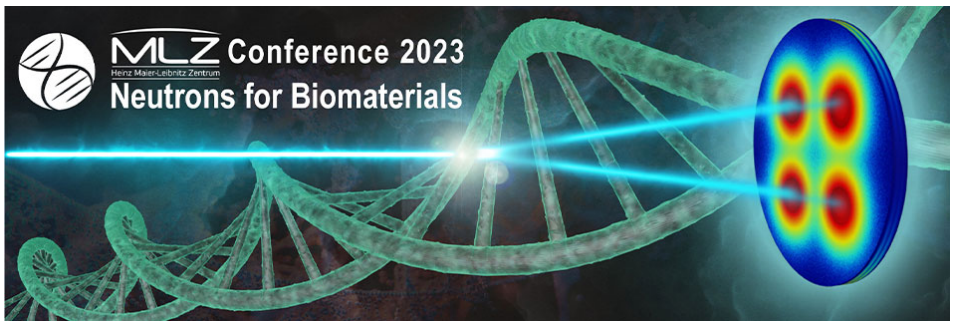
MLZ Conference 2023: Neutrons for Biomaterials



Report of Contributions

https://indico.frm2.tum.de/e/mlz-conference2023

Contribution ID: **2** Type: **Invited talk**

Degradable metallic implants: Details of the Magnesium-Bone Interface

Tuesday, May 23, 2023 10:40 AM (40 minutes)

Magnesium (Mg) and its alloys degrade under physiological conditions, which makes them interesting implant materials especially for osteosynthesis and cardiovascular applications. But how strong is the connection between the implant, the corrosion layer and the surrounding tissue, namely bone? Biomechanical approaches like push-out tests have shown that a degraded Mg-pin is surprisingly well connected with the bone irrespective the brittle look of the degradation layer. Still, not much is understood about how the degradation process proceeds in a living system because the correlated processes are highly complex and sufficient data describing the degradation *in vivo* is missing. Many chemical reactions take place in parallel and the living cellular environment can actively participate in the degradation process by altering not only the degradation rate but also the composition of the degradation layer underneath cells which is eventually remodeled into bone matrix. Therefore, we have to include the biological environment and response together with the microstructure and surface properties to tailor the degradation rate.
This presentation will outline how especially X-ray and neutron methodologies deliver valuable insights into the close interplay between microstructure, material degradation and biological response.

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Presenter: WILLUMEIT-RÖMER, Regine

Session Classification: Hybrid biomaterials

Track Classification: Hybrid biomaterials

Contribution ID: **3** Type: **Talk**

Kinetics of wood pretreatment using ionic liquids

Tuesday, May 23, 2023 4:40 PM (20 minutes)

It is known that ionic liquids enhance the exploit of resources from pretreated wood. More cellulose and lignin is made available as valuable chemicals for biodegradable products. We monitored the pretreatment process of beech wood by an ionic liqiud in operando using small angle neutron scattering. In this dynamic process we could identify three stages: (1) the impregnation, i.e. the flooding of the wood by the liquid, (2) the formation of small voids on the nanoscale, and (3) the formation of restructured nanocellulose fibrils on larger scales. In the first two stages the ionic liquid is rather confined that finally leads to swelling and the fracture of the cell walls. All of this is set in context with findings from other authors, and with the next step of enzymatic hydrolysis.

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Presenter: Dr FRIELINGHAUS, Henrich (JCNS)

Session Classification: Biomaterials for sustainability

Track Classification: Biomaterials for sustainability

Contribution ID: **4** Type: **Invited talk**

Multi-responsive nanostructured materials for the targeted delivery of anticancer agents

Tuesday, May 23, 2023 8:30 AM (40 minutes)

Abstract. Novel, multifunctional nanoparticles and hydrogels that exhibits a unique set of properties for the effective treatment of cancer are presented. The materials are comprised of polypeptidic and polyethylene oxide polymers that are a non-cytotoxic polymer. The amphiphilic hybrid materials assemble in aqueous media to form micelles or vesicles, comprised of an outer hydrophilic corona of PEO chains, and a pH- and redox- responsive hydrophobic layer based on poly(L-histidine) (PHis) and poly(L-cystein) (PCys). Due to the presence of the thiol groups of PCys, a crosslinking process was achieved further stabilizing the nanoparticles (NPs) formed. Dynamic Light Scattering, Static Light Scattering and Transmission Electron Microscopy were utilized to obtain the structure of the NPs. Moreover, the pH- and redox-responsiveness in the presence of the reductive tripeptide of glutathione (GSH) was investigated at the empty as well as the loaded NPs. The ability of the synthesized polymers to mimic natural proteins was examined by Circular Dichroism, while the study of zeta potential revealed the "stealth"properties of NPs. The anticancer drug doxorubicin (DOX) was efficiently encapsulated in the hydrophobic core of the nanostructures and released under pH- and redox- conditions that simulate the healthy and cancer tissue environment. It was found that the topology of PCys significantly altered the structure as well as the release profile of the NPs. Finally, in vitro cytotoxicity assay of the DOX-loaded NPs against three different breast cancer cell lines showed that the nanocarriers exhibited similar or slightly better activity as compared to the free drug, rendering these novel NPs very promising materials for drug delivery applications.
Hybrid-polypeptidic materials formed injectable in situ forming quickly self-healing hydrogels, responsive to alteration of pH and increase of temperature. The connection between the alteration of secondary structure of the polypeptides with the viscoelastic behavior was revealed by means of Rheology and Circular Dichroism. Small-Angle Neutron Scattering and Scanning Electron Microscopy were employed to shed light to the structure of the polymers and how it affects their rheological properties. The results suggest that these biomaterials have the potential to be used in a number of bioapplications like drug delivery.

