Stories from the interior of porous materials – recorded by NMR

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Accounting for the influence of molecular motion in NMR experiments is nearly as old as the discovery of NMR itself [1]. However, with the introduction of pulsed magnetic field gradients [2] NMR became a highly versatile tool for studying diffusion and flow in many areas such as physics, chemistry, material science, medical research and clinical routine.

We demonstrated recently how the concept of Skejskal and Tanner [2] keeps transforming and continues to offer new options in the context of porous media research. We reported on the use of second order magnetic fields which allow for the parallel acquisition of q-space [3], thus enabling real time monitoring of averaged propagators [4] and single-shot surface-to-volume ratio measurements in porous materials [5]. Furthermore, we implemented recently new imaging approaches for porous media which consist of disconnected pores. While this method is still based on the work horse of NMR diffusometry as introduced 50 years ago [2] deliberate extension of one gradient pulse [6] allows for Magnetic Resonance Pore Imaging (MRPI) at resolutions well beyond the limits of conventional MRI [7] even for arbitrary pore shapes [8].

Involving more than one pair of pulsed magnetic field gradients allows for the extraction of fractional anisotropy [9] based on Diffusive Diffusion Correlation SpectroscopY (DDCOSY) [10] or the study of higher order terms [11] as occurring in the expression for the short time behaviour of diffusion coefficients in porous media [12]. Using internal field inhomogeneities instead of external pulsed gradients may allow for the determination of pore length scales and surface relaxivities at low magnetic fields using 1D and 2D approaches [13].

This contribution aims to give a brief overview on the recent methods mentioned above, show their relevance for diffusion in porous materials and how this translates into tools for the structural characterisation of porous systems.

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