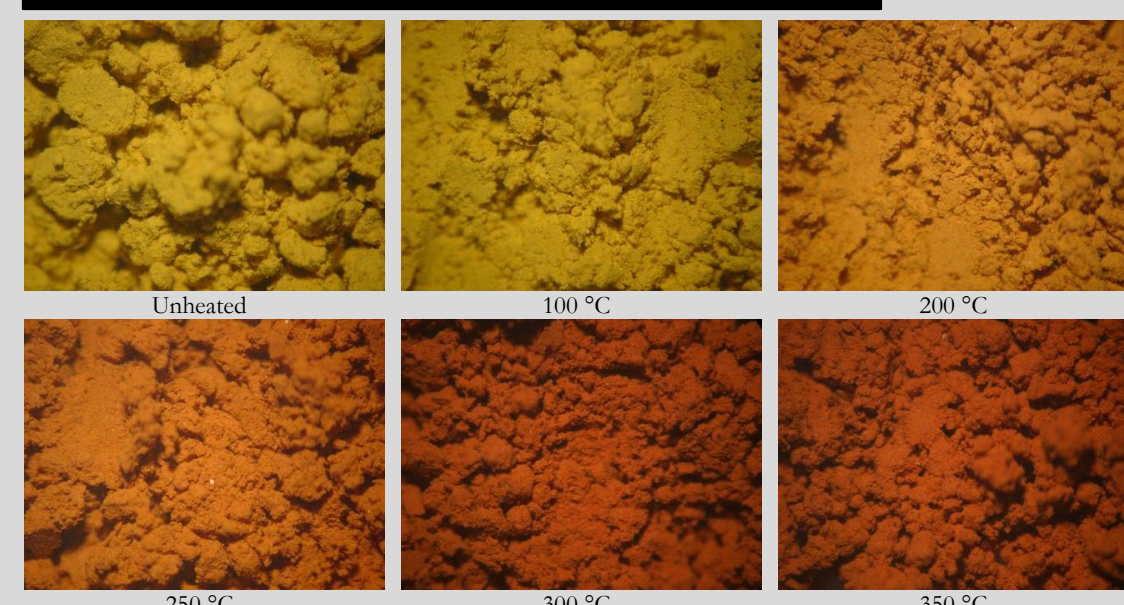


Initial Materials



| Material | Egg yolk | Linseed oil | Gum arabic | Casein |
|-------------|----------|-------------|------------|--------|
| Residue (%) | 5.0 | 0.4 | 0.1 | 6.3 |

