diffusion-fundamentals.org

The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Unconsolidated material characteristics obtained by PFGNMR using (two) different probe molecules

Bård A. Bendiksen, Espen H. Blokkdal*, Eddy W. Hansen

Department of Chemistry/University of Oslo, Oslo, Norway
*baardabe@student.matnat.uio

The characteristics (surface-to-volume ratio, pore radius, diffusion, surface relaxation strength, tortuosity) of a porous system composed of a fluid confined in unconsolidated glass beads were obtained by Pulsed Gradient Stimulated Echo (PGSTE) NMR using two different probe molecules, benzene and water, respectively. The measurements were carried out on a low field NMR instrument operating at 20 MHz proton frequency. Using a 13-interval pulse sequence, the effective diffusion coefficient D of a fluid (water and benzene, respectively) confined in a porous material (unconsolidated glass beads) was measured as a function of the square-root of diffusion time t_D (Fig. 1). The limiting diffusion coefficient D_0 and the surface-to-volume S/V-ratio were determined from Eq. 1 [1] where D_0 equals the bulk diffusion. The ratio between D_0 and the limiting diffusion D_∞ at long diffusion time is termed the tortuosity factor $\Gamma(= D_0/D_\infty)$ and is an important matrix parameter

$$D(t_D) = -\frac{4}{9\sqrt{\pi}} D_0^{3/2} \frac{S}{V} \sqrt{t_D} + D_0 \tag{1}$$

Also, the interaction strength ρ between a pore confined fluid and the matrix surface is of interest

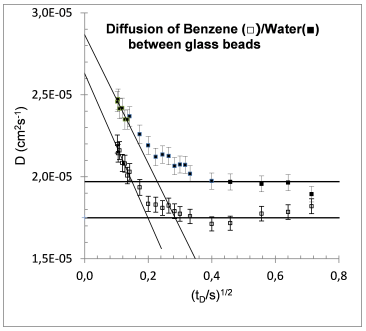

Figure 1: The diffusion coefficient of water/benzene between glass beads Vs the square root of diffusion time.

and is estimated from Eq. 2. $1/T_1$ and $1/T_{1b}$ are the observed relaxation rates of pore confined- and bulk fluids, respectively. A summary of the model fit (Eqs. 1 and 2) analysis is presented in Table 1 and

$$\frac{1}{T_1} = \frac{1}{T_{1b}} + \rho \frac{S}{V} \tag{2}$$

suggests that – within experimental error – the porous matrix characteristics (S/V and Γ) are the same, irrespective of the two fluids, and seems reasonable.

References

[1] P.P. Mitra, P.N. Sen, L.M. Schwartz: *Short-time behaviour of the diffusion coefficient as a geometrical probe of porous media*. Physical Review B **47**, 8565–8574 (1993)

[2] S.D. Senturia, J.D. Robinson: *Nuclear spin-lattice relaxation of liquids confined in porous solids*. SPE **10**, 237–244 (1970)

Parameter/Fluid	Benzene	Water
S/V (cm^{-1})	$1.3 \cdot 10^3$	$1.1 \cdot 10^3$
$\Gamma(= D_0/D_\infty)$	$(=2.63 \cdot 10^{-5}/1.75 \cdot 10^{-5})=1.5$	$(=2.87 \cdot 10^{-5}/1.96 \cdot 10^{-5})=1.5$
$\rho(cms^{-1})$	4.9	5.4
R(μm)	23	29

Table 1: Porous matrix (glass beads) and confined fluid (benzene and water) characteristics.