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Polymer Adsorption and Electrokinetic Potential of Dispersed Particles in Weak and Strong Electric Fields

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Abstract

A review on the effects of adsorbed non-ionic polymers and polyelectrolytes on the electrophoresis of dispersed particles is given. The variety of changes in the electrical double layer (EDL) structure and, in particular, electrokinetic potential in weak electric fields as a result of polymer adsorption is discussed. Examples on the dependence of zeta potential of particles on the adsorbed amount of polymers are described. An analysis of the influence of various complicating factors, namely polarization of the EDL, curvature of the surface and presence of electrolytes, on the calculation of polymer layer thickness from electrophoretic data has been performed. Results of electrophoretic measurements in suspensions of non-conventional particles (TiC, SiC and Si₃N₄) having adsorbed polyethylene oxide are presented. Regularities of the effect of anionic and cationic polyelectrolytes (PE) and their binary mixtures on the electrokinetic potential of dispersed particles (polystyrene, silica, bentonite and kaolin) as a function of the polymer dose, pH, charge density (CD) of the polyelectrolyte, as well as the mixture composition and the sequence of components addition are described. It has been shown that addition of increasing amount of anionic PEs increases the absolute value of the negative zeta potential of particles, while adsorption of cationic PEs results in a significant decrease in the negative ζ -potential and overcharging the particles surface; changes in the ζ -potential are more pronounced for samples with higher CD. In mixtures of cationic and anionic PEs, in a wide range of their composition, the ζ -potential of negatively charged particles is determined by the adsorbed amount of the anionic polymer independently of the CD of polyelectrolyte and the sequence of the mixture components addition. The role of coulombic and non-coulombic forces in the mechanism of polyelectrolytes adsorption and structure of adsorbed layers formed is discussed.

The results of comparative investigations on the effect of adsorbed polymers on the electrophoresis of dispersed particles in weak and strong electric fields are presented. It is shown that adsorption of non-ionic polymers only slightly (by about 20-50%) decreases the electrophoretic velocity (V_{ef}) of polystyrene, graphite and aluminium-oxide particles in strong fields (100-400 V/cm). This is in contrast to the electrophoresis in weak fields (5-20 V/cm) in which adsorption of these polymers gives a drop in V_{ef} by an order of magnitude or even more. In line with our theoretical predictions, it means that the non-linear (“cubic”) electrophoresis, that arises in strong electric fields, is independent of the position of the shear plane, i.e. the zeta potential value. It is determined mainly by the surface conductivity of particles, i.e. by the Dukhin number that characterizes the polarization of the electric double layer.

Keywords: particles, polymers, mixtures, electrophoresis, weak and strong electric fields

Highlights:

- effects of non-ionic/charged polymers on electrophoresis of dispersed particles discussed
- dependences of particles ζ -potential on the adsorbed amount of polymers
- electrophoretic measurements in suspensions of TiC, SiC, Si₃N₄ with adsorbed polymer
- effect of anionic and cationic polymers, their binary mixtures on ζ -potential of dispersions
- comparison of electrophoresis of polymer-covered particles in weak and strong electric fields

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