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Session Classification: Peptides, polymers and gels

Track Classification: Peptides, polymers and gels

Contribution ID: **5** Type: **Invited talk**

Optimization of SANS data in multiparameter spaces by Monte Carlo and Bayesian modelling

Small angle neutron scattering (SANS) is a powerful experimental technique for the investigation of soft matter and in particular biomaterials thanks to the high contrast between hydrogenated and deuterated components and its spatial resolving power in the nm scale (1-100 nm). We have used SANS to obtain details on the morphology of biomaterial nanostructures which often form multiple populations of particles in size and shape and furthermore can be organized hierarchically [1-3]. Model-dependent scattering functions which cover a vast number of scattering objects, e.g., spheres, cylinders, core-shell micelles, fractal structures etc. and their combinations are used to fit the collected experimental data, to confirm the existence of the different structural species and probe the organization at different length-scales. Monte Carlo simulated annealing algorithms have been proven a versatile tool for SANS data optimization, however, increasing the complexity of the scattering models leads to an increase of the number of the optimization parameters. This brings up the question of the independence between the fitted parameters and the validity of the applied models. In order to clarify such issues in data analysis, a Markov Chain Monte Carlo (MCMC) algorithm [4, 5] is applied to obtain the posterior distributions of the fitted parameters and naturally extract their uncertainties and mutual dependencies. The application of Bayesian inference will be presented with examples from vesicular systems with polydisperse size and lamellarity [6, 7] and self-assembling doubly responsive copolymers [8]. These works illustrate the potential of Bayesian analysis for the optimization of SANS from biomaterials using models with large number of optimization parameters.

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Session Classification: AI for biomaterials

Track Classification: AI for biomaterials

Contribution ID: **6** Type: **Talk**

Multivalent counterions-induced unusual stability of re-entrant protein against different denaturants

Wednesday, May 24, 2023 1:15 PM (20 minutes)

Protein solution undergoes a re-entrant phase transition from one-phase to two-phase and then back to the one-phase in the presence of tri and tetravalent counterions [1]. Tri and tetravalent (unlike mono and divalent) counterions induce short-range attraction between the protein molecules, leading to the transformation from one-phase to two-phase system. The excess condensation of these higher-valent counterions in the double layer around the BSA causes the reversal of charge of the protein molecules resulting into re-entrant of the one-phase, at higher salt concentrations. Taking the benefit of charge condensation of multivalent ions around BSA protein, we have demonstrated the unusual stability of the protein against commonly used denaturants such as temperature and ionic surfactant using small-angle neutron scattering (SANS) [2]. Unlike monovalent counterions, which promote the denaturants-induced protein unfolding, the unfolding is restricted in the presence of multivalent ions. The observations are beyond the scope of general understanding of protein unfolding and are believed to be governed by the ion-ion correlations driven strong condensation of the multivalent ions.

References

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Presenter: SAHA, Debasish (FZ Juelich)

Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **7** Type: **Talk**

Targeted drug delivery through nanoparticle optimization by small angle scattering

Monday, May 22, 2023 4:20 PM (20 minutes)

Effective therapeutics may be enabled by drug targeted delivery and optimized cellular penetration. Ideally drugs are specifically directed to the site of action to minimize side effects and optimize the therapeutic action. Off target drug delivery decreases the therapeutic index of a particular pharmacological treatment, particularly in the case of cyto-toxic drugs. In this work we have explored nanoparticles self-assembled from designer block co-polymers under specific solvent conditions as drug carriers. These particles offer an effective method to partition small hydrophobic drug molecules which can then be administered and target specific sites in the body. Small angle X-ray (SAXS) and neutron (SANS) scattering have provided important microscopic information to further optimize the delivery of drugs through the tailoring of particle morphology. Small angle scattering is ideally suited to probe particle structure and arrangements in situations which are close to physiological milieu. This perspective has been used to link particle morphology to two important aspects of targeted delivery: as a means to modulate the hydrodynamic interaction in blood flow for enhanced vascular delivery; and together with the locus of drug solubilization, these aspects have been correlated with cellular uptake and cytotoxicity.

