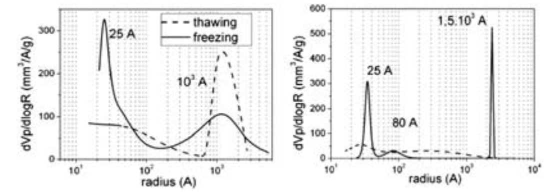

Fig. 2 Capacitive method: freezing and thawing of cement paste at 1 (left) and 7 (right) days.

Results obtained by both techniques show a good correlation (three maxima are observed) and thus provide a study of cement microstructure evolution.

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NMR measurement of gas-phase dynamics in a gas-fluidized particle bed using laser-polarized xenon NMR

R. W. Mair[a], M. S. Rosen[a], M. J. Barlow[b], D. Candela[c], R. L. Walsworth[a,d]
[a]Harvard-Smithsonian Center for Astrophysics, USA, [b]Sir Peter Mansfield Magnetic Resonance Center, University of Nottingham, UK, [c]Department of Physics, University of Massachusetts Amherst, USA, [d]Department of Physics, Harvard University, USA

Gas fluidization is a process in which solid particles experience fluid-like suspension in vertical gas flows [1]. Efficient mixing is easily achieved among fluidized solid particles, in which concentration and temperature gradients can be quickly eliminated [2]. Fluidization has been widely applied in food processing, pharmacy and other chemical engineering fields. However, an understanding of the combined dynamics of the particles and gas is far from complete.

We are using NMR techniques and laser-polarized ^{129}Xe as the fluidizing gas to experimentally probe gas dynamics in a fluidized bed. Previous NMR measurements studied the solid particles, which give strong conventional NMR signals, but convey no direct information about the gas flow [3,4]. Our experimental scheme allows direct measurement of xenon gas in both bubbles and the interstitial phase (emulsion) around particles, as well as adsorbed on the particle surface [5]. Previous studies have yielded a complete characterization of the particle bed consisting of ~75-μm Al_2O_3 particles as a function of xenon gas flow rate [6]. The three xenon components are visible as chemical-shift resolved peaks, and the variation of the fractional volume of the three components as a function of flow rate is shown in Fig. 1.

In this new study, we have made initial measurements of gas velocity in the fluidized bed column, using NMR **q**-space imaging techniques. Velocity-encoding NMR spectroscopy sequences have been used to probe gas dynamics in beds made from either ~75-μm Al_2O_3 particles or ~250-μm polyethylene particles. The transition from a static porous medium to a fluidized system has been studied, allowing a direct, noninvasive measure of the minimum fluidization velocity, u_{mf}, a parameter crucial in many models of bubble behavior in fluidized beds [1,2]. More chaotic and random motion is observed once bubbles begin to form.

Current studies are employing velocity-encoded MRI methods to track the physical location of bubble formation and transport along the length of the column. Successful implementation will allow for spatially resolved measures of bubble-throughflow and emulsion-phase velocity as a function of flow rate — parameters of great interest in the engineering community which are difficult to measure by any other method.

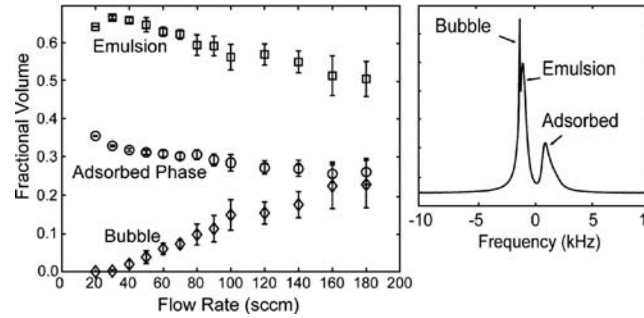

Fig. 1 Fractional volumes of ^{129}Xe within the bubble, emulsion and adsorbed phases of the Al_2O_3 particle bed as a function of flow rate. Each point is the average of 32 separate single-shot spectra acquired over a 5-min period. An example ^{129}Xe gas spectrum acquired from the Al_2O_3 bed at a flow rate of 50 standard cm3/min is shown in the inset.

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A small, low-cost embedded NMR sensor suitable for bulk measurement of porous materials

A.E. Marble[a,b], J.J. Young[a,c], I.V. Mastikhin[a], B.G. Colpitts[b], B.J. Balcom[b]
[a]MRI Centre Dept. of Physics, University of New Brunswick, PO Box 4400, Fredericton, NB, Canada E3B 5A3, [b]Dept. of Electrical and Computer Engineering, University of New Brunswick, PO Box 4400, Fredericton, NB, Canada E3B 5A3, [c]Dept. of Civil Engineering, University of New Brunswick, PO Box 4400, Fredericton, NB, Canada E3B 5A3

Despite growing interest in magnetic resonance of porous materials such as soils and concrete, critical limitations exist in terms of the types of measurements that can be made. Both spectroscopic and spatially resolved studies requiring superconducting magnets can only be carried out on samples of limited size. New advances in open, portable NMR instrumentation allow bulk relaxation and diffusion measurements to be made on arbitrarily large samples [1]. However, experiments of this type are limited by the penetration depth of B_0 and B_1. This constraint has permitted higher field (10–20 MHz) near surface studies [2], along with lower field measurements at a greater, but still limited, depth.

In many situations, it may be desirable to measure NMR parameters from deep within a sample. Examples in the porous media regime could include larger concrete structures and soil formations. Previous work has used RF coils embedded within concrete samples in order to alleviate the B_1 penetration problem [2]. Extending this idea, a small, low-cost NMR sensor suitable to be embedded within a large sample has been developed. NdFeB disk magnets provide a local B_0 field for a ^{1}H resonant frequency of between 6 and 10 MHz depending on the design. A printed circuit board surface coil is located immediately above one face of the magnets and tuned to resonance with capacitors on the opposite face. The entire arrangement is connected to a 2.5-mm-diameter coaxial cable and encased in epoxy. The inhomogeneous B_0 and B_1