4cj Composite Nanostructures: Protein and Nanoparticle Arrays Templated in Block-Copolymer Mesophases

Danilo C. Pozzo and Lynn M. Walker

The design of materials with tailored properties and function requires control over their structure in the nanometer scale. Engineering applications in biotechnology and nanotechnology also require that this is carried out using self-assembly processes that occur in large numbers (~10^{20} particles/L) and short timescales (ns – μs). In this work, we developed a novel approach through which an ordered template is used to control the structure of materials that would not otherwise self-assemble in solution (nanoparticles). We use close-packed cubic and cylindrical mesophases of a thermoreversible block copolymer (PEO-PPO-PEO) to impart order on dispersed nanoparticles and globular proteins.[1] The thermoreversible nature of the template (reverse gelation) allows for the dispersion of particles synthesized outside the template. This feature extends the applicability of this templating method to many particle-polymer systems and also permits a systematic evaluation of the impact of design parameters on the structure and mechanical properties of the nanocomposites. The influence of relative size (particle to template sites), relative concentration, temperature and shear are experimentally determined using small angle neutron scattering (SANS) and rheology.[2,3] SANS with contrast variation is used to independently characterize the structure of the polymer mesophase and the templated particles in a nanocomposite. SANS experiments also demonstrate that shear can be used to align the nanocomposites into single-crystal macro-domains; this is the first demonstration of the formation of single-crystalline nanoparticle superlattices. The outcome of this work serves as a basis for designing new nanocomposite materials.

[1]Pozzo, D. C.; Walker, L. M. Macromolecular Symposia 2005, (in press).

[2]Pozzo, D. C.; Walker, L. M. Langmuir (submited).

[3]Pozzo, D. C.; Hollabaugh, K. R.; Walker, L. M. J Rheol 2005, 49, 759.