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Presenter: GARVEY, Christopher (MLZ)

Session Classification: Nanomedicine

Track Classification: Nanomedicine

Contribution ID: **8** Type: **Poster**

Interactions with cellulose surfaces

Tuesday, May 23, 2023 5:20 PM (1h 10m)

Cellulose is the predominant polymer of the biosphere. An understanding of the interaction of cellulose surfaces with different kinds of adsorbed molecules is key to many fundamental questions in biological, environmental and materials sciences. Unlike other biopolymers, the synthases for cellulose polymerize the monomer (glucose) directly into the nanostructure, unitary crystallites called microfibrils. This mode of synthesis imposes, due to the crystallographic packing of the cellulose chains, a well defined surface chemistry and thus interactions to adsorb molecules on cellulose surfaces. Here we have examined and discuss the interaction of a simple model protein adsorbed from solution with a model flat cellulose surfaces with neutron reflectivity. Smooth deuterated cellulose films were prepared from reconstituted and spin coated bacterial as the substrate in order to optimize the contrast between the protein and the cellulose layer. A contrast variation series of the water sub-phase was performed to estimate the density of cellulose chains in the cellulose film. From this compositional information we draw inferences to the density of hydroxyl groups on the cellulose surface and compare this with the density of hydroxyl's on a microfibril surface. information we draw inferences to the density of hydroxyl groups on the cellulose surface and compare this with the density of hydroxyl's on a microfibril surface.

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Presenter: Dr GARVEY, Christopher (MLZ)

Session Classification: Poster session

Track Classification: Biomaterials for sustainability

Contribution ID: **9** Type: **Talk**

Polymer Brushes: topology variation and influence on nanoscale hydration

Monday, May 22, 2023 2:30 PM (20 minutes)

By utilizing time-of-flight neutron reflectometry (ToF-NR) under different relative humidity, we demonstrate that polymer brushes constituted by hydrophilic cyclic macromolecules exhibit more compact conformation with lower roughness compared to linear brush analogues, due to the absence of dangling chain ends extending at the interface. [1] In addition, due to increased interchain steric repulsions, cyclic brushes feature larger swelling ratio and increased solvent uptake with respect to their linear counterparts presenting the same composition and comparable molar mass. Moreover, the two topologies exhibit differences in ageing, upon repetitive cycling/drying trials. To correlate the equilibrium swelling ratios as a function of relative humidity for different topologies a new form of the Flory-like expression for equilibrium thicknesses is proposed. The relative humidity represents the chemical potential balance between brush and surrounding environment. The Flory-like expression, which has been utilized so far for thin polymer films, breaks down for the cyclic brush. Additional topological contributions need to be taken into account in this expression, in order to rationalize differences reflected in swelling ratios and solvent content between the linear and cyclic polymer brush topologies.

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Session Classification: Biomimetics and alive systems

Track Classification: Biomimetics and alive systems

Contribution ID: **10** Type: **Poster**

Understanding the Aggregation Kinetics and Conformational Changes in Amyloid-β42 (Aβ42) in Presence of Neuronal Phospholipids

Tuesday, May 23, 2023 5:20 PM (1h 10m)

Amyloid β42 (Aβ42) is predominantly found in the form of plaques in the brain tissues and stems the cognitive dysfunctionality in Alzheimer's. Aβ depending upon aggregation states Aβ42-monomer (M)/β-sheets/oligomer (O)/fibril (F), and amino acid lengths affect the model membrane mimetic systems [1-4]. The plasma membrane is the first biological structure encountered by Aβ42 and can play a vital role in Aβ42 fibrillation. Here, we have extracted the brain phospholipids which mainly involve Sphingomyelins (SM), Phosphatidylcholines (PC), Phosphatidylethanolamines (PE), Hexosylceramides (HCER) and Free Fatty Acids (FFA). We have studied the Aβ42 fibrillation and conformational changes in the presence of neuronal phospholipid unilamellar vesicles (ULV). The ULVs are characterized by dynamic light scattering (DLS) and Cryo transmission electron microscopy (CryoTEM). The hydrodynamic radius of ULVs was 65±15 nm and the diameter was 90 nm, averaged over all the CryoTEM images, using DLS and CryoTEM respectively. The monomeric Aβ42 (Aβ42-M) mixed with ULVs at 0.3w/v% and characterized by CryoTEM. ULVs bilayer remains intact with the freshly prepared Aβ42-M. However, Aβ42-M strongly interact with the ULVs and aggregate to form Aβ42-fibril (F). CryoTEM images showed that Aβ42-M aggregates and encapsulates the ULVs forming a necklace structure and also impairment of the ULVs bilayer was observed. Furthermore, Aβ42 mainly remains in β-sheet form, however, with neuronal phospholipids, it transforms into α-helix. This suggests that Aβ42 strongly associated with neuronal phospholipids which can play an important role in Aβ fibrillation and conformation.

