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Evaluation of particle charging in non-aqueous suspensions

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Abstract

Factors influencing the sign and size of effective surface (zeta) potential in suspensions of very low dielectric constants are evaluated. For non-aqueous suspensions it was found that Gutmann's donor number (DN = negative Lewis type molar acid-base adduct formation enthalpy) was successfully related to zeta potential changes, similarly as pH is optimal for aqueous suspensions. Negative molar proton dissociation enthalpy (Brønsted type HD number), negative hydrogen bond enthalpy (HB number), logarithmic hydrogen bond equilibrium constant (molar Gibbs free energy), standard reduction potential of solvated protons ($E^\circ(H_L^+/H_2)$), electrolytic dissociation potential of water ($E^\circ(H_2O/H_2, O_2)$) and electron exchange Fermi potentials could equally well be related to zeta potential changes. All these properties were linearly dependent on each other. Correlations to products of Gutmann's DN and AN numbers and other relevant properties such as polar, hydrogen bond and acid-base contributions to solubility parameters and surface tensions were found to be less successful particularly when very polar liquids were encountered. Commonly used DLVO models for repulsive interaction energy between particles in aqueous electrolyte suspensions have been simplified when dealing with low-polar, non-polar and apolar suspensions. When evaluating factors contributing to attractive and repulsive interaction energies, it is found that in order for the models to be relevant the extension of diffuse charging has to be much larger than the distance to repulsive barrier ensuring suspension stability. At this limit and at high surface potentials, the repulsive energy grows exceptionally large being in the range of lattice energy of each solid. The models fail when surface potential is low and the extension of diffuse charging is much smaller than the distance to repulsive barrier. Then interaction energies are reasonable. The investigated Au, SiO₂, Glass, TiO₂, Al₂O₃, CaCO₃, MgO suspensions fall between these limits. The attractive energy is small but significant as compared to repulsive energy. All energies were larger than the estimated lower limit for stable suspensions.

Key words

Zeta potential; non-aqueous (Au, SiO₂, Glass, TiO₂, Al₂O₃, CaCO₃, MgO) suspensions; acid-base adduct, proton dissociation, hydrogen bonding enthalpies; proton reduction and water electrolysis potentials; Fermi electron exchange energy

Introduction

Particle charging in non-aqueous liquid suspensions (sols) has received increasing attention due to enhanced technological interest. Investigations on dispersant aided stabilization of carbon particles in benzene [1,2] showed that the basic requirement was a sufficient surface charge. In fully or almost non-aqueous suspensions zeta potential is practically the only parameter available for characterization of particle charging. Electric charges and surface

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