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Dynamics of nanoparticles in models of soft and hard porous media

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The transport properties of nanoparticles in complex porous media impact the processing of polymer and hydrogel nanocomposites. In the limit of strong confinement, in which the size of nanoparticles is comparable to typical length scales within the complex confining medium, the local mechanisms that influence nanoparticle transport remain poorly understood. I will describe experiments in which we use optical microscopy to probe the diffusive and transport properties of particles of size 200-400 nm in models of hard and soft porous media. As models of hard porous media, we fabricate arrays of nanoposts that are arranged in a square lattice; as models of soft porous media we formulate aqueous soultions of hydrolyzed polyacrylade over a wide range of dilute and semi-dilute concentrations. In both quiescent diffusion and in flow-driven transport through hard media, we generally find that the dynamics of the nanoparticles become increasingly slowed and stretched as the particles are more strongly confined. Strong confinement leads to deviations from the dispersion behaviors expected for small solute molecules. In soft media, we find that the local viscosity experienced by the nanoparticles systematically underestimates the zero-shear rate viscosity measured using bulk rheology, which we attribute to coupling between particle and polymer dynamics. I will discuss these results and their implications for nanocomposite processing as well as for other applications that require confined transport of nanomaterials in complex media.