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Entanglement-Controlled Subdiffusion of Nanoparticles within Concentrated Polymer Solutions R.L. LEHENY, JHU, H. GUO, UCSD, G. BOURRET, R.B. LENNOX, M. SUTTON, McGill U., J.L. HARDEN, U. Ottawa — Microrheology techniques, in which colloids suspended in a complex fluid probe their mechanical environment, can provide unique information on the microscopic length scales characterizing the fluid's hierarchical structure. We describe x-ray photon correlation spectroscopy (XPCS) experiments tracking the motion of colloidal gold nanoparticles in solutions of high-molecular-weight polystyrene. The particle radius is tuned to be comparable to the length scales characterizing the entangled polymer mesh. Over displacements of nanometers to tens of nanometers, the particles undergo subdiffusive motion in which the particle mean-squared displacement grows as a power law in time, with power-law exponent, $\alpha < 1$, that depends on solution conditions. Scaling behavior of the nanoparticle mobility with respect to temperature and to polymer concentration and molecular weight indicates the subdiffusion results from the temporal evolution of the entanglement mesh in the immediate vicinity of the particles. The results thus provide a novel microscopic dynamical characterization of a key structural property of polymers and more broadly demonstrate the capability of XPCS-based microrheology to interrogate heterogeneous mechanical environments in nanostructured soft materials.

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