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

Wanted: Scalable tracers for diffusion

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Scalable tracers are potentially a useful tool to examine diffusion mechanisms and to predict diffusion coefficients, particularly for hindered diffusion in complex, heterogeneous, or crowded systems. Scalable tracers are defined as a homologous series of tracers varying in size but with the same shape, structure, surface chemistry, deformability, and diffusion mechanism. Both chemical homology and constant dynamics are required. Specifically, branching must not vary with size, and there must be no transition between ordinary diffusion and reptation. Ideally the tracers would be uniform, monodisperse, metabolically inert cylinders in 2D or spheres in 3D with continuously variable radius and tunable surface properties.

Scalable tracers will facilitate more rigorous diffusion measurements in which two types of measurements are clearly distinguished. Scalable tracers would be used to find the mean diffusion coefficient as a function of size, and nonscalable tracers would be used to find the variation due to differences in shape, surface properties, and the like.

Candidate scalable tracers are discussed for 2D diffusion in membranes and 3D diffusion in cytoplasm and nucleoplasm. Specific suggestions for the 3D case include the use of synthetic dendrimers or random hyperbranched polymers instead of dextran, and the use of core-shell quantum dots in which the shell thickness is used to vary the overall diameter.

Another useful tool would be a series of scalable tracers varying in deformability alone. These could be made by varying the density of crosslinking in a polymer, to make say “reinforced Ficoll” or “reinforced hyperbranched polyglycerol”. (Supported by NIH grant GM038133.)