Langmuir 2017, 33, 2325−2339

Determination of the Exact Particle Radius Distribution for Silica Nanoparticles via Capillary Electrophoresis and Modelling the Electrophoretic Mobility with a Modified Analytic Approximation

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ABSTRACT: In this study, we use aqueous dispersions of amorphous silica nanoparticles of various sizes to investigate whether electropherograms recorded from capillary electrophoresis experiments can be converted directly into exact number-based particle radius distributions, provided that there is a relaxation effect-based size selectivity of the electrophoretic mobility and provided that the electrokinetic potential ζ of the particles can be regarded to be homogeneous over the surface of the particles, independent of the particle size. The results of this conversion procedure are compared with number-based particle radius distributions obtained from a large set of transmission electron microscopy (TEM) data. For this specific example, it is shown that the modified analytic approximation developed by Ohshima adequately describes the mobility-dependent relaxation effect and the electrophoretic mobility of the particle as a function of the reduced hydrodynamic radius and electrokinetic potential, which is a prerequisite for the presented procedure. Simultaneously, we confirmed that for the given Debye length/particle diameter ratio the electrokinetic surface charge density can be regarded to be size-invariant (including spherical geometry and planar limiting case). It is shown that the accuracy of the results of the developed method is comparable to that gained by a large set of TEM data, which is important when a precise description of the particle size distribution is needed to deduce conclusions regarding the underlying mechanism(s) of particle growth. The values obtained for the dispersion (width) of the distribution show only a small negative deviation, when compared with the TEM data (4−16%).