Séminaire du laboratoire PIMM

Jeudi 3 juin 2021 à 13h30 sur Teams

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présentera dans le cadre du séminaire ses travaux intitulés :

A computational model for chemo-mechanical degradation of historical oil paintings due to metal soap formation

A large percentage of oil paintings in museum collections suffers from chemo-mechanical degradation phenomena due to metal soap formation. Metal soaps result from the chemical reaction between metal ions present in the pigments and saturated fatty acids released by the oil paint. They appear as large protrusions that disfigure the surface texture, possibly triggering mechanical damage and flaking of the painting. Despite that these phenomena have been widely observed in situ, the interaction between chemical and mechanical degradation processes is far from being understood. This work proposes a chemo-mechanical model to predict metal soap formation and the resulting chemo-mechanical damage in historical oil paintings. The chemical process is described by means of a diffusion-reaction model, whereby the spatial growth of the metal soap crystal takes place in a small reaction zone at the boundary of the crystal. Metal soap crystallization and growth, driven by the diffusion of saturated fatty acids and metal ions, result in a chemically-induced volumetric growth strain. This introduces stresses in the paint, ultimately promoting crack nucleation and propagation. The fracture process is simulated with a cohesive zone approach, using interface elements equipped with a traction-separation law. The mass flux-concentration relation at the interfaces is consistently specified as a function of the mechanical damage. A set of numerical simulations illustrates the capability of the model to predict metal soap crystallization and growth and the fracture induced in the paint – Figure 1. The study finally illustrates the influence of various chemical and mechanical parameters (i.e., the size of the metal soap nucleus, the mismatch in elastic stiffness parameters between the metal soap and paint materials, the fracture length scale of the paint material, the chemical growth strain and the reaction rate) on the chemo-mechanical degradation of the paint layer.

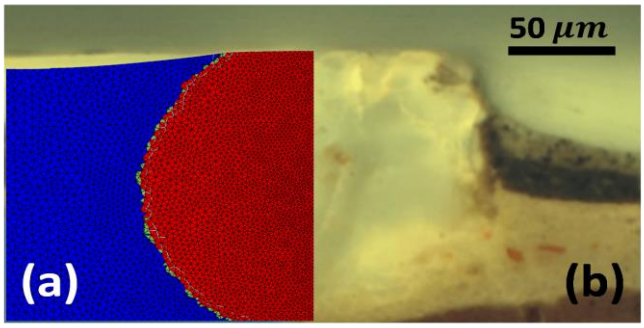

Fig. 1 : (a) Numerical simulation predicting the growth of a metal soap crystal (red colour) and qualitative comparison with (b) metal soap crystal observed in paint cross-section from *Marten Soolmans* (Rembrandt).

References

1. Eumelen G.J.A.M., Bosco E., Suiker A.S.J., Van Loon A., Iedema P.D. (2019). *A computational model for chemo-mechanical degradation of historical oil paintings due to metal soap formation.* Journal of the Mechanics and Physics of Solids 132:103683.
2. Eumelen G.J.A.M., Bosco E., Suiker A.S.J., Hermans J.J., Van Loon A., Keune K., Iedema P.D. (2020). *Computational modelling of metal soap formation in historical oil paintings: the influence of fatty acid concentration and nucleus geometry on the induced chemo-mechanical damage.* SN Applied Sciences 2, 1310.