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Presenter: DUBEY, Purushottam (JCNS - 4)

Session Classification: Poster session

Track Classification: Lipids and membranes

Contribution ID: **11** Type: **Poster**

KWS-X: A SAXS/WAXS Laboratory Beamline at JCNS-MLZ

Tuesday, May 23, 2023 5:20 PM (1h 10m)

The new customized SAXS/WAXS instrument from XENOCS have be installed in the JCNS SAXS-Lab1 from the end of 2021. As a young member of our small angle scattering instrument by using X-ray as beam, the new instrument is equipped with a high flux metal-jet source and a moveable Eiger 2R4M SAXS detector. With additional 4-axis motorized WAXS detector and Bonse-Hart USAXS the scattering vector q can cover a wide area from 0.0002 to 7 Å-1 corresponding to the structure from few Angstroms to Micrometers. Compared to other instruments, it also comprises a large sample environment station that can be used with ambient pressure conditions. A large number of sample environmental accessories make it possible to perform experiments at temperatures from -150oC to 1000oC, under shear, tensile, SEC-SAXS, RheoSAXS etc. The design and the plenty of sample environments make the instrument a powerful research tool for biomaterials structure investigation. It is a powerful complementary tool for our neutron scattering instruments.

Some typical applications at soft matter or biomaterials area include:
• Structure and interactions of protein, nucleic acid
• In-situ monitoring of protein conformational changes, protein aggregation
• Hierarchical structures of biomaterials, e.g. collagen, chitosan
• Drug delivery systems based on nanoparticles, vesicles or liposomes
• Characterizing monoclonal antibody-protein antigen interactions
• Structure and interaction of polymers, colloids, hydrogels, surfactants and micellers
• Determine the phase of self-assembled block-copolymers or liquid crystalline polymers
• Test the tensile properties of polymer or follow the degree of crystallinity
• Monitor the size, shape and stability of fat globules in dairy upon aging, drying and digestion
• Structure and size of polysaccharides and proteins in hydrated systems

References

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Presenter: Dr WU, Baohu (JCNS-MLZ, FZ Juelich)

Session Classification: Poster session

Track Classification: Peptides, polymers and gels

Contribution ID: **12** Type: **Poster**

Dynamics and structure in sustainable and functional biopolymer-based composite films

Tuesday, May 23, 2023 5:20 PM (1h 10m)

Hydrogel films made from responsive polymers are able to switch between a swollen (extended polymer chains) and a contracted film state (coiled polymer chains) in response to slight changes in their surroundings. In recent studies, we demonstrated the versatility of a multi-responsive diblock copolymer, containing a zwitterionic poly(sulfobetaine) and a nonionic poly(N-isopropyl acrylamide) block, in thin-film geometry. With neutron scattering techniques such as time-of-flight neutron reflectometry and grazing-incidence small-angle neutron scattering (ToF-NR, ToF-GISANS), we identified discrete thin-film states, regarding their thickness, solvent content, and morphology, which can be precisely tuned upon changing external stimuli such as temperature, relative humidity, and the composition of the surrounding solvent vapor.

In future studies, we aim for using responsive biomaterials such as cellulose, as functional materials, due to their sustainability, biodegradability, high abundance, and low cost. Recent studies focused on the structural properties of cellulose nanofibrils during dynamic processes such as swelling and drying. For a fundamental understanding of their functionality, both the structure and the internal dynamics of the moieties are important. Therefore, these future studies will have a strong focus on the investigation of dynamical parameters using neutron techniques e.g., quasi-elastic neutron scattering (QENS) or neutron backscattering spectroscopy.

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Session Classification: Poster session

Track Classification: Biomaterials for sustainability

Contribution ID: **13** Type: **Talk**

Towards an improved understanding of food emulsions via neutron scattering and neutron spectroscopy

Thursday, May 25, 2023 9:10 AM (20 minutes)

The stability of food emulsions depends -beside other effects- on a complex interplay between proteins, phospholipids, oil and water. Preparing milk-based and sustainable plant-based emulsions requires good knowledge in interfacial and emulsion stabilization mechanisms, affected by the emulsion composition. To understand these mechanisms in detail different length scales from interatomic to macroscopic distances need to be investigated.
Neutron scattering techniques provide insight into such emulsions on these length scales depending on the technique used. Combining structural information on molecular length scales from small angle x-ray and neutron scattering (SAXS and SANS) with time dependent neutron spin echo spectroscopy (NSE) allows to expand our understanding towards intermolecular interactions within the interface. These interactions are linked to the emulsion stability –the elastic properties of the protein or protein/phospholipid stabilized oil/water interface on molecular length scales. NSE provides in this combination the time dependent correlation function in reciprocal space, S(q,t), on molecular length scales and time scales in the nanosecond range relevant for thermally driven motion of mesoscopic systems such as the emulsion interfaces.
This presentation introduces the neutron and x-ray scattering techniques which broadens the classical characterization of food emulsions. Results from emulsions stabilized with ⍁-lactoglobulin as a representative milk protein, and different plant-based proteins, are presented and discussed. Contrast variation by deuteration of some components of the emulsions is applied to focus on the interfacial region, relying on the uniqueness of neutrons.
Connecting these emerging results with classical characterizations such as interfacial tension or viscoelasticity helps understanding the complex mechanisms of interfacial stability and may contribute to a knowledge driven development of sustainable food emulsions.

