THESES

INTERACTIONS BETWEEN SILICA NANOPARTICLES AT LIQUID/VAPOUR AD SOLID/LIQUID INTERFACES

AUTHOR:

GYULA TOLNAI

SUPERVISOR:

Dr. ZOLTÁN HÓRVÖLGYI

Budapest University of Technology and Economics

Department of Physical Chemistry

2005

PUBLICATIONS

1. A. Agod, Gy. Tolnai, N. Esmail, Z. Hórvölgyi: Compression of Nanoparticulate Arrays in a Film Balance: Computer Simulations, Progress in Colloid&Polymer Sci. 125 (2004) 54-60

2. A. Agod, E. Hild, E. Kálmán, A. L. Kovács, Gy. Tolnai, Z. Hórvölgyi: Contact Angle Determination of Nanoparticles: Real Experiments and Computer Simulations, J. Adhesion, 80(10-11) 2004 1055-1072

3. G. Tolnai, A. Agod, M. Kabai-Faix, A. L. Kovács, J. J. Ramsden, Z. Hórvölgyi: Evidence for secondary Minimum Flocculation of Stöber Silica Nanoparticles at the Air-Water Interface: Film Balance Investigations and Computer Simulations, J. Phys. Chem. B. 107 11109-11116 (2003)

4. Gy. Tolnai, F. Csempesz, M. Kabai-Faix, E. Kálmán, Zs. Keresztes, A.L. Kovács, J.J. Ramsden, Z. Hórvölgyi: Preparation and characterization of surface-modified silica-nanoparticles, Langmuir, 17(19), 2683-2687 (2001)

5. G. Tolnai, G. Alexander, Z. Hórvölgyi, Z. Juvancz, A. Dallos: Stabilization of gas chromatographic stationary phases with nanosized particles, Chromatographia, 53 (No. 1/2) 69-75, 2001

INTRODUCTION

In my PhD work interfacial (liquid/vapour and solid/liquid) interactions of Stöber silica nanoparticles were studied as a function of particle sizes and the wetting properties of particles. The possibility of interfacial film transfer from liquid/vapour onto solid supports was also investigated. Some relevant correlations among the particle hydrophobicities, dispersibilities and compressibility of particles at water/air interface were established. Furthermore, the experimentally determined interparticle energy values were compared with calculated (based on theroretical considerations) results in order to obtain more and detailed quantitive and qualitive information about the interfacial interparticle interactions.

THESES

I.

Preparation method has been developed for controlled surface modification of Stöber silica nanoparticles. It has been demonstrated that particles with different hydrophobic character can be prepared using trimethylsilyl N,N-dimethyl carbamate in different concentration in acetonitrile medium. It was also shown that the kinetic stability of alcosols of surface modified particles was suitable for further studies.

II.

Based on water/air interfacial studies it has been found that the wettability of unmodified (hydrophilic) Stöber silica nanoparticles significantly changed with their size. For bigger particle sizes lower values could be calculated for advancing contact angles. This observation

VI.

a) It has been shown that the optical waveguide lightmode spectroscopy (OWLS) technique can be applied for investigating the sorption properties of Stöber silica nanoparticles from alcoholic media at solid/liquid interface. As a result of the study the decay lenght of solvation repulsive interaction energy between the macroscopic surface and the nanoparticle can be calculated.

b) Size dependence of repulsive interaction decay length has been examined. It has been found that the decay legth values significantly decreased with increasing particle sizes. This observation is in a good agreement with the size dependent wettability of Stöber silica particles obtained from film balance study.

V.

Model system and method have been proposed for theoretical and experimental investigations of 2D miscibility of different hydrophobic particles. Water/air interfacial miscibility of silica nanoparticles with different surface energies has been investigated by using film balance and Brewster angle microscope. It has been found that the methods which were introduced for the study of interfacial molecular films can alsobe applied for solid nanoparticulate films.

can be attributed to different reaction conditions during the particle preparation.

III.

a) Repulsive particle-particle interaction energy values were determined from surface pressure-surface area isotherms of unmodified silica nanoparticles. It has been found based on a comparative analysis of the experimental and calculated (DLVO model) energy values that the particle-particle interaction energy cannot be described by the „classic" DLVO theory. The experimentally determined repulsive energies were found to be significantly higher than the calculated DLVO energy values. More than one order of magnitude differences were attributed to hydration repulsion between the particles.

b) The size dependence of decay length of repulsive interparticle energy has been investigated at water/air interface. It has been established that the decay length increases with the particle sizes. This observation is in a good agreement with the contact angle data calculated for the different-size particles.

IV.

It has been shown that the hydrophobicity of silica nanoparticles has a great effect on the dispersibility, structure formation and compressibility of particles at water/air interface. Increased hydrophobicity of particles results in a lower dispersibility and compressibility, as well, that can hinder the formation of maximum close-packed particulate arrays in the film balance.