IFE/E-2019/015

"Evolving Soft Matter: Shape, Dynamics and Functionality" The Geilo School 2019, March 11-21, Geilo, Norway

Report number **IFE/E-2019/**015	ISBN: 978-82-7017-924-4	ISSN: 2535-6380
Date: 8/22/2019	DOCUS ID: 38184	Number of pages:

Client:

Title: “Evolving Soft Matter: Shape, Dynamics and Functionality”
The Geilo School 2019, March 11-21, Geilo, Norway

Summary:

This report contains the complete program, poster abstracts, lists of lecturers and participants at the “Geilo School” held at Bardøla hotel, Geilo (Norway) March 11-21, 2019.

Prepared by (digitally signed):
Geir Helgesen

Reviewed by (digitally signed):
Arne T. Skjeltorp

Authorised by (digitally signed):
Bjørn Hauback

Institute for Energy Technology
P.O. Box 40, NO-2027 Kjeller, Norway / P.O. Box 173, NO-1751 Halden
Telephone: +47 63 80 60 00/ +47 69 21 22 00
http://www.ife.no / firmapost@ife.no

Contents

1 Introduction

This report contains the complete program, poster abstracts, lists of lecturers and participants at the "Geilo School" (GS) held at Bardøla hotel, Geilo (Norway) March 11-21, 2019. This is the twenty-fifth GS in a series held every two years since 1971 [1]. The theme of the school was "Evolving Soft Matter: Shape, Dynamics and Functionality", which is in the forefront of current research in the area of Soft Matter science.

The sub-themes of the School are outlined below.

A) *Shape* is an important concept in many areas of soft matter like colloidal and interface science, crumpling of two-dimensional sheets, as well as surfaces and membranes in biology. The description and control of shape in surfaces and interfaces is thus of wide interest in *evolving soft matter systems*.

B) *Dynamics* in evolving soft matter occurs as nonequilibrium phenomena where local shape and curvedness changes in moving surfaces and interfaces as for example in growth, fracture, deformation, pattern formation, flocking behavior and morphogenesis in living matter.

C) *Functionality* of evolving soft matter is important in many applications like the use of foams, adhesives, detergents, cosmetics, paints, food additives, lubricants, smart materials and soft robotics. In addition, functionality is obviously abundantly important in all biological materials.

Financial support to this Geilo School was principally from the Research Council of Norway, grant no. 297257. Support was also received from the SINE2020 program (grant no. 654000-SINE2020 - H2020-INFRADEV-2014-2015/H2020-INFRADEV-1-2014-1), Norwegian University of Science and Technology (NTNU), Trondheim (Norway), and the Institute for Energy Technology, Kjeller (Norway).

A list of previous Geilo schools can be found here:
https://ife.no/en/project/the-geilo-schools/

April 2019

Arne T. Skjeltorp

Director of the Geilo School 2019

2 Program of the Geilo School 2019

Evolving Soft Matter: Shape, Dynamics and Functionality

1st Day Monday March 11		
18:30	*Arrival Bardola hotel, Geilo*	*Bus transportation of participants from Oslo central station and Oslo airport to Geilo*
18:30	*Registration*	
19:30	*Reception*	*In bar at Bardola hotel*
20:00	*Dinner*	
22:00	*Arne Skjeltorp*	*Opening in Bardolasalen*
2nd Day Tuesday March 12		
08:30-11:30	Alain Goriely	Does soft matter matter to the matter of brain matter?
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-17:30	Stéphane Douady	Evolving Shape – Leafs and Lungs
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
3rd Day Wednesday March 13		
08:30-09:30	Stéphane Douady	Evolving Shape - Movements
09:30-11:30	Ramin Golestanian	1. Physics of Microswimmers 2. Hydrodynamic Coordination
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-16:30	Ramin Golestanian	Phoretic Active Matter
16:30-17:30	Eric Clement	Bacterial Suspensions
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
4th Day Thursday March 14		
08:30-10:30	Eric Clement	Bacterial Suspensions (continued)
10:30-11:30	Stig Ove Bøe (seminar)	Mechanical modelling of tissue scale epithelial contractions
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-18:30	Poster session	Posters left on display until Wedn. March 20
5th Day Friday March 15		
08:30-11:30	Petra Rudolf	Molecular motors and switches on surfaces
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-16:30	Heloisa Bordallo (seminar)	Squeezing antigens in silicates allows controlled release and improved functionality of the hepatitis B vaccine
16:30-17:30	Jarle Breivik (seminar)	Curing cancer once and for all
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	

Each lecture hour lasted for about 50 min including questions and a 10 min break
Coffee breaks approximately 10:15-10:30 and 16:15-16:30

6th Day Saturday March 16		
8:30-11:30	David Hu	1. Viscoelastic saliva of the frog tongue 2. Grooming and wicking of the cat tongue 3. Weight-lifting and reaching of the elephant trunk
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-17:30	Maria Helena Godinho	1. Shape and Morphology of (Cellulosic) Filaments 2. Cellulose in Motion
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
7th Day Sunday March17		
Free	***Choice of excursions to nearby scenic places or various skiing events in the mountains***	
8th Day Monday March 18		
08:30-11:30	Tom Witten	Manipulating the three dimensional shape of thin sheets by controlling their internal structure
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-16:30	David Nelson	1. Introduction to spatial population genetics
16:30-17:30	Maria Helena Godinho	3. Cellulose-based structural colours
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
9th Day Tuesday March 19		
08:30-09:30	David Nelson	2. Spatial gene drives and pushed genetic waves (CRISPR/Cas 9)
09:30-10:30	Irep Gozen (seminar)	A nanotube-mediated route to protocell formation
10:30-11:30	Adrian Rennie	Organisation of soft matter - studying material as it becomes useful
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-17:30	Adrian Rennie	Organisation of soft matter - studying material as it becomes useful (continued)
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
10th Day Wednesday March 20		
08:30-09:30	David Nelson	3. On growth and form of microorganisms on liquid substrates
09:30-10:30	Alexander Belushkin (seminar)	Neutron scattering methods for studies of shape, dynamics and their relation to functions of complex systems
10:30-11:30	Jon Otto Fossum (seminar)	Clay matters
11:30-15:30	*Discussions, outdoor activities and lunch*	
15:30-16:30	Jon Otto Fossum (seminar)	Clay matters (continued)
16:30-17:30	Paul Dommersnes (seminar)	Synthetic active matter from a physicist's perspective
17:30-18:30	Tutorial group meetings and informal discussions with lecturers	
19:30	***Geilo School Closing Dinner***	***Geilo Awards, Poster Prizes etc.***
11th Day Thursday March 21		
07:30-11:30	*Departure*	*Bus transportation of participants from Geilo to Oslo airport (11:30) and Oslo central station*

Sponsors:

3 Poster Abstracts

Maintenance of natural dynamics and functioning parameters of the rivers in terms of intensive mining activities

Anisimova Larysa[1], Andrieiev Vasil[1], Tiapkin Oleh[2]

1 – Institute for Nature management problems and ecology, National Academy of Science of Ukraine;
2 - National Technical University Dnipro Polytechnic

Abstract

Since 1928, dams and reservoirs have been built on the Dnieper River. There only 100 km are preserved in their natural state of 908 km of the total Dnieper length on the territory of Ukraine, the rest are regulated. On the territory of the Dnipropetrovsk region 101 reservoirs were created on the rivers (excluding the Dnieper), 3292 ponds and three major canals: Dnieper-Donbass, Dnieper- Kryvyi Rih, Dnieper-Ingulets.

