Seeing inside porous building materials: NMR study of moisture transport during drying

Teresa Diaz GONÇALVES[1*], Vânia BRITO[1] and Leo PEL[2]

[1] National Laboratory for Civil Engineering (LNEC), Av. do Brasil 101, Lisboa – Portugal
[2] Department of Applied Physics, Eindhoven University of Technology (TU/e), POBox 513, 5600 MB Eindhoven – The Netherlands

* teresag@lnec.pt

Abstract: Nuclear Magnetic Resonance (NMR) provides non-destructive imaging techniques for quantitative mapping of certain chemical elements in materials. Its immense possibilities justified already the attribution of five Nobel Prizes in the last 50 years.
NMR has been used in medicine since the 1980s. More recently, it proved to be also suitable to study porous building materials like stone, mortars and ceramics. In this case, however, the measurement of NMR signal is not straightforward because in general building materials contain magnetic impurities such as ferromagnetic ions. Specific experimental procedures are therefore needed, and specially adapted NMR machines have to be used.
Here, we show the possibilities of proton NMR to monitor the evolution of the moisture content across porous building materials during drying of specimens saturated with pure water or salt solutions. This type of application has great interest for the architectural heritage where most decay processes are related to the presence of water, and where one of the most damaging of such processes derives from the crystallization of soluble salts. NMR may help understanding the mechanisms behind those processes, and assessing the efficacy and durability of materials and treatments.
The experiments we describe use two different experimental set-ups, allowing one-dimensional (1D) and two-dimensional (2D) measurements, respectively. The 1D technique provides profiles expressing the concentration of the H^+ ion over the length of the specimen, each corresponding to a different moment. The several profiles give the evolution of the moisture content across the specimen, giving a direct insight into the transport. In the 2D technique, the results are given as a sequence of 2D images where the concentration of the H^+ ion is expressed by a colour scale. The several images can afterwards be used to produce time-lapse animations which provide a very clear understanding of the drying process.

Keywords: Nuclear magnetic resonance; porous building materials; drying; moisture

Acknowledgements: This work was performed under the research project DRYMASS (ref. PTDC/ECM/100553/2008) which is supported by national funds through the Fundação para a Ciência e a Tecnologia (FCT) and LNEC. The experiments were performed at the Department of Applied Physics of TU/e.