

Modelling the degradation of cellulose in permanent paper under archival conditions

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Introduction

The concept of permanent paper was developed in the late 20th century to address the issue of acidic paper degradation in archives and libraries, caused by acid-catalyzed hydrolysis of cellulose [1]. The standard ISO 9706 for paper permanency recommends the use of at least 2 % of alkaline reserve for acids neutralization. If the global kinetics of degradation is efficiently reduced [2][3], the chemical reactions still need to be fully characterized.

Methodology

To address this, papers with various amount of alkaline reserve (0 to 20 %) and acidity levels (pH 6 to 10) were artificially aged at 90 °C under different relative humidity (RH) conditions and partial pressure of oxygen. The degree of polymerization of cellulose, pH, alkaline reserve (AR), and water content were monitored over time.

Results

Based on experimental observations, it was confirmed that the alkaline reserve effectively slows down the kinetics of paper degradation. The alkaline reserve partially reacted with acids, resulting in the degradation of alkaline paper being impacted by oxygen more than acidic paper (figure). Under oxidizing conditions, two mechanisms appear to occur simultaneously: one dependent on the water concentration and the other not. To account for these observations, a kinetic model will be developed that considers all of these factors.

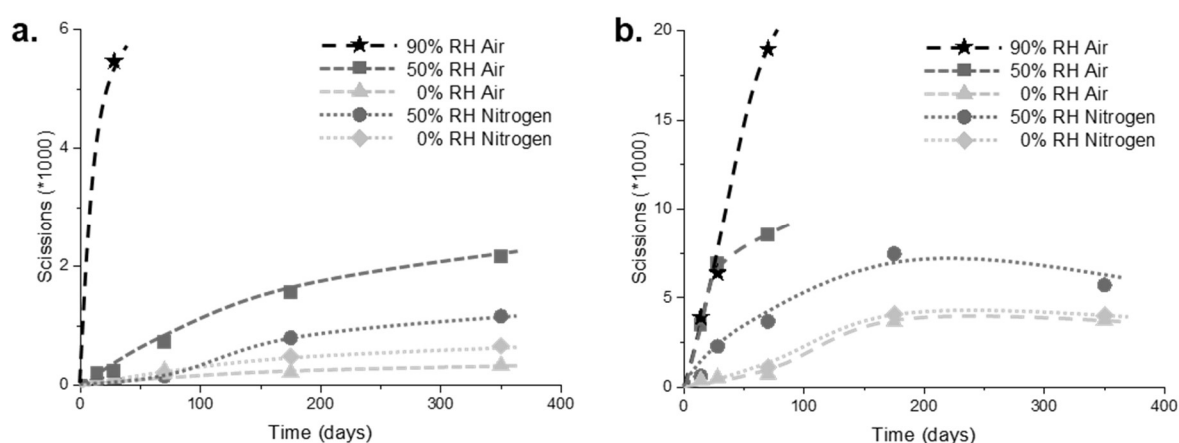


Figure. Chemical degradation of cellulose (glycosidic scissions) under different ageing conditions for a paper with 3 % AR, pH 9 (a) and with 0 % AR, pH 6 (b).

[1] Tétreault J et al., Cellulose, 2019 :26, 3.

[2] Ahn K, Rosenau T, Potthast A, Cellulose, 2013 :20, 4.

[3] Vibert C et al., Carbohydr. Polym., 2023 :310, 4.