As a result of the creation of the Dnieper reservoirs, the river has lost the mouth parts and is forcibly pumped by pumping stations to the levels of the reservoirs. The mouth of some rivers has been transferred (e.g. the Orel River with the help of the constructed canal 50 km downstream of the Dnieper River). Dozens of small rivers disappeared from the surface of the earth. Landscape of river valleys (e.g. the Samara river). Changed in the area of mine workings. As a result of open pit mining for the mining and processing plants were transferred to an underground collector (e.g. part of the Saksagan River).

To preserve the rivers of the steppe part of Ukraine, the practice of straightening or transporting the streambeds is used. This is especially true in areas of mining and processing plants.

In the past, the streambed of the Ingulets was subject to change and transfer. A similar transfer of streambed was carried out in our time in the area of tailing dump of the Ingulets mining and processing plant. To divert water into a new streambed and protect the quarry from flooding in the spring flood, the project provides for the installation of protective dams. Analysis of the results of instrumental measurements of depths, flow rates, flow parameters, thickness of bottom sediments, as well as transverse profiles of the natural streambed, confirms in the long term, the parameters of the new streambed will approach the parameters of the natural streambed as close as possible.

DIRECTIONAL SPREADING OF A VISCOUS DROPLET ON A CONICAL FIBRE

Tak Shing Chan[1], Fan Yang[2] & Andreas Carlson[1].

[1] *Mechanics Division, Department of Mathematics, University of Oslo, Oslo 0316, Norway*
[2]*Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ 08544, USA*

Abstract

If a droplet is placed on a substrate with a conical shape it spontaneously starts to spread in the direction of a growing fibre radius. We describe this capillary spreading dynamics by developing a lubrication approximation on a cone and by the perturbation method of matched asymptotic expansions. Our results show that the droplet appears to adopt a quasi-static shape and the predictions of the droplet shape and spreading velocity from the two mathematical models are in excellent agreement for a wide range of slip lengths, cone angles and equilibrium contact angles. At the contact line regions, a large pressure gradient is generated by the mismatch between the equilibrium contact angle and the apparent contact angle that maintains the viscous flow. It is the conical shape of the substrate that breaks the front/rear droplet symmetry in terms of the apparent contact angle, which is larger at the thicker part of the cone than that at its thinner part. Consequently, the droplet is predicted to move from the cone tip to its base, consistent with experimental observations.

INVESTIGATION OF DYNAMICAL BEHAVIOR OF BIOPOLYMERS ON A SUBSTRATE AT A SINGLE-MOLECULE LEVEL

E. Dubrovin[a,b], T. Schäffer[c], D. Klinov[b].

[a]*Lomonosov Moscow State University, Moscow, Russian Federation*
[b]*Federal Research and Clinical Center of Physical-Chemical Medicine, Moscow, Russian Federation*
[c]*University of Tübingen, Tübingen, Germany*

Abstract

Adsorption of biopolymers, such as DNA and proteins, on a surface is of high fundamental and biotechnological relevance. Knowledge of conformational and kinetic characteristics of adsorbed DNA and protein structures may be important for understanding of different physicochemical and biological processes. In this work, the conformational dynamics of individual biopolymer molecules adsorbed on model surfaces has been directly studied using atomic force microscopy. The obtained results represent a new insight into the dynamics of reorganization of biopolymer molecules upon adsorption on a surface and may be useful in biotechnology, for example, for the development of biocompatible materials and sensor surfaces.

Acknowledgements. The work was partially supported by Russian Science Foundation (17-75-30064).

Determining the role of the ionic radii of interlayer cations for CO_2 capture in smectite clay

Kristoffer W. Bø Hunvik[1*], Leide Cavalcanti[2,1], Matthias Daab[3], Konstanse K. Seljelid[1], Vegard Josvanger[1], Roosevelt D. Droppa[4], Barbara Pacáková[1], Paulo H. Michels-Brito[1], Kenneth D. Knudsen[1,2], Josef Breu[2], Jon Otto Fossum[1]

[1]*Department of physics, NTNU – Trondheim, Norway*
[2]*Institute for Energy Technology – Kjeller, Norway*
[3]*Lehrstuhl für Anorganische Chemie, University of Bayreuth – Bayreuth, Germany*
[4]*Centro de Ciências Naturais e Humanas,Universidade Federal do ABC - Santo André SP, Brazil*

*kristoffer.hunvik@ntnu.no

Experiments and simulations have shown that CO_2 (like H_2O) intercalate in smectite nano-lamellar clays, both in the supercritical ($scCO_2$)[1], and in the gaseous/liquid phase[2]. Understanding how clay swells and adsorbs CO_2 is vital for CCS and potential capturing applications, e.g. filtering of combustion gases.

Our group has demonstrated that CO_2 intercalates into dry synthetic Fluorohectorite (Fh) clay with Na^+, Ni^{2+} or Li^+ as interlayer cations. We found that Li-Fh clay retain CO_2 (0.23 ton of captured-CO2/m3-clay) up to a temperature of 35°C, at ambient pressure, and that the captured CO_2 can be released by heating above this temperature [3]. Ni-Fh demonstrate an exceptionally high CO_2 adsorption capacity [5] compared to other materials. Furthermore, Ni-Fh and Li-Fh show much faster intercalation kinetics than the Na-Fh case, which possibly is related to the ionic radii, and the polarizability of the CO_2 molecule.

Recently, we have also studied (Cs-, Ca-, Ba-) Fh clay [6] in a capillary based custom-made high-pressure cell using synchrotron XRD. We confirm that the kinetics of the adsorption depends on the specific cation, clay layer charge, temperatures and pressure. Our recent studies show crystalline swelling of Ni-Fh within seconds in response to CO_2 exposure, and we find that neither Cs-Fh, Ca-Fh and Ba-Fh show any sign of crystalline swelling when exposed CO_2.

