



Hematite nanoparticle monolayers on mica: Characterization by colloid deposition

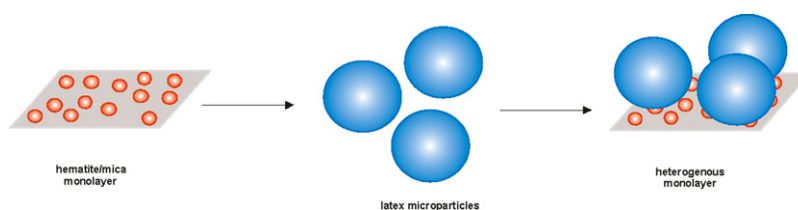
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HIGHLIGHTS

- ▶ Well-characterized hematite monolayers on mica were produced.
- ▶ Deposition experiments showed deviations from the mean-field DLVO theory.
- ▶ Useful reference data for bioparticle adhesion were obtained.

GRAPHICAL ABSTRACT



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ABSTRACT

Colloid particle deposition (also referred to as colloid enhancement, CE) was applied to characterize hematite nanoparticle monolayers on mica. The average size of hematite particles (determined by AFM and dynamic light scattering) was 22 nm. The monolayers were produced under diffusion-controlled transport from suspensions of various bulk concentration at pH 3.5, $I = 10^{-2}$ M, where the particles exhibited a positive zeta potential of 39 mV. The monolayer coverage, quantitatively determined by AFM and SEM, was regulated within broad limits by adjusting the deposition time. The electrokinetic properties of hematite monolayers produced in this way were studied using the streaming potential method. The dependencies of the monolayer zeta potential on the coverage, pH and ionic strength were determined. Hematite monolayers were used as heterogeneous substrates for colloid particle deposition studies involving negatively charged polystyrene latex particles (800 nm in diameter). An anomalous deposition of latex particles on substrates exhibiting a mean negative zeta potential was observed for higher ionic strength. These deviations from the classical DLVO theory were quantitatively interpreted in terms of the heterogeneous nanoparticle coverage distribution governed by fluctuation theory. However, for low ionic strength of 10^{-4} M latex particle deposition proceeded in accordance with the DLVO theory. These data obtained for hematite can be used as useful reference states for analyzing particle or bacteria adhesion to heterogeneous surfaces covered by macromolecules and proteins.

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1. Introduction

Hematite, the most stable of iron oxides, is widely used as synthetic pigment in paints, ceramics and as an anti-corrosion agent [1]. It has significance for catalysis in the Haber process [2,3], the Fisher–Tropsch synthesis [4,5], the desulfurization of natural gas, oxidation of alcohols, production of butadiene, etc. [5]. It is also used

in photovoltaic cells (water splitting) and in processes of chlorophenol and azo dyes photodegradation [6].

Many practical applications of hematite involve thin films deposited on various surfaces, which serve as gas, alcohol or humidity sensors, electrodes in lithium batteries [7], photo-anodes, etc.

A convenient and flexible method of hematite film preparation consists in controlled self-assembly of nanoparticles from aqueous suspensions (sols). However, despite the potential significance of this process, there are few systematic works devoted to this subject [8–10].

In our previous works [11,12] the self-assembly method was studied in more detail. Hematite nanoparticle monolayers on mica were produced under diffusion-controlled conditions from stable

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