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Evaporation of bound and free water from drying cellulose fiber poultices

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One of the innovative application of cellulose fibers is the desalination of masonry structures in the field of architectural heritage conservation [1]. Wet poultices, classically composed of cellulose fibers and clays, are coated on the porous material to be treated, and kept in place before being removed when dry. The efficiency of the process partly depends on the drying behavior of the poultice, but so far little is known concerning cellulose drying. Understanding drying properties of cellulose fibers poultices present a real challenge since, due to the complex porous properties of the medium, it may contain several types of water liable to evaporate successively or simultaneously [2], and it may deform significantly.

We followed the drying of cellulose poultices with Nuclear Magnetic Resonance (NMR). Different NMR sequences were used which provided the evolution of key internal characteristics in time: 1) the water saturation distribution; 2) respective bound and free water content (through different NMR relaxation times); 3) the sample shape. From this information we identified the different regimes of drying of cellulose poultices in relation with their microstructure evolution.

In a first period, the sample remains saturated and bulk water evaporates at a constant rate. This induces an axial shrinkage of the sample. A second period starts once the maximum possible shrinkage is reached. Now air starts to penetrate the sample. However, the water saturation decreases almost homogeneously throughout the sample. The drying rate remains constant during this period too, as in a model porous medium [3]. Finally, at the end these two periods, 90% of water (almost all the free water) initially in the poultice has been evaporated. Then a falling drying rate period starts, associated to the development of a dry front inside the sample (from the free surface), and the evaporation of bound water (adsorbed) in cellulose fibers. This period leads to a further shrinkage of the structure due to fibers shrinkage. We conclude that, due to their specific fibrous structure the drying of cellulose poultices is particularly efficient, as almost 100% of the free water initially in the sample may be evaporated at a constant rate.

References

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