[1] Loganathan, N., Bowers, G. M., Yazaydin, A. O., Schaef, H. T., Loring, J., Kalinichev, A. G., & Kirkpatrick, R. J. **(2018)** The Journal of Physical Chemistry C, 122.8 4391-4402. (2018).
[2] Giesting et al, Env. Sci. Tech. **(2012)** 46, 5623
[3] Michels L, Fossum JO, Rozynek Z, Hemmen H, Rustenberg K, Sobas P, Kalantzopoulos G, Knudsen KD, Janek M, Plivelic T, da Silva G, **(2015)** Scientific reports, 5:8775,
[4] Cavalcanti, L. P., Kalantzopoulos, G. N., Eckert, J., Knudsen, K. D., & Fossum, J. O. **(2018)** Scientific reports, 8, 11827
[5] M. Stoter, D.A. Kunz, M. Schmidt, D. Hirsemann, H. Kalo, B. Putz, J. Senker, J. Breu, **(2013)** Langmuir 29, 1280-1285

LIPID NANOTUBES: A POSSIBLE ROUTE TO PROTOCELL FORMATION AND GROWTH

Elif S. Köksal[a], Susanne Liese[b], Ilayda Kantarci[a], Ragni Olsson[a], Andreas Carlson[b], Irep Gözen[a,c,d]

[a] *Centre for Molecular Medicine Norway, Faculty of Medicine, University of Oslo, 0318 Oslo, Norway*
[b] *Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Oslo, 0315 Oslo, Norway*
[c] *Department of Mathematics, Faculty of Mathematics and Natural Sciences, University of Oslo, 0315 Oslo, Norway*
[d] *Department of Chemistry and Chemical Engineering, Chalmers University of Technology, SE-412 96 Göteborg, Sweden*

Abstract

Membrane-enclosed cellular compartments create spatially distinct microenvironments which confine and protect biochemical reactions in the cell. On the early Earth, the autonomous formation of compartments is presumed to have enabled encapsulation of nucleotides, satisfying a starting condition for the emergence of life. Recently, surfaces have become into focus as potential platforms for the self-assembly of prebiotic compartments, as notably enhanced vesicle formation was reported in the presence of solid interfaces. The detailed mechanism of such formation at the mesoscale however is still under discussion. Here we report on the spontaneous transformation of lipid reservoirs on solid substrates to unilamellar membrane compartments through a sequence of topological changes, proceeding via a network of interconnected lipid nanotubes. We show that this transformation is entirely driven by surface-free energy minimization and does not require hydrolysis of organic molecules, or external stimuli such as electrical currents or mechanical agitation. The vesicles grow by taking up the external fluid environment, and can subsequently separate and migrate upon exposure to hydrodynamic flow. This may explain, for the first time, the details of self-directed transition from weakly organized bioamphiphile assemblies on solid surfaces to protocells with secluded internal contents.

END OF COOPERATIVITY: CHAIN EXCHANGE KINETICS IN MIXED POLYMERIC MICELLES

Nico König[1,2], Lutz Willner[1] and Reidar Lund[2]

[1] *Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science (JCNS-1) and Institute for Complex Systems (ICS-1), 52425 Jülich, GERMANY*

[2] *Department of Chemistry, University of Oslo, 0371 Oslo, NORWAY*

Abstract

Here we present a kinetic study [1] on the chain exchange in mixed polymeric micelles containing partially crystalline cores. We are specifically interested in understanding how cooperative phenomena such as crystallization and melting affect the dynamics of self-assembled systems. As a model system we use n-alkyl-PEO (C_nH_{2n+1}-O-(CH_2-CH_2-O)$_{100}$H) with a molecular weight of roughly 5 kg/mol. In water these molecules form star-like micelles with a strongly segregated alkane core that partially crystallizes. This creates an additional energy barrier that needs to be overcome during chain expulsion.[2] We employ time-resolved small-angle neutron scattering in combination with the kinetic zero-average contrast technique to track the exchange kinetics.[3]

We investigated mixtures of C28-PEO and C22-PEO and determined the respective melting enthalpies using differential scanning calorimetry (DSC) which was quantitatively compared to the kinetic data obtained from TR-SANS. We found that the core crystallization occurs cooperatively while the intermicellar chain exchange processes of C28-PEO and C22-PEO are virtually decoupled. Nevertheless the cooperative crystallization affects the separate exchange kinetics of both species.

References

[1] König, N., Willner, L., Pipich, V., Zinn, T., and Lund, R. Cooperativity during Melting and Molecular Exchange in Micelles with Crystalline Cores. *Physical Review Letters*, **122**, doi:10.1103/PhysRevLett.122.078001 (2019).

[2] Zinn, T., Willner, L., Pipich, V., Richter, D. and Lund, R. Effect of Core Crystallization and Conformational Entropy on the Molecular Exchange Kinetics of Polymeric Micelles. *ACS Macro Letters* **4**, 651-655, doi:10.1021/acsmacrolett.5b00197 (2015).

[3] Willner, L., Poppe, A., Allgaier, J., Monkenbusch, M. and Richter, D. Time-resolved SANS for the determination of unimer exchange kinetics in block copolymer micelles. *Europhys. Lett.* **55**, 667-673, doi:10.1209/epl/i2001-00467-y (2001).

ELECTROSTATIC SELF-ASSEMBLY OF FACETTED, ANISOTROPIC, AND HELICAL NANOPARTICLE SUPERSTRUCTURES

Ville Liljeström[1], Ari Ora[2], Joona Mikkilä[2], Jon Otto Fossum[1], Mauri A. Kostiainen[2].

[1]*Department of Physics, NTNU Norwegian University of Science and Technology, Norway*
[2]*Department of Bioproducts and Biosystems, Aalto University, Finland*

Abstract

Electrostatic interaction is one of the most important factors that determine the colloidal stability and aggregation behavior of water-soluble colloidal particles. Electrostatic repulsion increases the colloidal stability whereas electrostatic attraction between oppositely charged particles easily leads to aggregation of particles, such that distinct periodic structures self-assemble. However, the ionic strength of the solvent modulates the electrostatic interaction.

We have studied the effect of particle geometry (shape, patchiness) and surface charge properties on the ionic strength dependent electrostatic self-assembly of structures with specific physical and chemical properties. The nanoparticles used in the study are on one hand biological particles (protein cages, viruses) and on the other hand uniform or close to uniform synthetic nanoparticles (gold nanoparticles, polymer dendrimers). The self-assembly of various combinations of oppositely charged nanoparticles occurs in a range of ionic strengths. We have characterized the assembly conditions and the structure of the self-assemblies using both (light and X-ray) scattering and (light and electron) microscopy methods.

