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Paper Engineering Technology applied on the Preservation and Conservation of Cultural Heritage on Paper

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Introduction

The different researching lines in the field of Preservation and Conservation of Cultural Heritage on Paper tend to evolve and join other scientific fields in order to comprehend and embrace all the problematics caused by the aging of paper and its nature. Almost every decision made to stabilize the biochemical deterioration of cellulose is strongly conditioned by factors related to the papermaking process of that specific paper. These factors may include the fiber's origin, the beating, the cooking and bleaching treatments, the technology used in the papermaking, the additives included in the fiber's solution and posterior surface treatments such as the sizing or the coating among others.

The field of Paper Engineering is focused on the development of papermaking technologies through new products and treatments. Those, in addition to the many testing methods used in this field –measurement of paper physical and optical properties, such as tensile strength or brightness ISO-, may be extrapolated to the field of Paper Conservation, adding new criteria and information about how any treatment affects the treated heritage, opening a window for new products and treatments, more bio-compatible with the cellulose nature, allowing to reduce the using of strong chemics and other procedures that are harmful for the environment.

Background

This PhD project aims to adapt some Paper Engineering "green" technologies –such as nanomaterials based on cellulose, natural polymers and enzymes-, to paper Conservation treatments and procedures as a new source of products, with the intentionality of developing and offering new preservation and conservation alternatives, combined with new testing methods, also adapted to the field of Paper Conservation.

Enzymes in Paper Conservation

The possibilities that the use of enzymes may offer in the field of Paper Conservation is due to their specific action on specific substrates. The use of oxidoreductases has already been tested in the removal of some animal and starch based adhesives. These enzymes may be also used to treat the paper discoloration caused by the degradation products of the cellulose or the distinctive stains caused by microorganisms like fungi or mold (Fig. 1), or metal/fungi based *foxing*, which are some of the optical damages that interfere with the legibility of works of Art on Paper, Archives - and Library Materials.

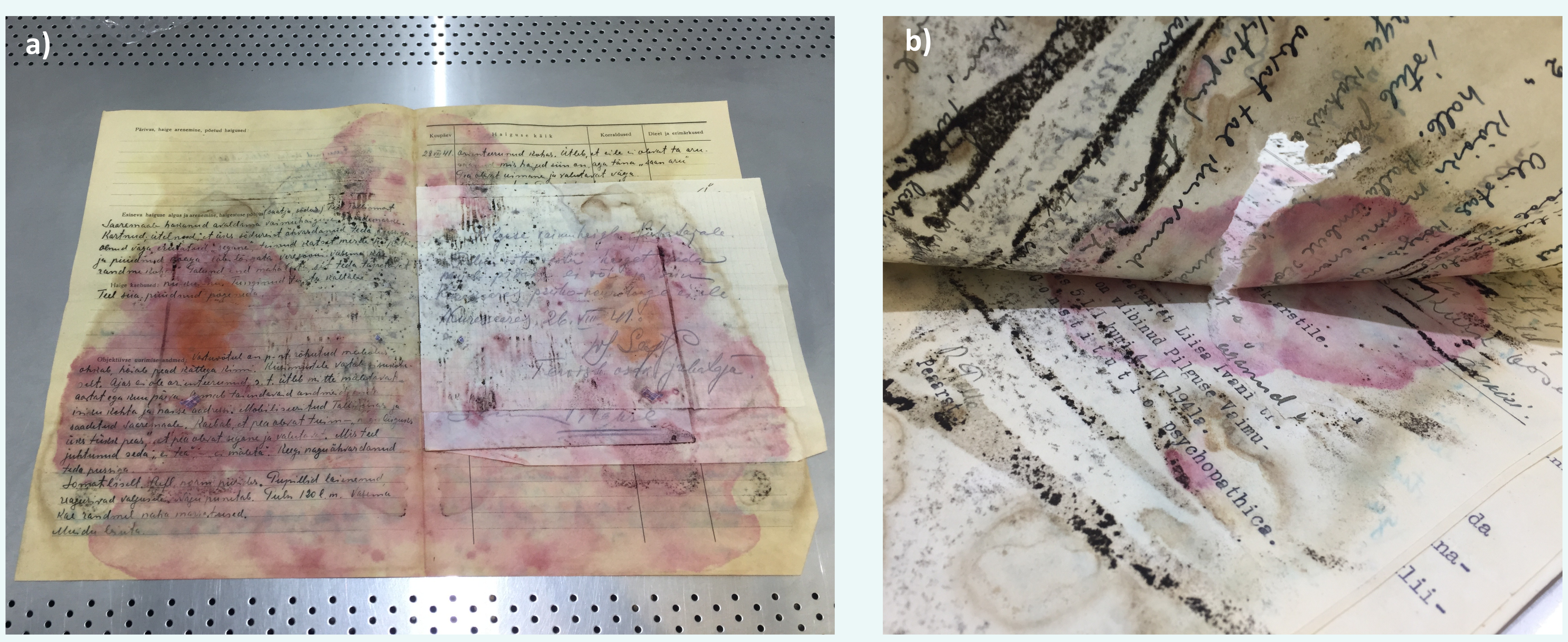

Figure 1. a) Documents with colorful stains and structural damages caused by mold and other microorganisms. b) Detail of some structural damages caused by this microorganisms. Source: Rabanedo-Cerrillo, E; National Archives of Estonia, 2020.

