

## DY 46: Complex Fluids, Colloids, Micelles and Vesicles (joint session CPP/DY)

Time: Thursday 15:00–17:45

Location: H 0110

**Invited Talk**

DY 46.1 Thu 15:00 H 0110

**Colloids and the depletion interaction: multi-phase coexistence of colloidal mixtures** — ●REMCO TUINIER — Laboratory of Physical Chemistry, Department of Chemical Engineering and Chemistry & Institute for Complex Molecular Systems, Eindhoven University of Technology, The Netherlands

Colloids are the building blocks of many natural (e.g., clay, milk, blood) and technological (e.g., paint, storage media, cosmetics, shaving foam) systems. The big question underlying related innovations is how can colloidal systems be formulated and designed towards the desired properties? To do this, the forces between the colloidal particles need to be controlled. Adding depletants (non-adsorbing polymers or small colloids) is key to controlling the attractive interactions [1]. This talk provides a detailed exploration of the phase behaviour of complex colloidal mixtures. While hard spheres can undergo a fluid-solid phase transition, anisotropic hard particles such as rods, cuboids, discs or boards exhibit a richer phase behaviour. The addition of depletants to anisotropic colloids gives rise to orientation-dependent attractions resulting in non-trivial phase behaviour. It is demonstrated that such mixtures exhibit a strikingly rich multi-phase coexistence behaviour [2].

[1] H.N.W. Lekkerkerker, R. Tuinier, M. Vis, *Colloids and the Depletion Interaction*, 2nd edition, Springer, 2024.

[2] J. Opdam, V.F.D. Peters, H.H. Wensink, R. Tuinier, *J. Phys. Chem. Lett.* 14 (2023) 199-206.

DY 46.2 Thu 15:30 H 0110

**Light-induced manipulation of colloidal particles in a photosensitive polymer-dye system** — ●ANNA LÓPEZ DE GUEREÑU and SVETLANA SANTER — Room 2.025 University of Potsdam Physics and Astronomy Karl-Liebknecht-Str. 24-25 14476 Potsdam Germany

In this study, we explore the optical and physical properties of a photosensitive surfactant system consisting of mesoporous silica particles in an aqueous solution with a fluorescent dye and an azobenzene-containing surfactant. The latter undergoes reversible photo-isomerization from trans- to cis-configuration upon UV/blue light exposure on a picosecond timescale, offering precise control over particle aggregation. The formation of the dye/surfactant complex adds complexity to the system.

Light-driven diffusioosmosis (LDDO) facilitates remote colloid control, with mesoporous colloids acting as a source or sink for the surfactant, influencing mutual interactions between particles.

The surfactant's isomerization state determines its adsorption affinities, influencing particle interactions. The trans-isomer accumulates in pores and forms a complex with the dye, while the cis-isomer remains outside the pores. Upon irradiation, the cis-surfactant generates a diffusioosmotic flow, causing a repulsion of particles. Wavelength and intensity modulate this process, allowing to control these structures. The dye provides an additional dimension to the system, adding to its complexity due to its influence on the surfactant isomerization and the LDDO process.

DY 46.3 Thu 15:45 H 0110

**Mesoporous silica colloids: surfactant cleaning, wetting and surface diffusion** — ●ANTONIO STOCCO — Institut Charles Sadron, University of Strasbourg, CNRS, France

We have investigated the use of mesoporous silica colloids to remove cationic surfactants from water. Porous silica colloids diffuse at the surface of water and in the volume, interacting with cationic surfactants that can adsorb inside the pores of these particles. We observed that surfactant adsorption on mesoporous silica depends dramatically not only on the particle pore size but also on specific counterion effects. We measured striking differences both on a macroscopic property of the interface, i.e. surface tension, and also at a single particle level by evaluating the translational diffusion of partially wetted particles at the fluid interface.

DY 46.4 Thu 16:00 H 0110

**Kinetics of phase separation inside complex random porous media** — ●ROUNAK BHATTACHARYYA<sup>1,2</sup> and BHASKAR SEN GUPTA<sup>1</sup> — <sup>1</sup>Department of Physics, Vellore Institute of Technology, Vellore, Tamil Nadu, India 632014 — <sup>2</sup>Institute for Theoretical Physics and

BioQuant, Heidelberg University, 69120 Heidelberg, Germany

The kinetics of phase separation of segregating fluid mixtures imbedded in porous media is an active field of research due to its great scientific interest and industrial applications. The subject is well understood in the case of ordered pores (e.g., cylindrical pore). But most of the real experimental porous systems are random in nature and are poorly understood. Experimental limitations come from the difficulties in probing the real space geometry using scattering experiments. Also, the theoretical and numerical studies are challenging because of the complex topology of the materials. At this meeting, we will present the findings of our study on the phase separation dynamics of segregating binary fluid mixtures inside random porous materials using large-scale molecular dynamics simulations. Different random porous structures are considered to understand the effect of pore morphology on the coarsening process. We find the existence of two different growth regimes and the crossover is related to the average diameter of random pores. The Porod law and Superuniversality hypothesis are also examined. Finally, the non-equilibrium aging dynamics and the corresponding scaling laws will be discussed for such systems.

**30 min. break**

DY 46.5 Thu 16:45 H 0110

**Screening Behavior of Nano-Ions in Aqueous Solutions** — ●THOMAS TILGER and REGINE VON KLITZING — Department of Physics, Technische Universität Darmstadt, Darmstadt, 64289, Germany

Due to their special properties, which make them suitable for many applications, the interest in nano ions grew during the last years. They turned out to be promising new materials for e.g. wastewater treatment, separation of nuclear waste and to stabilize foams. Especially for the last application, it is crucial to understand how the interaction between nano ions and the interaction between interfaces in the presence of nano ions can be described.