Our results confirm that uniform nanoparticles often self-assemble into well-defined periodic superstructures. The lattice parameters can be directly related to the dimensions of the building units. The conditions where assembly occurs can mostly be related to the surface charge properties, whereas the macroscopic habit of the nanoparticle superstructures can be related to the shape and assembly mechanism of the building units. [1-3]

[1] Self-assembly and modular functionalization of three-dimensional crystals from oppositely charged proteins, V Liljeström, J Mikkilä, MA Kostiainen, *Nature Communications*, **5**, 4445

[2] Electrostatic self-assembly of soft matter nanoparticle cocrystals with tunable lattice parameters, V Liljeström, J Seitsonen, MA Kostiainen, *ACS Nano*, **9** (11), 11278-11285

[3] Cooperative colloidal self-assembly of metal-protein superlattice wires, V Liljeström et al. *Nature Communications*, **8** (1), 671

FOAM FORMATION ANALYSIS DURING DRAINAGE OF SURFACTANT SOLUTION

Nicolle LIMA[1], Shima PARSA[2], David WEITZ[2] and Márcio CARVALHO[1]

[1]Department of Mechanical Engineering, PUC-Rio, Rio de Janeiro, Brazil
[2]John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, USA

Foam is widely used in oil recovery operations to maximize oil production, and solve problems caused by either a thief zone or gravity override. Foam, that can be pre-formed and injected in the reservoir or produced in-situ through the pore space, fills the high permeability areas known as thief zones and divert the displacing fluid into the direction of trapped oil, reducing the relative permeability of gas and leading to a more stable flood front. The presence of liquid lamellae between gas bubbles in the foam also reduces the gas mobility, by the increase of the gas apparent viscosity. The flow mobility is a function of the pore geometry and foam properties. However, the dynamics of foam in a porous media is not fully understood due to its complexity. The goal of this research is to study foam formation during drainage of a two-dimensional porous media glass model by visualizing the pore scale displacement flow of a surfactant solution by injected gas. A microfluidic setup composed by glass micromodel, syringe pump, pressure transducer and microscope is used to study the evolution of the phase distribution and foam characteristics as a function of pore space geometry and flow conditions through image processing.

COLLECTIVE MOTION OF QUINCKE ROTATING BEADS

E. Martinez[1], T. F. Kristiansen[1], B. Pacáková[1], J. V. I. Timonen[2], P. G. Dommersnes[1] and J. O. Fossum[1]

[1]*Department of Physics, Norwegian University of Science and Technology* (NTNU)*, 7491 Trondheim, Norway.*
[2]*Department of Applied Physics, Aalto University School of Science, Espoo FI-02150, Finland*

Abstract

Insulating particles suspended in a carrier liquid may start to rotate with a constant frequency when subject to an electric field. This phenomenon is known as Quincke roller. A single isolated rotating particle exhibit no translational motion at low Reynolds number, however interacting rotating particles may move relative to one another or in the presence of a wall. Here we present experimental results on collective dynamics and self-assembly in a suspension of electro-rotating granular particles. Depending of the value of the electric field or the concentration of the particles is it possible to find different behavior like gas or vortices. We perform Particle Image Velocimetry in order to compute the vorticity and velocity of the systems and also simple tracking procedure were performed as a complementary way of characterization. One of the main striking results founded is the size of the vortices can be controlled with the electric field. This fact points out to future applications of the systems, for example, as photonic materials.

Contact information :
E. Martinez: etien.martinez@ntnu.no
P. G. Dommersnes: paul.dommersnes@gmail.com

Clay nanoparticle organization at the air-liquid interface

Paulo H. Michels-Brito[1], Antonio M. Gasperini[2], Ximena Puentes-Martinez[3], Leide P. Cavalcanti[1,4], Josef Breu[5], Koiti Araki[6], Kenneth D. Knudsen[1,4], Jon Otto Fossum[1,*]

[1]*Norwegian University of Science and Technology – NTNU, Trondheim, Norway*
[2]*Brazilian Synchrotron Light Lab – LNLS, Campinas, Brazil*
[3]*University of Boyacá, Colombia*
[4]*Institutte for Energy Technology – IFE, Kjeller, Norway*
[5]*University of Bayreuth, Germany*
[6]*University of Sao Paulo – USP, Sao Paulo, Brazil*

*jon.fossum@ntnu.no

We present a study on the structural organization of clay colloidal particles at the air-liquid interface where we monitor the film self-assembly and stability. Clays and modified clays are studied on a Langmuir Trough using Grazing Incidence techniques (GID and GIXOS). The film thickness and in-plane organization are monitored to determine the efficiency of the mechanisms for adsorption control on different interfaces. The results are important for particle coating studies and for the development of new methods of assembling clay colloidal particles on liquid surfaces/interfaces. This effect is currently much studied in relation to Pickering emulsions where particle coatings on droplets effectively prevent droplet coalescence and produce very stable surfactant-free emulsions. The adsorption of colloidal particles at the surface of liquid droplets [1] has applications in several areas like pharmaceutics, oil and gas sector, not only for encapsulation properties using surfactant-free emulsions, but also for the features of manipulation of the colloidal particles such as clays through external forces, like electric field [2]. Here we show that we can study the ordering of clay nanoparticles in a confined two-dimensional surface like a Langmuir Trough and recreate the process of Janus clay-platelets preparation using synthetic Fluorohectorite clays [3].

1. Dommersnes, Rozynek, Mikkelsen, Castberg, Kjerstad, Hersvik, Fossum. (**2013**) Nature Comm, 4, 2066
2. Gholamipour-Shirazi, Carvalho, Huila, Araki, Dommersnes, Fossum **(2016)** Scientific Reports 6, 37239
3. Stoeter, Goedrich, Feicht, Rosenfeldt, Thurn, Neubauer, Seuss, Lindner, Kalo, Moeller, Fery, Foerster, Papastavrou, Breu. (**2016**). Angew. Chem. Int. Ed., 55, 7398–7402.