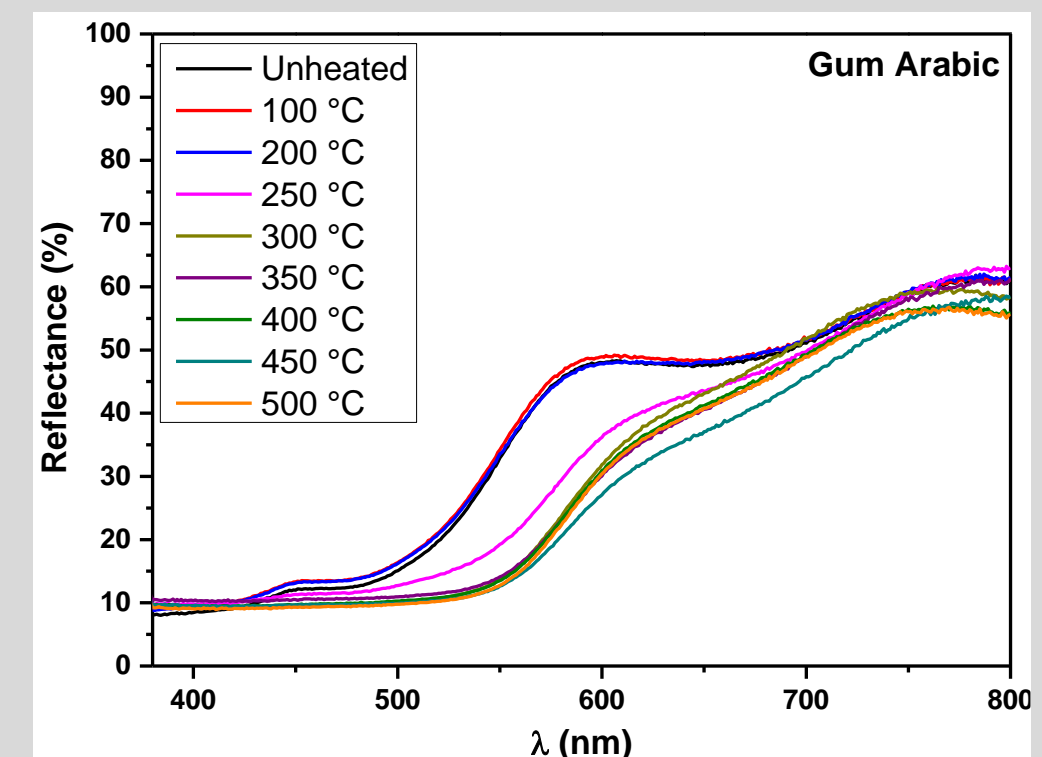
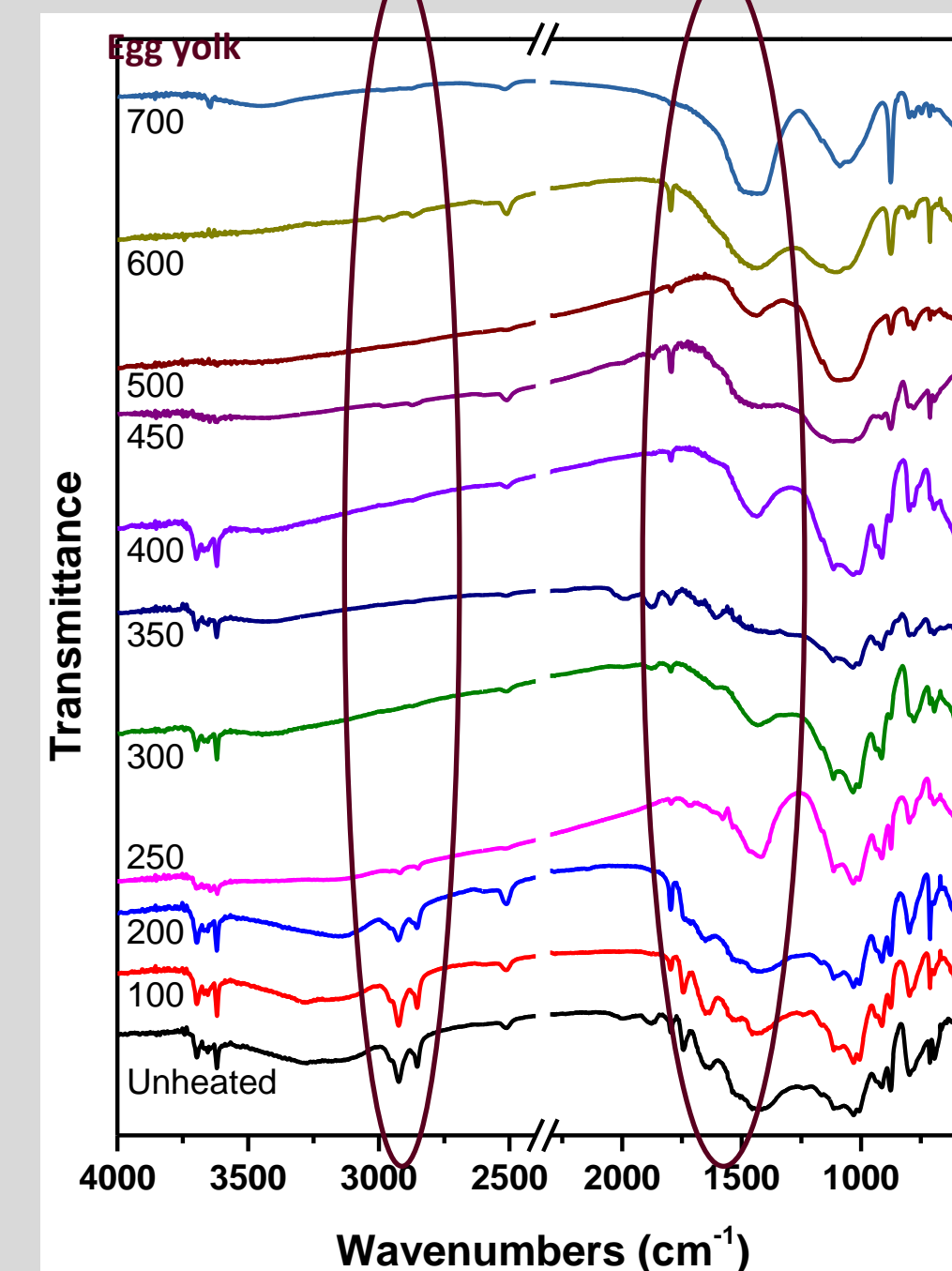
Annealing Protocol



