

## Self-diffusion in a macroscopically aligned lyotropic hexagonal phase templated hydrogel

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Lyotropic liquid crystal (LLC) materials (e.g., LLC templated hydrogels [1]) have potential for a wide range of applications such as drug-delivery [2]. Typically the LLC phases (e.g., lamellar and hexagonal) exist as a powder distribution of director orientations, but macroscopically aligned phases can be prepared using external fields (e.g., magnetic fields) [3]. The majority of the applications of these materials are dependent on transport processes and as such characterizing this is pertinent. Self-diffusion (i.e., random translational motion) is the most fundamental form of molecular transport and provides important information regarding the size of a molecule in solution and the environment that the diffusion is occurring in (e.g., as for restricted diffusion) [4–6]. The self-diffusion in macroscopically aligned LLC phases (e.g., lamellar and hexagonal) is anisotropic due to the nanostructures present [6].

The macroscopically aligned lyotropic hexagonal phase of the non-ionic surfactant decaethylene glycol monododecyl ether ( $C_{12}EO_{10}$ ) was used to template a polyethylene glycol diacrylate (PEG-DA) hydrogel and the self-diffusion of water was found to be independent of the diffusion time (up to 3 s) [7]. Initial diffusion tensor imaging results performed  $\sim 456$  days after the sample was prepared indicated that the diffusion anisotropy was retained with storage at  $\sim 22$  °C (Figure 1).

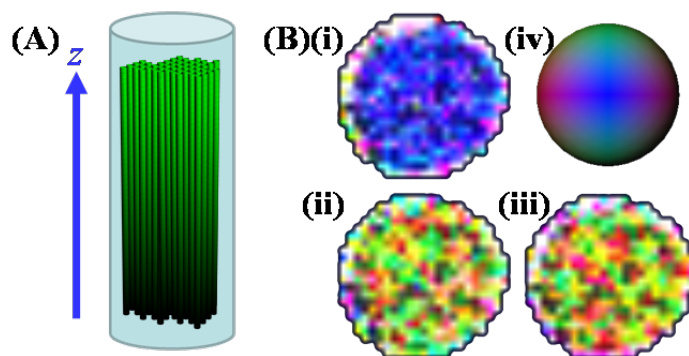


Figure 1: Diffusion tensor imaging results for the self-diffusion of water in a templated hydrogel after storage. (A) Schematic of the alignment in the hydrogel in a 5 mm Wilmad NMR tube. (B) Diffusion tensor images for an axial slice (voxel size:  $0.196\text{ mm} \times 0.196\text{ mm} \times 0.5\text{ mm}$  (slice thickness), diffusion time: 70 ms). (B)(i), (ii) and (iii) show images for the first, second and third eigenvectors, and (iv) a directional representation.

### References

- [1] J.D. Clapper, C.A. Guymon: *Physical behavior of cross-linked PEG hydrogels photopolymerized within nanostructured lyotropic liquid crystalline templates*. *Macromolecules* **40**, 1101–1107 (2007)
- [2] D. Gin, C. Pecinovsky, J. Bara, R. Kerr: *Functional lyotropic liquid crystal materials*. *Struct. Bond.* **128**, 181–222 (2008)
- [3] G.J.T. Tiddy: *Surfactant-water liquid crystal phases*. *Phys. Rep.* **57**, 1–46 (1980)
- [4] W.S. Price: *NMR studies of translational motion*. Cambridge University Press, New York (2009)

- [5] J. Kärger, C. Papadakis, F. Stallmach: *Structure–mobility relations of molecular diffusion in interface systems*. In: *Molecules in interaction with surfaces and interfaces*, Springer Berlin, Heidelberg, 127–162 (2004)
- [6] P.T. Callaghan: *Pulsed field gradient nuclear magnetic resonance as a probe of liquid state molecular organization*. *Aust. J. Phys.* **37**, 359–387 (1984)
- [7] S.A. Willis, G.R. Dennis, G. Zheng, W.S. Price: *Preparation and physical properties of a macroscopically aligned lyotropic hexagonal phase templated hydrogel*. *React. Funct. Polym.* (2013), In Press (Accepted 21/02/2013)