To directly measure the interaction between well-defined interfaces, colloidal probe atomic force microscopy (CP-AFM) has proven to be a powerful tool. As a model system for nano ions, we chose superchaotropic Keggin ions in aqueous solutions at different concentrations and investigated their influence on the interaction between colloidal silica beads.

It turned out that - despite their large size of approximately one nanometer - the interaction between the silica beads can still be described by the DLVO-theory of electrolyte solutions, consisting of a van der Waals attraction and an electrostatic double layer repulsion. However, the obtained screening lengths exhibit a significant deviation from the ones expected according to the nominal ionic strength of the solutions. The strength of this deviation increases with the concentration of the solutions and might be a hint for an ion aggregation.

DY 46.6 Thu 17:00 H 0110

**Protein cluster formation in protein-polymer mixtures** — ●ANUSHA HIREMATH, FAJUN ZHANG, and FRANK SCHREIBER — Institut für Angewandte Physik, Universität Tübingen, Germany

Understanding protein cluster formation is crucial for unraveling the mechanisms behind diseases like Alzheimer's and Parkinson's, which are linked to specific protein aggregation. Protein clusters, serving as precursors in protein crystallization [1], are also essential to comprehend the nature of protein aggregation. In this study, static and dynamic light scattering (SLS and DLS) are employed to investigate Bovine Serum Albumin cluster formation driven by depletion interactions [2] in the presence of Polyethylene Glycol (PEG) with varying sizes and concentrations. Using a two-exponential fit model, we illustrate the decreasing diffusion coefficient trend with increasing PEG concentration and size, marking the transition from a dilute to a semi-dilute regime [2]. This decrease in diffusion coefficients suggests an increased attractive potential between proteins, indicating the formation of small clusters. The apparent molecular weight from SLS indicates the formation of protein clusters above a threshold PEG concentration, which decreases with increasing PEG size. Furthermore, we find that larger PEGs accelerate cluster formation. This work demonstrates that the depletion attraction by adding PEG can balance the electrostatic repulsion, leading to the cluster formation in protein solutions.

[1] Zhang, F., *J Phys Condens Matter*, 29, 443002(2017). [2] Zosel, F. et al., *PNAS*, 117, 13482(2020).

DY 46.7 Thu 17:15 H 0110

**Phase Behaviour and Structures Induced by Adding Cosurfactant to Nonionic Micelles - Rodlike Assembly of Small Micelles** — ROBERT F. SCHMIDT<sup>1</sup>, SYLVAIN PRÉVOST<sup>2</sup>, MIRIAM SIMON<sup>3</sup>, YESHAYAHU TALMON<sup>3</sup>, and MICHAEL GRADZIELSKI<sup>1</sup> — <sup>1</sup>Stranski-Laboratorium für Physikalische Chemie, Inst f. Chemie, TU Berlin, Str. des 17. Juni 124, D-10623 Berlin, Germany — <sup>2</sup>ILL, 71 Rue de Martyrs, Grenoble, France — <sup>3</sup>Dep. of Chemical Engineering, Technion, Haifa 3200003, Israel

Addition of cosurfactant is a way to control systematically structure and properties of surfactant formulations. Normally this leads to continuously changing the packing parameter and transforming spherical to wormlike micelles and at higher concentration to bilayers via a first order phase transition. Here we show a completely different self-assembly behaviour seen for a classical nonionic surfactant (Tween 20) and 2-ethylhexylglycerol (EHG) as cosurfactant. Structural characterisation by light and neutron scattering (SANS) and cryo-TEM, shows that elongated assemblies are formed, which are composed of individual micelles that are locally ordered in a cylindrical fashion. A first-order phase transition takes place but only a smaller fraction of amphiphile is initially forming a bilayer structure and complete transformation to bilayers occurs within the single-phase region for EHG concentrations higher than the ones of the phase transition. This very uncommon structural evolution can be rationalised by the particular

structure of the amphiphilic molecules involved and this finding extends our common assumptions about surfactant assembly.

DY 46.8 Thu 17:30 H 0110

**Cryo Atom Probe Studies of 5CB, 8CB and Their Mixture** — KUAN MENG, PATRICK STENDER, SEBASTIAN EICH, and GUIDO SCHMITZ — Stuttgart University, Institute for Materials Science, Heisenbergstr. 3, 70569, Stuttgart, Germany

The development of Cryo-FIB enabled studies of various delicate samples of high interest, such as SEI, ferritin and porous borosilicate. Generally, frozen organic materials exhibit complex mass spectra and a high dependence on measurement parameters. Following our earlier measurements on frozen liquids [1], we are studying the evaporation and fragmentation of different liquid crystals. In detail, 5CB (4-Cyano-4'-pentylbiphenyl) and 8CB (4-Cyano-4'-octylbiphenyl) were chosen for investigation due to their relatively simple chemical structure and hydrophobically-induced stability.

Both types of samples, pure 5CB and 8CB, evaporate predominantly as intact molecules, which suits our previous observation in the n-tetradecane study [1]. As a consequence, these two type of molecules can be distinguished even in the mixture, due to their effective mass difference. The dependence of mass spectra on the evaporation conditions and the miscibility of both species will be presented in the talk.

[1] Meng, K., Schwarz, T., Weikum, E., Stender, P., & Schmitz, G. (2022). Frozen n-Tetradecane Investigated by Cryo-Atom Probe Tomography. *Microscopy and Microanalysis*, 28(4), 1289-1299.