EFFECT OF IONS AND LAPONITE ADDITION ON VISCOUS FLOW OF MIXTURES CLOSE TO THE EXFOLIATION CRITICAL TEMPERATURE

Yu.L. Ostapchuk[1], O.D. Alekhin[2], A.G. Galichev[3], Ye.G. Rudnikov[2]

[1]IPE, [2]Taras Shevchenko National University of Kyiv, Ukraine, os@ukr.net
[3]Bryansk State Technical University, Bryansk, Russia

Abstract

It was shown earlier [1, 2] that ions can be surrounded by solvate shell near the critical point of mixture. It causes that part of the large-scale nanosize fluctuations of the order parameter in the mixture becomes charged. Under this assumption, the interaction of ions with condensed system in the near-critical state can be considered as the interaction of "charged" nanosize fluctuations of the order parameter with "uncharged" ones. It has been experimentally shown that shear critical viscosity flow of isobutyric acid-water mixture (ISOBAW) and this mixture with addition of different concentrations of ions [2] and laponite nanoparticles [3] quantitatively correspond to the equation of critical viscosity [4] with fixed value of the wave vector q=0,02. Analysis allowed to conclude about similar behaviors of ions and laponite influence on mixtures. Critical parameters and parameters of the equations of state of the ISOBAW + K^+Cl^- and ISOBAW + laponite system have been obtained.

The weak interaction of the laponite with the mixture in comparison with the ion can be qualitatively explained by the model presentation as follows: 1) laponite disk (surrounded by a solvate shell) has quadrupole moment. Its interaction with the fluctuations of the ISOBAW mixture (that has a dipole moment) can be considered as quadrupole-dipole. 2) At the same time, the interaction of the positively or negatively charged ion (surrounded by a solvate shell) with water and isobutyric acid can be considered as more strong coulomb-dipole interaction. In both cases, it is assumed that the influence of the electric fields of particles added to the system is manifested on nanosize scale of charged fluctuations or nanodiscs surrounded by solvate shells. It is experimentally shown that the addition of ions and laponite to mixture leads to a narrowing of the three-dimensional phase diagram of the correlation length.

[1] O.D. Alekhin, Ukr. J. Phys. 47, 11, 1045 (2002).

[2] O.D. Alekhin, J.L. Ostapchuk, Ye.G. Rudnikov, A.V. Voyteshenko Russian J. Phys. Chem. A 88 9 1519 (2014).

[3] O.D. Alekhin, Yu.L. Ostapchuk, et.al. VIII International Conference “Physics of Liquid Matter: Modern Problems-8”, Kyiv, Ukraine, 18-22.05.2018, Abstracts, P.3-255.

[4] O.D. Alekhin , Ukr. J. Phys. 2, 138 (2004); O.D. Alekhin, Yu.L. Ostapchuk, Ye.G. Rudnikov, A.G. Galichev et.al. XXI G.Puchkovska International School-Seminar "Spectroscopy of Molecules and Crystals" Ukraine, Beregove, 22-29.09.2013, Abstracts, O-2, P.44; O.D. Alekhin, Yu.L. Ostapchuk, A.G. Galichev et.al. VII International Conference “Physics of Liquid Matter: Modern Problems-7”, Ukraine, Kiev, 27-31.05.2016. Abstracts, P. 9-23.

ENTROPY APPROACH OF COMPUTATION AND FORECASTING OF ASYMMETRIC CHARACTERISTICS OF MIXTURES UNDER THE EXTREMAL CONDITION

M.C. Potomkin[1,2], A.G. Galichev[3], Ye.G. Rudnikov[1]

[1]*Taras Shevchenko National University of Kyiv, Ukraine*
[2]*NCP Ltd. Kyiv, Ukraine, ncp@univ.kiev.ua*
[3]*Bryansk State Technical University, Bryansk, Russia*

Abstract

The problem of constructing the calorific equations of state and calculating the thermodynamic parameters of mixtures near the critical point using the parameters of their components remains an urgent task of the condensed matter physics. To solve it, a method of choosing the countdown start for calorific values is founded, in which the corresponding states law for liquids is satisfied, according to [1]. It should be noted that applied calculations in the oil and gas industry are tied to the absolute values of entropy and enthalpy for different fractions in the absence of coherence. An analysis of thermodynamic consistency conditions in the dissolution of solution components [2] allow concluding that a consistent calculations of the solution parameters for variable values are approximate due to excessive non-additive contributions to them; similar calculations are exact for values which remain constant for components. Using the systems approach [3] for liquid components of non-ideal solutions (C4H8O2 - H2O, CH4O – C6H14, C6H7N – D2O) along the liquid-vapor equilibrium curve, the combinations of thermodynamic parameters have been found, the relations between which are described by power functions. It allowed us obtaining new constants for solutions components, to which consistent rules for calculating the solution parameters were applied.

The isothermal conversion from the coexistence curve to the isobar P = 1 atm has been carried out, which corresponds to obtained earlier [4] and literature [5] refractometric liquid-liquid data. The inverse problem has been solved, for mixtures and for mixtures with salts addition, the main parameters of the theory of critical mixtures have been found. The new concepts of the entropy, energy, and refraction concentrations are introduced, with which the determination of partial values of temperature, pressure, chemical potential, and refraction potential in the extended canonical formalism of critical liquid-liquid mixtures are connected. It has been shown that the addition of salt to mixture leads to a non-universal character of the influence on the critical parameters and asymmetric contributions to the form of the extended equation of state, although the system doesn't out beyond the universality class of the three-dimensional Ising model.

[1] E.A. Guggenheim, J. Chem. Phys., 1945, 13, 253
[2] Ya.Liu, P.H. Daum, Aerosol Science, 2008, 39, 974
[3] Ye.G. Rudnikov, A.D. Alekhin, Monitoring. Science and Technology, 2013, 3, 74.
[4] A.D.Alekhin, et.al. Journal of Molecular Liquids, 2003, 105, 2–3, 191.; A.D. Alekhin, et.al. Russian J. Phys. Chem. A 2014, 88, 9, 1519
[5] A. Toumi, M. Bouanz, Journal of Molecular Liquids, 2005, 122, 74; L.A. Bulavin, A.V. Oleinikova, et. Al. Bulletin of Kyiv National University, Phys. and Math., 2001, 1, 411.