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Presenter: HEIDEN-HECHT, Theresia (JCNS-4)

Session Classification: Food

Track Classification: Food

Contribution ID: **14** Type: **Talk**

Exploring the limits of passive macromolecular translocation through lipid membranes

Monday, May 22, 2023 5:00 PM (20 minutes)

Translocation of macromolecules through the cellular membrane mostly occurs via pore formation involving a strong local disruption of the membrane, or via endocytosis, which requires the second translocation step –endosomal escape. Passive translocation of macromolecules is highly desirable for biomedical applications but rare due to their size, complexity, polarity, or other factors. We found that non-ionic alternating amphiphilic polymers (AAP) can generally cross lipid membranes passively without damaging the membrane.[1] The ability to tune AAP average polarity and polarity profile by changing the lengths of the building blocks and their mass ratio[2] allowed us to get many insights into the mechanism of AAP translocation mechanism and explore the limits of passive macromolecular translocation.
The translocation process was studied by time-evolution Pulse Field Gradient (PFG) NMR with the support of Neutron Reflectometry (NR) using Phosphatidylcholine (PC) lipid bilayers as model membranes. PFG NMR allows to access independently adsorption and desorption, as well as the concentration of the translocating species in/at the membrane, whereas NR is useful to describe the localization of AAP inside the membrane.
We show that the translocation process consists of a fast, molecular weight (MW) dependent AAP membrane saturation in conjunction with a slow MW-independent release process. With the help of NR we find that the AAPs with short blocks can fully solubilize in the membrane interior while translocation, whereas the AAPs having long hydrophilic blocks adsorb to the membrane only by the hydrophobic blocks leading to the translocation via flip-flop mechanism. Therefore, varying the AAP polarity profile from homogenous to block-like changes the translocation mechanism, but does not restrict the translocation. The translocation time of the AAP through lipid membranes can be varied from minutes to many hours depending on the AAP molecular weight, polarity, polarity profile, lipid composition of the membrane, temperature, and other parameters.
We believe that the detailed and systematic study of the AAP translocation phenomenon will be useful for the fundamental understanding of the macromolecular translocation processes and can lead to interesting biomedical applications.

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[2] E. Kostyurina, J. U. De Mel, A. Vasilyeva, M. Kruteva, H. Frielinghaus, M. Dulle, L. Barnsley, S. Förster, G. J. Schneider, R. Biehl, J. Allgaier, Macromolecules 2022, 55, 1552–1565.

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Presenter: KOSTYURINA, Ekaterina

Session Classification: Nanomedicine

Track Classification: Nanomedicine

Contribution ID: **15** Type: **Invited talk**

Investigating Biomembrane Mimics and Lipid-Based Biomaterial Surfaces with Neutrons

Tuesday, May 23, 2023 1:30 PM (40 minutes)

Lipids are ubiquitous constituents of biological matter, notably of biomembranes, but also widely used for biomedical applications such as drug delivery systems. To understand their biological roles and functional properties, detailed structural insights are often required. We use neutron scattering and reflectometry to characterize well-defined experimental models of biomembranes and lipid-based biomaterial surfaces. The talk will cover several examples, including the conformation of membrane-bound saccharides on the surfaces of bacteria [1], the influence of glycolipids on the properties of lipid membranes [2, 3], the interaction of antibodies and other proteins with the PEGylated surfaces of lipid-based drug delivery systems [4, 5], and the role of lipids in the prey capture slime of velvet worms [6].

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Primary author: SCHNECK, Emanuel

Presenter: SCHNECK, Emanuel

Session Classification: Lipids and membranes

Track Classification: Lipids and membranes

Contribution ID: **16** Type: **Poster**

Small-Angle and Inelastic Neutron Scattering from Polydisperse Oligolamellar Vesicles Containing Glycolipids

Tuesday, May 23, 2023 5:20 PM (1h 10m)

Glycolipids are known to stabilize biomembrane multilayers through preferential sugar-sugar interactions that act as weak transient membrane crosslinkers [1, 2]. We use small-angle and inelastic neutron scattering on oligolamellar phospholipid vesicles containing defined glycolipid fractions in order to elucidate the influence of glycolipids on membrane mechanics and dynamics.
Small-angle neutron scattering (SANS) reveals that the oligolamellar vesicles (OLVs) obtained by extrusion are polydisperse with regard to the number of lamellae, n, which renders the interpretation of the inelastic neutron spin echo (NSE) data [3] non-trivial. To overcome this problem, we propose a method to model the NSE data in a rigorous fashion based on the obtained histograms of n and on their q-dependent intensity-weighted contribution. This procedure yields meaningful values for the bending rigidity of individual lipid membranes and insights into the mechanical coupling between adjacent membrane lamellae, including the effect of the glycolipids.

