

Structure-properties relationship in artificially aged paper

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Paper has been used in Europe since the 12th century and is still a key material, as proven by the ever-growing production of printing paper. Its affordable cost, natural origin and recyclability take part in this success. At the digitization era, the durability of paper is also of major importance. Permanent paper produced according to ISO 9706 standard should last a few centuries and be a good complement to digital storage for long-time archiving of documents. Determining its usable lifetime is essential for such applications, yet this is conditioned by its mechanical strength. [1]

Paper is a multi-scale structured material mainly made of plant fibres, such as wood or cotton, that are essentially composed of semi-crystalline cellulose. The ageing of paper induces the degradation of fibres through cellulose chemical scissions and chemical modifications that can lead to lack of interfiber bonding. [1] This work aims at understanding how chemical degradation leads to mechanical damage by investigating the link between microscopic structure and macroscopic behaviour of paper.

The present study combines experimental testing with image analysing and numerical modelling. We obtained different stages of degradation by artificially ageing a permanent paper at 90° C and 50% relative humidity in air during 2 to 25 weeks. Mechanical measurements such as tensile and zero-span tensile strength were carried out according to TAPPI standards. The fracture surface was observed under scanning electron microscope and the bulk material was analysed before and after the mechanical tests by X-ray microtomography. [2] The images are used to determine characteristics of the fibrous network such as fibre length and bounding. These values feed a digital model of the paper, whose parameters are adjusted to match mechanical data.

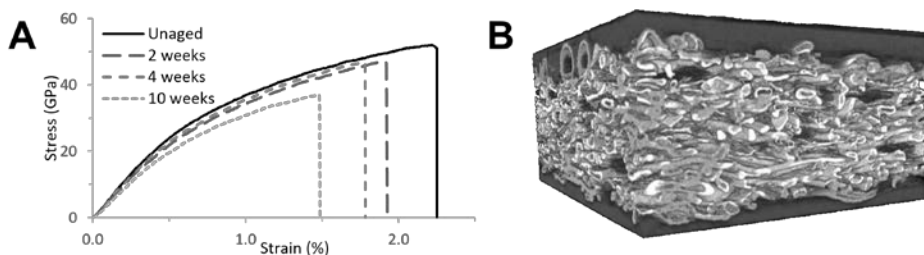


Fig. 1: Stress-strain curves of paper at different stages (A), and tomography of the paper (B)

References

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