DIFFUSION MAPS OF *BACILLUS SUBTILIS* BIOFILMS VIA MAGNETIC RESONANCE IMAGING

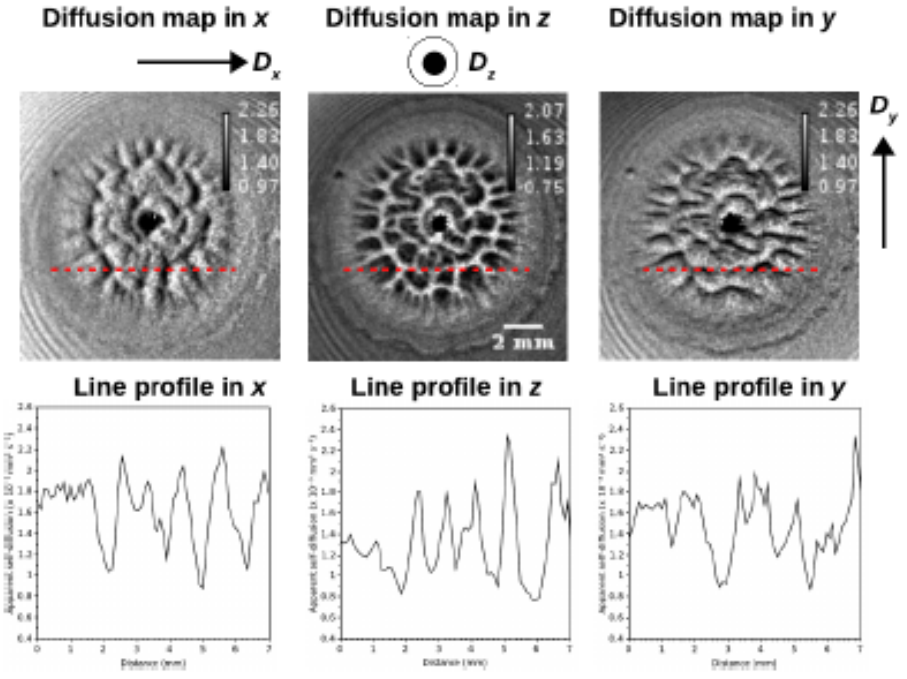
Ramon V. Galdino, Clayton A. Benevides, Rômulo P. Tenório*.

Centro Regional de Ciências Nucleares do Nordeste (CRCN-NE/CNEN), Recife, Brazil.

*romuloptenorio@cnen.gov.br

Abstract

We report the use of high-resolution magnetic resonance imaging to obtain self-diffusion coefficient maps of the *Bacillus subtilis* biofilm surface. Some strains of *B. subtilis* develops wrinkles on surface that has been proposed to participate in fluid transport along the biofilm structure. Here, we would like to check this theory making measurements of the diffusion coefficient, *D*, in the biofilm using the technique of diffusion-weight-nuclear magnetic resonance microimaging (DW-microMRI) to highlight the role of wrinkled channels in the diffusion processes. Our results shows an anisotropy and a heterogeneous diffusion behavior dependent on the direction and presence of the channels. Finally the method is noninvasive and the contrast can be tuned for specific regions or even completely suppressed.



DESIGN AND CONSTRUCTION OF AN AUTOMATED SYSTEM FOR MICROORGANISMS IDENTIFICATION BASED ON LASER SCATTERING AND PATTERN RECOGNITION

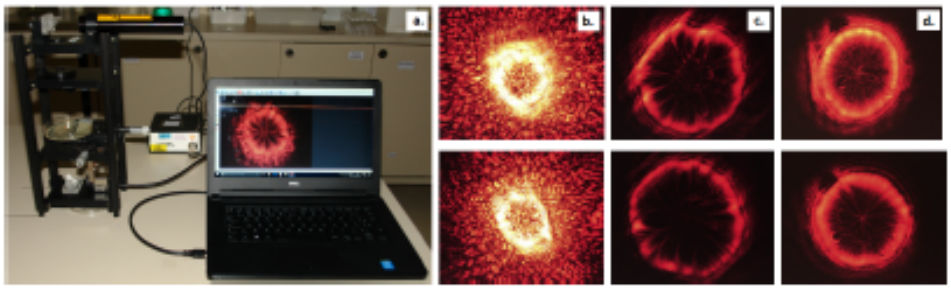
Natália A. A. Kitaoka, Clayton A. Benevides, Rômulo P. Tenório*.

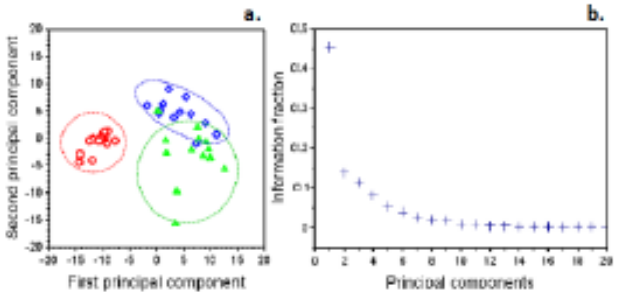
Centro Regional de Ciências Nucleares do Nordeste (CRCN-NE/CNEN), Recife, Brazil.

*romuloptenorio@cnen.gov.br

Abstract

The identification of microorganisms between different types and species level is of great importance in hospital, food industry and pharmaceutical companies. Phenotypic differences between microorganisms manifest themselves at the level of their colonies. In recent works, were found that different species which shows similar visual morphology provided distinctive forward-scattering pattern. Currently, there are some methods of identification that vary from microorganism to microorganism that are laborious, time consuming, and costly to implement. Therefore, we aim to construct a non-expensive portable light-scattering table device, based on the acquisition of colony laser scattering images of different types of microorganisms, and using pattern recognition strategies, to classify, distinguish and identify microorganism at the level of its genres.





INFLUENCE OF SYSTEM GEOMETRY ON SOFT MATTER BEHAVIOR NEAR THE CRITICAL POINT ON MACRO AND MESO SCALES

Ye.G. Rudnikov[1,2], A.D. Alekhin[1]

[1]*Taras Shevchenko National University of Kyiv, Ukraine, rudnikof@yahoo.com*
[2]*National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"*

Abstract

The interactions of molecules near the second kind phase transitions and critical points of liquids and solutions are mainly indirect collective interactions [1], in which the atomic and molecular degrees of freedom do not play a decisive role [2]. Indirect interactions lead to the appearance of long-range correlations in the system at distances less than correlation length of the system but significantly more than characteristic molecular sizes. The properties of inhomogeneous systems on such spatial meso-scales are characterized by non-Gaussian distribution functions [1]. For liquids, the characteristic size of the correlation length can be determined, for example, by the method of molecular light scattering. Behavior of the same systems on spatial macro-scales can be considered as an ensemble of new structural units videlicet clusters of order parameter fluctuations [3] that interact weakly with each other. On macro-scale, the properties of the system are described by the Gaussian distribution function [1]. Comparison of mechanical, calorific and correlation characteristics of liquids at meso- and macro-scales using experimental data in terrestrial and space conditions for the correlation length, susceptibility, heat capacity and magnitude of the gravitational effect allows establishing a qualitative similarity of system properties at different spatial scales. These include the presence of extremum lines on non-monotonic temperature dependences, as well as the scaling character of the dependences of these quantities on the linear size of the system [3].