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Primary authors: BANGE, Lukas; HOFFMANN, Ingo; SCHNECK, Emanuel

Presenter: SCHNECK, Emanuel

Session Classification: Poster session

Track Classification: Lipids and membranes

Contribution ID: **17** Type: **Talk**

Sustainable cellulose nanofibril-based multifunctional templates

Tuesday, May 23, 2023 5:00 PM (20 minutes)

Cellulose nanofibrils (CNF) are derived from wood and thus renewable biomaterials par excellence. There nanoscale diameter, high aspect ratio, mechanical strength, and flexibility make them ideally suited as nanoscale building blocks for replacing synthetic nanocomposite materials, membranes, and templates for organic electronics and photovoltaics. Being dispersed in water, CNF dispersions facilitate green chemistry approaches; spray deposition allows for facilitating ultra-smooth, scalable, and nanoporous thin CNF films as advanced templates for hybrid materials. They find application in biosensors, electrodes, and soft robotics. In view of circular bioeconomy, the recycling capacity of such templates is vital, and thus it is mandatory to understand their interaction with water. We hence apply grazing incidence small-angle neutron scattering (GISANS) and neutron reflectometry (NR) to investigate in situ their behaviour, such as swelling and nanoscale rearrangement, under humid environment. Our results show a remarkable structural reversibility of hybrid thin films. Applying functional layers, such as advanced green-chemistry colloids inks for optoelectronic applications, often necessitates the application of water-based dispersions on the CNF templates. Here, time-of-flight GISANS is used to elucidate the potential imbibition of the functional materials into the template and the accompanying nanostructural changes in the nanoporous CNF templates due to the interaction with water.

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Session Classification: Biomaterials for sustainability

Track Classification: Biomaterials for sustainability

Contribution ID: **18** Type: **Invited talk**

Timescale of SARS-CoV2 spike protein mediated membrane fusion

Tuesday, May 23, 2023 2:50 PM (40 minutes)

The fusion of viral and host cell membranes is a pivotal step in the infection and life cycle of any virus. Despite the massive global research interest in SARS-CoV-2 many aspects of the fusion process are still only rudimentarily understood. Biological fusion assays are widely applied to study different steps of viral-host membrane fusion, however, multidisciplinary approaches offer a broader range of parameters to study and the exact timescale of the fusion on a microscopical scale is still elusive. Here, we report the establishment of a new model system for viral fusion based on the neutron scattering behavior of tailored unilamellar lipid vesicles with specific membrane proteins, either SARS-Cov2 spike or ACE2 receptor proteins. Our target was to design individual vesicles from cellular material which only contain the membrane proteins included in the initial cellular plasma membrane and none of the organelle membranes within the cell. Thus, by protein expression on the cells, individual virion and target vesicles could be designed. The results of creating 100 nm unilamellar vesicles by extrusion were confirmed by several methods, among the dynamic light scattering as well as neutron scattering. A contrast matched fusion experiment with SANS allowed us to determine the timescale of the fusion between SARS-Cov2 virions and human host cells which speeds up by several orders of magnitude in the presence of the SARS-CoV2 spike protein.

[1] S. Jaksch et al., *Timescales of Cell Membrane Fusion Mediated by SARS-CoV2 Spike Protein and its Receptor ACE2*, in preparation.

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Session Classification: Lipids and membranes

Track Classification: Lipids and membranes

Contribution ID: **19** Type: **Invited talk**

Learning about wood nanostructure and moisture interactions with SANS

Tuesday, May 23, 2023 4:00 PM (40 minutes)

Wood is an abundant hierachical biomaterial with a wide variety of current and potential uses. The technological applications of wood range from sustainable building materials to advanced functional nanomaterials made of its smallest building blocks. The wood cell walls consists of well-oriented, elongated structural units from the molecular level to the macroscale, with water being present at all levels. Scattering methods have proven highly useful for non-destructive characterization of the composite-like structure of wood cell walls and their moisture interactions. In particular, results obtained with small-angle neutron scattering (SANS) have made a significant contribution to our understanding of the cell wall structure at the level of cellulose microfibrils (diameter 2-3 nm) and microfibril bundles (diameter 10-20 nm). SANS allows us to observe the moisture-induced swelling of the microfibril bundles, which can be analysed using the WoodSAS model [1]. It can also be used to measure the diameter of microfibril bundles in unprocessed, wet wood samples [2]. Moreover, we have utilized SANS for *in situ* experiments investigating the drying behavior of wood [3] and the exchange of liquid water within the fibrillar structures [4]. This presentation provides an overview of our recent works using SANS to learn about the nanostructure and moisture interactions of wood cell walls.

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[4] Penttilä, P.A., Zitting, A., Lourençon, T., Altgen, M., Schweins, R., Rautkari, L. (2021) *Cellulose*, https://doi.org/10.1007/s10570-021-04253-3

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Session Classification: Biomaterials for sustainability

Track Classification: Biomaterials for sustainability

Contribution ID: **20** Type: **Talk**

The role of charge for interactions intrinsically disordered proteins with bio-membranes.

