Repeated application of diffusion gradient pulse pairs [1] in a pulsed field gradient (PFG) experiment provides important insights into pore microstructure. For example, the dimensions and eccentricity of yeast cells were measured from the fourth order term of the double-PFG signal attenuation when the mixing time between the two encoding blocks is long [2]. In this abstract, we propose an alternative double-PFG technique to address the same problem, which exploits the diffusion-diffraction phenomenon [3] in double-PFG experiments [4]. In our approach, all diffusion gradients in a single acquisition are applied along the same direction with a mixing time of 0. The experiment is subsequently repeated with diffusion gradients applied along different directions.

As demonstrated in [4], the expected signal for this pulse sequence is given by \( \tilde{\rho}(q)^2 \tilde{\rho}(2q)^* \), where \( \tilde{\rho}(q) \) is the Fourier transform of the pore shape function. This expression for the NMR signal attenuation leads to two interesting observations: (i) the first signal minimum occurs at exactly half the q-value necessary to observe nonmonotonicity in a single-PFG experiment; (ii) the diffraction minima are replaced by zero-crossings making the diffraction pattern robust to the heterogeneity of the specimen. We calculated the NMR signal attenuation from ellipsoidal pores with different eccentricities using the expressions in [5].

The proposed method makes it possible to observe diffusion-diffraction phenomenon in anisotropic pores even when the pore orientations are randomly distributed. The first zero-crossings of the diffraction patterns with gradients applied along different directions can be used to quantify the compartment size as well as the pore shape anisotropy using double-PFG acquisitions with 0 mixing times, hence mitigating the effect of relaxation-related signal loss.

References:

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