The theory of M.Fisher's finite-dimensional scaling for limited meso- scale systems [4] and the equations of the effect of gravity for macro- scale systems of various linear sizes are compared. It has been concluded that the equations of extremum lines and the dependences of the characteristics of the system on its size on the meso- and macro- scales are described using different critical exponents [3]. A qualitatively similar picture holds for the temporal characteristics of the critical fluid on the meso- and macro- scales. This conclusion was made on comparison of temporal theory of a finite-size scaling for limited meso-size systems and equations of inhomogeneous equilibrium effect of gravity establishing near the critical point. From our point of view, these processes can simulate the glue flowing, mountain avalanches moving, processes during the explosion, spreading of biological populations and others.

[1] I.R. Yukhnovsky, M.P. Kozlovsky and I.V. Pylyuk, Microscopic phase transitions theory in three-dimensional systems. Lviv, Eurosvit Publisher, 2001.
[2] A.Z. Patashinskii and V.L. Pokrovskii, Fluctuation Theory of Phase Transition, Pergamon, Oxford,1979.
[3] A.D. Alekhin, A.K. Dorosh, Ye.G. Rudnikov Critical state of substance under the Earth gravity, Politehnika, Kiev, 2013.
[4] M.E. Fisher, M.N. Barber, Phys. Rev. Lett. 1972, 28, P. 1516.

SPONTANEOUS COMPARTMENTALIZATION OF ARTIFICIAL CELLS ON SOLID SUPPORTS

Karolina Spustova[1], Elif Senem Köksal[1], Irep Gözen[1,2,3]

[1]Centre for Molecular Medicine Norway, Faculty of Medicine, University of Oslo, 0318 Oslo, Norway
[2]Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Oslo, 0315 Oslo, Norway
[3]Department of Chemistry and Chemical Engineering, Chalmers University of Technology, SE-412 96 Göteborg, Sweden

Abstract

Compartmentalization in biological cells provides segregation of the internal contents, allowing for multiple incompatible biochemical reactions to occur simultaneously in specialized environments. How such compartments emerged over time from primitive protocells, the hypothetical prebiotic precursor of life on earth, is still subject of debate. Here we report on an artificial cell model where spontaneous compartmentalization is observed on solid substrates, governed by the membrane-surface interaction. Upon deposition of multilamellar phospholipid vesicles consisting of mixtures of zwitterionic and negatively charged lipids, on solid supports in the presence of multivalent cations, the vesicles initially wet the surface and spread laterally in a circular manner. When the cations are subsequently depleted, the membrane gradually de-wets the surface while spontaneously transforming into adhered giant unilamellar vesicles with multiple intra-vesicular compartments. Several tens of compartments can grow and even merge inside a single artificial protocell. The transformation can be accelerated by a mild temperature increase, which is known to significantly weaken the adhesion at the membrane-substrate interface, promoting the de-wetting process. The formation of compartmentalized membrane containers neither requires biological machinery, such as membrane-interacting proteins, nor a supply of chemical energy, as it is entirely determined by fundamental materials properties and interfacial events. It is therefore likely that such processes may have succeeded at naturally occurring interfaces in the presence of lipid aggregates under early Earth conditions. The observed phenomena may enrich the debate around the development of primitive life with a new feasible pathway to compartmentalized protocell structures.

NANO-WRAPPING OF NANO-PARTICLES

O. Trigueiro Neto[1], V. V. Liljeström[1], K. Araki[2], P. G. Dommersnes[1], J. O. Fossum[1]

[1]*Department of Physics, Norwegian University of Science and Technology – NTNU, 7491 Trondheim, Norway*
[2]*Universidade de São Paulo USP*

The goal of this project is the development of ways to encapsulate/wrap and "protect" assemblies of nano-particles. Such encapsulations can, for example, be done by encapsulating in colloidal shells consisting of many particles [1], or, as we will pursue further in this project: wrapping in single nano-sheets [2].
Here we will investigate encapsulation by clay mineral nano-sheets (of different lateral sizes), that have mechanical properties [3] similar to Graphene Oxide or Graphene sheets, already proven capable of wrapping particles of different sizes [4,5,6].
Clays (e.g. mica) can be decorated with, or also wrap, magnetic nanoparticles [7,8,9]. This can allow for improved control of magnetic particle transportation in porous media, for targeted delivery of magnetic nano-particles, or for controlled extraction of the magnetic nano-particles.
In order to study and achieve the clay wrapping described above, we use microfluidic systems, to produce double emulsions [4,10] in the μm range. Characterization of nano-particles structuring inside produced capsules will be done using SAXS/WAXS, SANS and microscopy techniques.
The project is motivated by the prospect of enabling protected (from environment) transportation and controlled release of magnetic tracer nano-particles in oil-reservoirs.
The project is granted from the Research Council of Norway, Petromaks2: "Nanofluids for IOR and Tracer Technology", project number: 268252.

1. Rozynek, Z., Mikkelsen, A., Dommersnes, P., & Fossum, J. O. (2014). Electroformation of Janus and patchy capsules. *Nature communications*, *5*, 3945.
2. Paulsen, J. D., Démery, V., Santangelo, C. D., Russell, T. P., Davidovitch, B., & Menon, N. (2015). Optimal wrapping of liquid droplets with ultrathin sheets. *Nature materials*, *14*(12), 1206.
3. Stöter, M., Gödrich, S., Feicht, P., Rosenfeldt, S., Thurn, H., Neubauer, J. W., ... & Fery, A. (2016). Controlled exfoliation of layered silicate heterostructures into bilayers and their conversion into giant Janus platelets. *Angewandte Chemie*, *128*(26), 7524-7528.
4. Ju, S. A., Kim, K., Kim, J. H., & Lee, S. S. (2011). Graphene-wrapped hybrid spheres of electrical conductivity. *ACS applied materials & interfaces*, *3*(8), 2904-2911.
5. Luo, J., Zhao, X., Wu, J., Jang, H. D., Kung, H. H., & Huang, J. (2012). Crumpled graphene-encapsulated Si nanoparticles for lithium ion battery anodes. *The journal of physical chemistry letters*, *3*(13), 1824-1829.
6. Kaufman, G., Montejo, K. A., Michaut, A., Majewski, P. W., & Osuji, C. O. (2017). Photoresponsive and Magnetoresponsive Graphene oxide microcapsules fabricated by droplet microfluidics. *ACS applied materials & interfaces*, *9*(50), 44192-44198.
7. Deda, D. K., Cardoso, R. M., Uchiyama, M. K., Pavani, C., Toma, S. H., Baptista, M. S., & Araki, K. (2017). A reliable protocol for colorimetric determination of iron oxide nanoparticle uptake by cells. *Analytical and bioanalytical chemistry*, *409*(28), 6663-6675.
8. Zuin, A., Cousseau, T., Sinatora, A., Toma, S. H., Araki, K., & Toma, H. E. (2017). Lipophilic magnetite nanoparticles coated with stearic acid: A potential agent for friction and wear reduction. *Tribology International*, *112*, 10-19.
9. Uchiyama, M. K., Toma, S. H., Rodrigues, S. F., Shimada, A. L. B., Loiola, R. A., Rodríguez, H. J. C., ... & Farsky, S. H. P. (2015). Ultrasmall cationic superparamagnetic iron oxide nanoparticles as nontoxic and efficient MRI contrast agent and magnetic-targeting tool. *International journal of nanomedicine*, *10*, 4731.
10. Shah, R. K., Shum, H. C., Rowat, A. C., Lee, D., Agresti, J. J., Utada, A. S., ... & Weitz, D. A. (2008). Designer emulsions using microfluidics. *Materials Today*, *11*(4), 18-27.

