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Translational diffusion at the surface of porous media with magnetic impurities via Fast Field Cycling NMR relaxometry

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Many natural or manufactured porous media intrinsically contain paramagnetic impurities inside their solid matrix which generate internal gradients when introduced in a magnetic field [1]. These internal gradients may lead to significant errors in the measurements of the diffusion coefficient if the classical pulse field gradient techniques are used [2]. The implementation of compensating pulse sequences based on bipolar gradients is also less effective due to the short relaxation times experienced in such samples [2]. In the present contribution exactly the shortening of the longitudinal relaxation time of protons due to their interaction with the paramagnetic centers (Fe^{3+}) located on the surface is exploited to extract information about the translational displacement of molecules on the surface. The porous samples under investigation are both porous ceramics containing increased amount of magnetic impurities and gray cement under different hydration conditions. The diffusion coefficient of water (polar) and cyclohexane (nonpolar) molecules at the interface is extracted using the Fast Field Cycling NMR relaxometry [3]. The technique relies on comparison of the experimental relaxation dispersion curves with a two phase exchange model taking into account the protons relaxation by the interaction with paramagnetic centers located on the surface of porous media [3, 4]. It is observed a stronger reduction of the diffusion coefficient by the interaction with the surface in the case of water (polar) molecules as compared with cyclohexane (nonpolar) ones. The porous ceramics under study were fabricated with a controlled amount of magnetic impurities using the conventional method of preparation from powders which are first dry pressed and then subject to thermal treatment [4]. Six samples (S0-S10) with increasing concentration of Fe_2O_3 were prepared by adding 0, 2, 4, 6, 8 or 10g of Fe_2O_3 to 100g of mixed powder. To extract the pore size distribution of the produced samples they were examined by scanning electron microscopy, the DDIF (Decay due to Diffusion in the Internal Fields) technique [1] and a new proposed technique [5] which relies on the attenuation of the echo train in the well-known CPMG technique due to diffusion in internal gradients. The magnetic characterization of the produced samples was done using a vibrating sample magnetometer indicating a linear dependence of the susceptibility constant with the Fe_2O_3 content. The cement samples under study were prepared using gray cement CEM I 52.5 R and different water to cement ratios. The diffusion coefficient on the surface of cement grains was evaluated at different hydration temperatures (5, 15, 25 and 35 °C) revealing a constant value in the investigated temperature range.

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