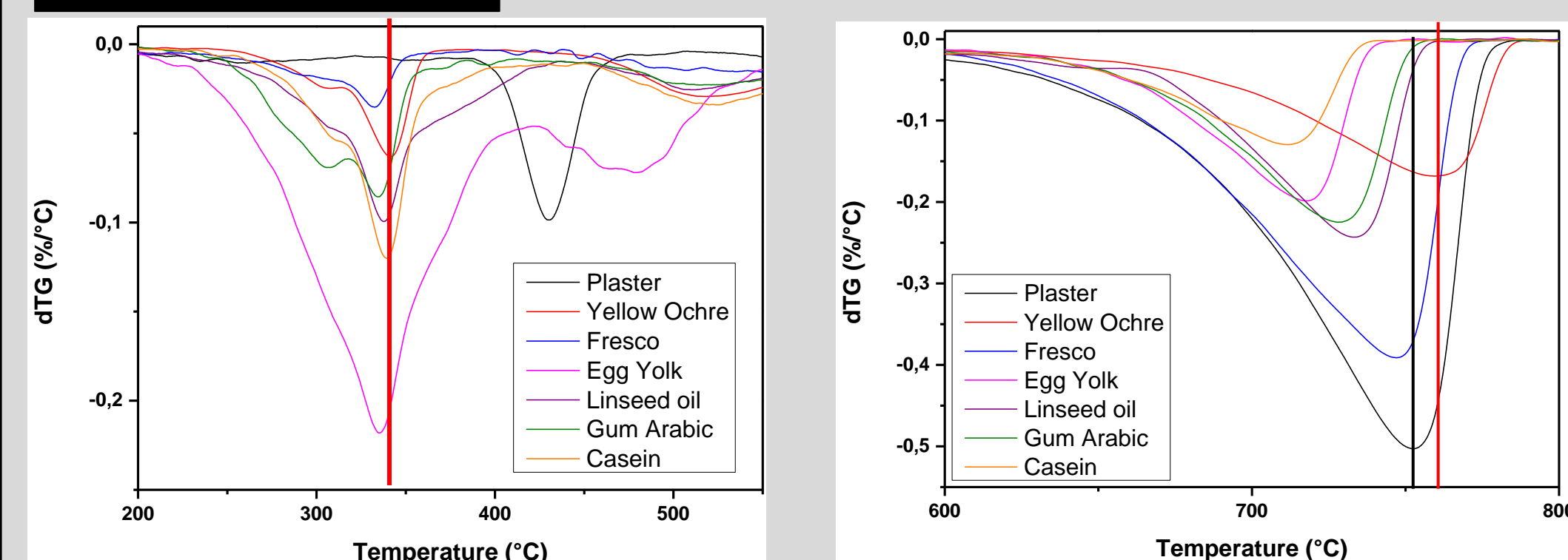
Change of color: 200-250 °C

Crackling 400 °C

Collapse 600 °C



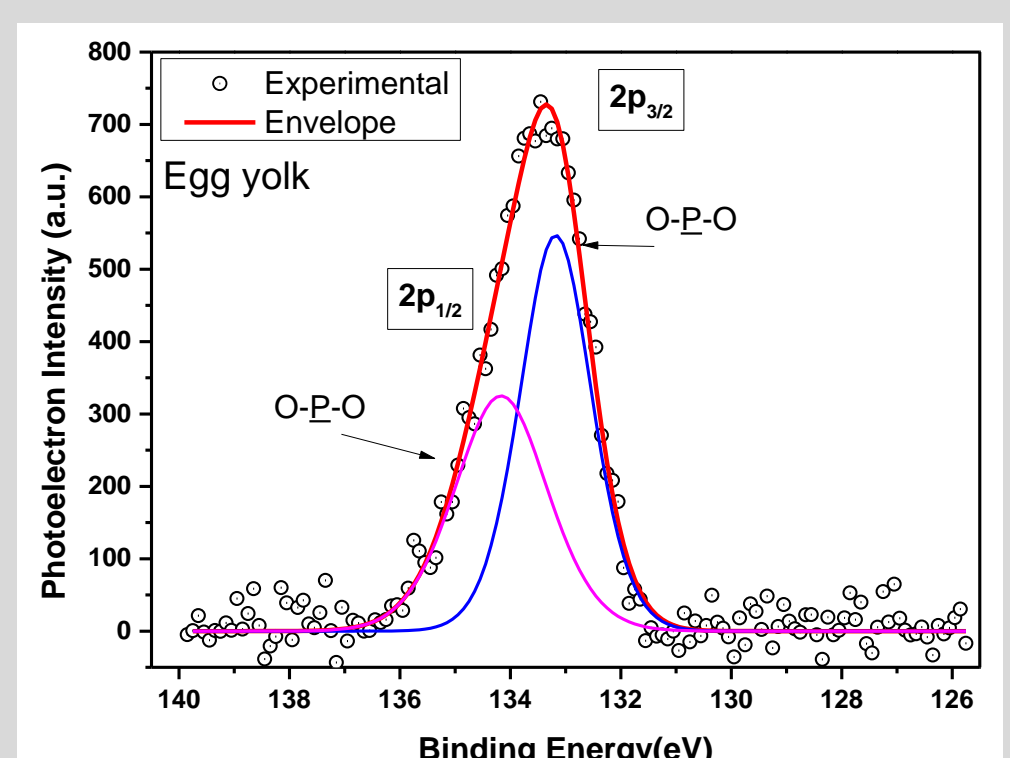
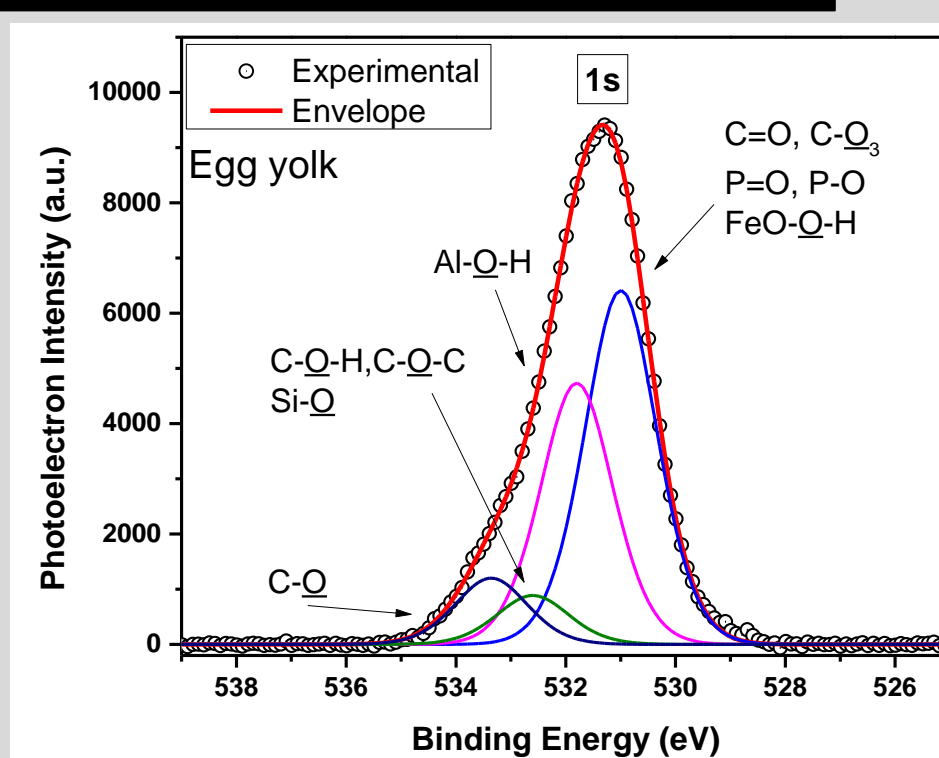
Painting Layers



Ochre (Goethite): 341 °C
Fresco: 332 °C
Egg yolk: 335 °C
Linseed oil: 338 °C
Gum arabic: 335 °C
Casein: 339 °C

Plaster: 754 °C
Ochre: 759 °C
Fresco: 747 °C
Egg yolk: 717 °C
Linseed oil: 734 °C
Gum arabic: 730 °C
Casein: 709 °C

XPS Analysis



Conclusions

- ❖ Plaster degradation: Beginning T_{max} > 400 °C (calcite decomposes above 600 °C)
- ❖ Binder: Alterations for T_{max} > 250 °C
- ❖ Change of color for T_{max} > 200 °C (340 °C)
- ❖ Calcite & FeOOH decomposition: In lower temperatures with organic presence

400 °C: First appearance of cracklings
500 °C: Decomposition of organics (at least)



The surviving wall paintings maintain organic indication

Acknowledgements

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