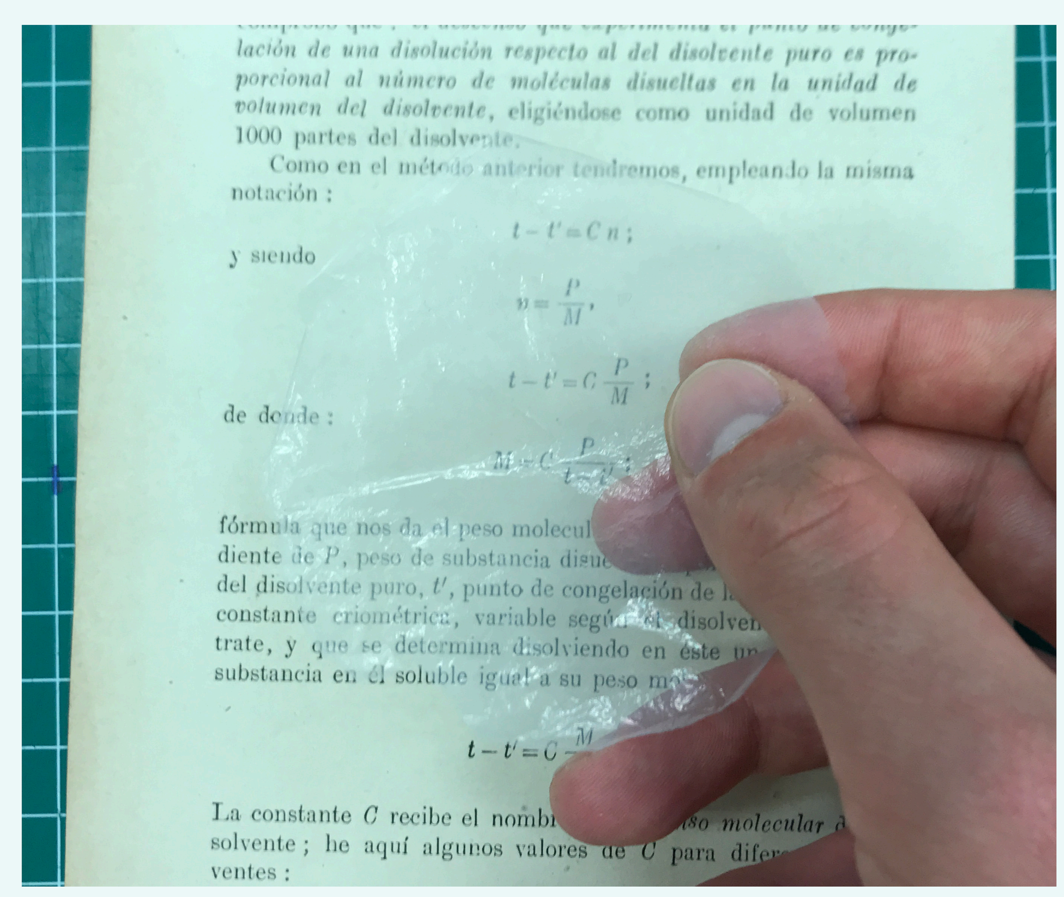

Figure 2. Appearance of a bacterial cellulose film (BC). Source: Rabanedo-Cerrillo, E; UPC, 2023.

Nanocellulose in Paper Conservation

The use of nanofibrillated cellulose (NFC), bacterial cellulose (BC) or crystalline nanocellulose (CNC), has been tested as a reinforcement material in some cases on Paper Conservation (Fig. 2/ Fig. 3). It is a potential substitute for Japanese tissues due its mechanical strength, transparency and biocompatibility to the cellulose.

Nanocellulose has been implemented in resizing treatments as well, increasing structural strength in old and weak papers. The addition of products such as alkaline or silver particles (Ag) into the nanocellulose solutions, or films, has demonstrated to increase the barrier protection of the paper to the attack of microorganisms, and raises the pH up, stopping, or slowing down, biochemical degradation mechanisms such as oxidation or acidification of the treated Heritage on paper.

In progress

- Development of new treatments with enzymes for reducing optical damages in the paper structure such as discoloration caused by the degradation products of the cellulose, mold and fungi stains, and metal-based or fungi based *foxing* degradation.

- Development of new nanocellulose films with more physical properties to make it easier to handle; new nanocellulose solutions for resizing and treating iron-gall ink' damaged documents.

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