A multi-physics and multi-scale model to predict historical paper degradation

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Introduction

Paper is a complex multi-scale material mainly consisting of cellulose fibres bonded to each other to form a discrete network. The moisture and temperature induced expansions of individual fibres are transmitted in the network through the inter-fibre bonds, often resulting in undesirable macroscopic deformations (Fig. 1) [1]. At the same time, degradation of paper may occur in a longer time scale due to biological, physical and chemical processes (Fig. 2). This poses a crucial problem in the conservation of paper-based ancient documents.

Figure 1: Cockling of an intaglio print, due to moisture fluctuations. Canadian Conservation Institute (Source: www.canada.ca/en/conservation-institute)

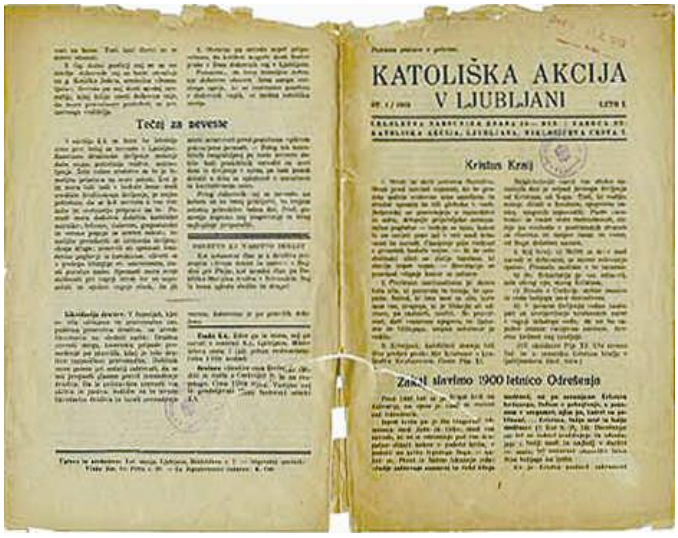

Figure 2: A degraded leaflet from the 1900s. National and University Library, Ljubljana, Slovenia.

In order to increase the lifetime of historical paper, it is important to gain a deep understanding on the mechanisms triggering damage.

For instance, cellulose degradation is a relevant mechanism to be accounted for. [2]. In Figure 3, the chemical structure of cellulose is shown.

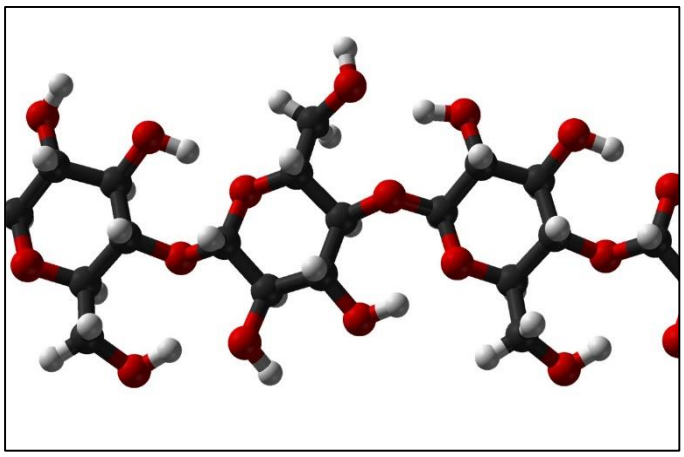

Figure 3: The cellulose macromolecule. (Red: Oxygen; Black: Carbon; White: Hydrogen)

Goals of the project

To predict the long term response of paper-based artefacts a multi-scale and multi-physics approach is required. The aim of this research is to develop a numerical model to predict degradation and aging of historical paper-based documents, in order to formulate physically based practical guidelines to be used by conservators.

References

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