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SHORT COMMUNICATION

A macroion correlation effect on the structure of charged stabilized colloidal suspensions: a self-consistent integral equation study

Fatiha Smain · Fouzia Ould-Kaddour

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Abstract Using the mean field Poisson–Boltzmann (PB) and the Ornstein–Zernike (OZ) integral equation theories, we have determined the macroions effective interactions and the structure of charged stabilized colloidal suspension for a large charge range of macroion and screening parameter values. The renormalized parameters are calculated by solving the PB equation written in the framework of the modified Jellium model. The structures have been determined by solving the OZ equation coupled with a self-consistent integral equation, which is related to the Verlet's modified closure. Our results of the effective parameters are in good agreement with the experimental data, also the structure presents acceptable improvement compared to the Monte Carlo simulation data, against the HNC structure results, PACS: 61.20 Gy, 82.70 Dd, and 82.70 Kj.

Keywords Colloidal suspension · Effective interactions · Structure · PB and OZ equations

Abbreviations

PB	Poisson–Boltzmann equation
OZ	Ornstein–Zernike equation
OCM	One component model
PM	Primitive model
DLVO	Derjaguin, Landau, Verwey, and Overbeek theory
RDF	Radial distribution function
SC2VM	Double self-consistent Verlet modified closure
VM	Verlet modified closure

F. Smain (✉) · F. Ould-Kaddour
Département de Physique, Laboratoire de physique théorique,
Faculté des sciences, Université Abou Backr Belkaid,
BP 119, Tlemcen 13000, Algérie
e-mail: Fatiha_smain@yahoo.fr

Introduction

Colloidal dispersions have recently attracted much experimental [1] and theoretical [2, 3] attention. This great interest can be understood by the importance that these systems play in medical, biological, and industrial applications [4, 5]. Colloidal suspensions which are an extreme example of a large asymmetric electrolyte contain mesoscopically large particles from the nanometer to the micrometer size regime, colloids, together with other ionic species and solute molecules. The colloidal particles are significantly larger than the solvent molecules, but small enough to show Brownian motion [3]. Many industrial products are essentially colloidal suspensions (paints, inks, food, detergents, and cosmetics). The biological colloidal particles, e.g., micelles, synthetic polymeric particles, viruses, proteins, etc., play an important role in biological process, e.g., blood.

Due to the large asymmetry of the size and charge between colloids and the other ionic species present in solution, the study of this kind of systems is a very difficult task [5]. Within McMillan–Mayer theory of solutions, colloidal dispersions can be studied using two different levels of description [2, 3, 5]. The first level is based on a detailed description of each particle (size, charge), which gives the primitive model (PM). The PM supposes that the interaction potentials between different particles are taken to be composed of a long-range Coulomb interaction and a short-range hard-core repulsion. Unfortunately, due to the large charge and size asymmetry between the macroions and the microions, the methods of numerical simulations and integral equation theories seem to be only partially successful [6]. The second level of description exploits the large size asymmetry between the ionic species. In this case, microion degrees of freedom are integrating out [2, 3, 7–11], leaving only a state-dependant effective interaction potential between newly