Thursday, May 25, 2023 11:00 AM (20 minutes)

Intrinsically disordered proteins (IDPs) are a class of proteins that do not have a defined three-dimensional structure but may fold if a binding partner is present. In our current research we focus on the interaction of two neuronal IDPs with bio-membranes where binding to the membrane induces configurational changes or folding:
α-Synuclein (αSyn) is associated with various neurogenerative disorders, including Parkinson's disease, which is characterized by fibril formations in the human brain. αSyn plays an important role in synaptic vesicle trafficking and is involved in membrane interactions[1,2]. NMR and MD simulation showed that αSyn interacts with the membrane by partially forming α-helices, starting at the N-terminus and including a kink in the alpha helix. The fraction of αSyn in the bound α-helical state at the N-terminal increases with the amount of charged lipids in the membrane [3]. While the disordered C-terminal region stays disordered. Interaction of αSyn with differently charged lipid bicelles was measured by Circular Dichroism (CD) Spectroscopy at SOLEIL and showed increasing of α-helical structure for charged membranes.
Synaptobrevin-2 (Syb2) is a vesicle-associated integral membrane protein. Syb2 plays an important role in vesicular membrane fusion at the neuronal synapse by participating in the dynamic formation of the SNARE complex. Syb-2 anchors with a short transmembrane region to the membrane and has a large intrinsically disordered soluble region (1-96) which shows a gradually increasing rigidity from the N to C terminus that correlates with an increase in lipid binding affinity. One of the techniques is Neutron Reflectometry, which we plan to use to investigate the interaction of αSyn and Syb2 with membranes (DMPC/DMPG) of varying charge composition (fraction of negative DMPG in neutral DMPC) to examine the configuration in/at the membrane and in the adjacent solution.

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[2] Bellani et al., Common. Integr. Biol. 2010, 3, 106.
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Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **21** Type: **Talk**

HETEROPROTEIN COMPLEX FORMATION BASED ON LACTOFERRIN AND β-LACTOGLOBULIN: A SMALL-ANGLE NEUTRON SCATTERING STUDY

Thursday, May 25, 2023 9:30 AM (20 minutes)

Milk proteins exhibit wide diversity of physicochemical properties which make them attractive for many pharmaceutical and food applications. Major milk proteins are β-lactoglobulin, α-lactalbumin, serum albumin, and lactoferrin. Amongst these proteins, lactoferrin and β-lactoglobulin are considered to be the most versatile in terms of physicochemical properties and mainly due to the possibility of heteroprotein complex formation, which are of great interest in new food products development.

Heteroprotein complex formation between these two proteins can be prompted or reversed as a result of various environmental conditions, including the solution pH, salt addition, temperature, stoichiometry of the individual components, etc. Thus, in this study, the molecular interaction of human lactoferrin and β-lactoglobulin and formation of a high-degree protein complexes at pH 5.9, and the influence of molar ration of individual components, salt and temperature on our model systems were studied using small-angle scattering methods.

The results consistently displayed that the complexation between the LF and BLG occurs at pH 5.9 and the LF-2(BLG) hetero-complexes formation takes place. The solution scattering data treatment revealed that both LF and BLG in individual solutions are present as dimers of a radius of gyration 51Å and 25Å, respectively, whilst their complexes have a radius of gyration of 75Å (1:2.5 molar ratio) and 56Å (1:10 molar ratio). Moreover, when studying the effect of salt on the hetero-complexation it was shown that the interactions of BLG and LF are different in the presence of NaCl, resulting in macromolecular complexes of smaller radius of gyration from 75Å (at 0 mM NaCl) to 45Å (at 200 mM NaCl). The SANS results obtained for LF and BLG mixture at (molar ratio 1:2) investigated for thermal effect has shown that the complexes become unstable at 65°C and complete unfolding and aggregates formation takes place at the temperature of 90°C.

The experiments were performed at KWS-2 small-angle neutron scattering diffractometer operated by JCNS at the Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany. L.A. gratefully acknowledges the support from project no.: 20.80009.5007.27. R.V.E. gratefully acknowledges the national research program no: PN 23.21.01.02.

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Session Classification: Food

Track Classification: Food

Contribution ID: **22** Type: **Talk**

Effect of the chain conformation on the structure of protein single-chain nanoparticles.

Monday, May 22, 2023 2:50 PM (20 minutes)

Single chain nanoparticles (SCNPs) are unimolecular polymer chains folded or collapsed via intramolecular cross-linking under high dilution, leading to sparse conformations and a topological polydispersity similar to that of intrinsically disordered proteins (IDPs). Currently, there is great interest in expanding this technology to biodegradable and biocompatible polymers, including proteins. For this purpose, we fabricated BSA-SCNPs via intramolecular cross-linking of denatured bovine serum albumin (BSA) using disuccinimide ester linkers that mainly react with lysine moieties in a polypeptide. SANS measurements demonstrated that the denatured protein progressively shrinks along with a lowering of the scaling exponent by cross-linking, thus allowing for size control of the BSA-SCNPs.
To extend SCNPs to polypeptides, it is important to understand the role of the chain conformation of the precursor on the resulting SCNP morphology. For this, we have systematically varied the solvent conditions (pH, salt and denaturant concentrations) of BSA solutions as well as the cross-linker (length and concentration) and studied the resulting SCNPs by dynamic and static light scattering as well as small angle neutron scattering. Our results indicate that the precursor conformation has an effect on the SCNP morphology. In particular, we found that more extended precursor conformations are able to collapse more as the intramolecular cross-links are increased. In addition, a longer cross-linker is more effective in chain compaction due to its ability to form larger intramolecular loops.