Contact information:
O Trigueiro Neto – osvaldo.t.neto@ntnu.no
J O Fossum – jon.fossum@ntnu.no

4 Organizers and Lecturers

Organising Committee

Name	Address	E-mail
Skjeltorp, Arne T.	Institute for Energy Technology and Giamag Technologies AS Kjeller, Norway	arne.skjeltorp@ife.no
Helgesen, Geir	Institute for Energy Technology Kjeller, Norway	geir.helgesen@ife.no
Løkseth, Trine	Institute for Energy Technology Kjeller, Norway	trine.loekseth@ife.no

Programme Committee

Dommersnes, Paul	Norwegian University of Science and Technology - NTNU Trondheim, Norway	paul.dommersnes@ntnu.no
Fossum, Jon Otto	Norwegian University of Science and Technology - NTNU Trondheim, Norway	jon.fossum@ntnu.no
Knudsen, Kenneth	Institute for Energy Technology Kjeller, Norway	kenneth.knudsen@ife.no

Lecturers

Clement, Eric	ESPCI, Paris, France	eric.clement@upmc.fr
Douady, Stéphane	Univ. Paris-Diderot, France	stephane.douady@univ-paris-diderot.fr
Godinho, Maria Helena	New University of Lisbon, Portugal	mhg@fct.unl.pt
Golestanian, Ramin	Max Planck Inst., Göttingen, Germany	ramin.golestanian@ds.mpg.de
Goriely, Alain	Oxford Univ., UK	goriely@maths.ox.ac.uk
Hu, David	Georgia Tech., USA	hu@me.gatech.edu
Nelson, David	Harvard Univ., USA	drnelson@fas.harvard.edu
Rennie, Adrian	Uppsala Univ., Sweden	adrian.rennie@physics.uu.se
Rudolf, Petra	Univ. Groningen, Netherlands	p.rudolf@rug.nl
Witten, Tom	Univ. of Chicago, USA	tten@uchicago.edu

Seminars

Belushkin, Alexander	Joint Institute for Nuclear Research, Dubna, Russia	belushk@nf.jinr.ru
Bordallo, Heloisa	Copenhagen Univ., Denmark	bordallo@nbi.ku.dk
Breivik, Jarle	University of Oslo, Norway	jarle.breivik@medisin.uio.no
Bø, Stig Ove	Oslo University Hospital, Norway	stig.ove.boe@rr-research.no
Dommersnes, Paul	NTNU, Trondheim, Norway	paul.dommersnes@ntnu.no
Fossum, Jon Otto	NTNU, Trondheim, Norway	jon.fossum@ntnu.no
Gözen, Irep	University of Oslo, Norway	irep.gozen@ncmm.uio.no

5 Participants

First name	Surname	Country	Email
Ana	Almeida	Portugal	ana.almeida@fct.unl.pt
Larysa	Anisimova	Ukraine	lanisimova@gmail.com
João	Canejo	Portugal	jpgc@fct.unl.pt
Tak Shing	Chan	Norway	taksc@math.uio.no
Oleksii	Datsiuk	Ukraine	dassoft@ukr.net
Olga	Datsiuk	Ukraine	lelenka@ukr.net
Evgeny	Dubrovin	Russia	dubrovin@polly.phys.msu.ru
Kristoffer	Hunvik	Norway	kristoffer.hunvik@ntnu.no
Elif	Köksal	Norway	elif.koksal@ncmm.uio.no
Nico	König	Norway	nico.konig@kjemi.uio.no
Ville	Liljeström	Norway	ville.v.liljestrom@gmail.com
Etien	Martinez Roman	Norway	etien.martinez@ntnu.no
Paulo Henrique	Michels Brito	Norway	paulo.h.m.brito@ntnu.no
Nicolle	Miranda de Lima	USA	nicollelimarj@hotmail.com
Jiri	Muller	Norway	jiri@ife.no
Yuriy	Ostapchuk	Ukraine	os@ukr.net
Barbara	Pacáková	Norway	barbara.pacakova@ntnu.no
Olga	Paseka	Russia	paseka@physics.msu.ru
Rômulo	Pinto Tenório	Brazil	romuloptenorio@cnen.gov.br
Mykola	Potomkin	Ukraine	ncp@univ.kiev.ua
Roger	Pynn	USA	rpynn@indiana.edu
Rossana	Rojas	Norway	rossanar@math.uio.no
Yevgenii	Rudnikov	Ukraine	rudnikof@yahoo.com
Pedro Emanuel	Santos Silva	Portugal	pess@fct.unl.pt
Diogo	Saraiva	Portugal	dv.saraiva@campus.fct.unl.pt
Konstanse Kvalem	Seljelid	Norway	konstaks@stud.ntnu.no
Karolina	Spustova	Norway	karolina.spustova@ncmm.uio.no
Viktor	Stojkoski	Macedonia	vstojkoski@manu.edu.mk
Osvaldo	Trigueiro Neto	Norway	osvaldo.t.neto@ntnu.no
Ana Catarina	Trindade	Norway	ana.c.trindade@ntnu.no

Tittel: “Evolving Soft Matter: Shape, Dynamics and Functionality” The Geilo School 2019, March 11-21, Geilo,

Dokumentklasse:

Signaturer:

Author:	Geir Helgesen ife.no\Geir.Helgesen	2019-09-24 11:03:02 (UTC+00:00)
Review Approval:	Arne Torbjørn Skjeltorp ife.no\Arne.Skjeltorp	2019-09-24 11:16:26 (UTC+00:00)
Content Approval:	Bjørn Christian Hauback ife.no\Bjorn.Hauback	2019-09-26 08:21:08 (UTC+00:00)