Electrical conductivity of suspensions of particles with thin electric double layers

S.D. Balika and M.Ya. Sushko

Mechnikov National University, 2 Dvoryanska Str., 65026 Odesa, Ukraine,
E–mail: svitlana.balika@gmail.com

We present a theory accounting for the effect of the electric double layer (EDL) on the bulk electrical conductivity σ_{eff} of suspensions of nanosized particles. The theory is based on our recent results [1,2], obtained within the compact-group approach (CGA), for macroscopically homogeneous and isotropic 3D dispersions of hard-core–penetrable-shell spheres embedded in a continuous matrix. The shells are inhomogeneous and characterized by a radially symmetrical conductivity profile $\sigma_2(r)$. The rule of dominance for the overlapping constituents suggests that the local value of the conductivity in the system is determined by the distance from the point of interest to the center of the nearest particle. The desired σ_{eff} is shown to satisfy a certain integral relation that becomes rigorous in the quasistatic limit and is valid for the entire range of admissible volume concentrations c of the cores.

We apply this theory to suspensions of particles (cores) with thin EDLs (shells). In this case, the model profile $\sigma_2(r)$ is actually the conductivity distribution in the EDL surrounding an isolated particle and can, therefore, be estimated through the well-known Gouy–Chapman and Dukhin solutions to the Poisson–Boltzmann equation. Using such a model to process experimental data for suspensions of nanosized latex particles in aqueous KCl and HCl solutions of different molarities, we show its capability of recovering σ_{eff} in wide ranges of c.

We also discuss the uses of the model for estimating: the conductivity of the suspending liquid; the surface charge acquired by particles upon being dispersed into the base liquid; the parameters of their EDLs; the role of the ion mobilities near the interface; and that of the surface conductivity.

1. M. Ya. Sushko, A. K. Semenov, *J. Mol. Liq.* **279**, 677 (2019).
2. M. Ya. Sushko, A. K. Semenov, arXiv:1811.10591 (2019).