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Session Classification: Biomimetics and alive systems

Track Classification: Biomimetics and alive systems

Contribution ID: **23** Type: **Talk**

Coacervation of graft double hydrophilic block polyelectrolyte with oppositely charged surfactant

Tuesday, May 23, 2023 9:10 AM (20 minutes)

Polyelectrolyte–surfactant (PE–S) complexes have attracted great interest because of their wide industrial applications ranging from cosmetics, detergents, food technology and paints to drug delivery. It is well-known fact that block copolymers consisting of a polyelectrolyte block and a neutral hydrophilic block (double hydrophilic block polyelectrolytes, DHBP) co-assemble in aqueous solutions with oppositely charged ionic surfactants in core-shell nanoparticles which have cores formed by water-insoluble polyelectrolyte-surfactant complex. Such complexes can form a number of diverse morphologies depending on polyelectrolyte and surfactant chemical composition, on their ratio and on mixing conditions (e.g., spherical or cylindrical micelles and vesicles) in a broad range of sizes. Although, many of the similar systems have been already described in the literature, the detailed knowledge about PE-S complexes based on graft copolymers with polyelectrolyte backbones and neutral hydrophilic grafts is still missing.

In this communication, we investigated the co-assembly of fully-ionized poly(methacrylic acid-co-polyethyleneglycol methacrylate) (PMAA-PEGMA) graft DHBP and oppositely charged cationic surfactant N-dodecylpyridinium chloride (DPCl) in alkaline solution. The results demonstrated the influence of polymer morphology on assembly behavior by revealing that association of graft DHBP differs from that of linear one and from homopolyelectrolytes resulting in formation of micrometer-sized coacervate particles[1]. The investigation was focused on resolving structural and dynamical characteristics of the system combining light, X-ray, neutron scattering with DOSY NMR and neutron spin echo (NSE) experimental techniques. We have shown the formation of two types of DPCl micellar structures forming the PE-S complex with PMAA-PEGMA chains in the system: (i) small elongated micellar aggregates with fast diffusion and (ii) large aggregates of densely packed micelles with a slow diffusion, presented only in coacervate phase[2].

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Session Classification: Peptides, polymers and gels

Track Classification: Peptides, polymers and gels

Contribution ID: **24** Type: **Invited talk**

Challenges in the structure and dynamics of transport in the stratum corneum

Monday, May 22, 2023 1:50 PM (40 minutes)

The outermost layer of mammalian skin, called the stratum corneum (SC), constitutes a self-healing barrier against moisture loss and ingress of foreign substances. The SC comprises flat "bricks" (50-100 micron wide and 1 micron thick corneocytes largely filled with keratins) held together by a 'mortar' of 6-10 layers of lipids (100 nm thick). The corneocytes are hydrophilic, while the lipid matrix is hydrophobic. The ability and way of a chemical to pass the SC is a key point for risk assessment and development of cosmetics.

I will present a realistic multi-scale model with which to study transport through the SC, starting with atomistic simulations on an Angstrom scale and ending with diffusion through the full SC. We explicitly calculate the defected nature of the layered structure between corneocytes and endow it with the local anisotropy such that diffusion across layers differs from diffusion within layers. We study the crossover between transcellular and extracellular transport, as controlled by the relative hydrophobicity (or lipophilicity) of a species, the anisotropic diffusivity within the lipid matrix, the relative mobilities between the lipid matrix and the corneocytes, and the different spatial dimensions of the structure. I will present a number of unanswered questions that could potentially be addressed through neutron scattering, in terms of both structure and dynamics.

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Session Classification: Biomimetics and alive systems

Track Classification: Biomimetics and alive systems

Contribution ID: **25** Type: **Poster**

Mucin –a colloidal sol: insights from scattering studies

Tuesday, May 23, 2023 5:20 PM (1h 10m)

Mucins are an important group of biomacromolecules that function as soft wet barriers to chemical transport and shear stress in the physiological milieu [1]. They are characterized by a charged and highly glycosylated linked peptide backbone and a propensity to form cross-links by a range of mechanisms. The fundamental structural unit is a bottle-brush-like morphology organized into higher level aggregates, or networks forming a gel which is resistant to flow. By virtue of domains involving hydrophilic/hydrophobic, hydrogen bonds and electrostatic interactions, mucins have a complex hierarchical structure [2]. Small angle scattering, its ability to probe the hierarchy of structure over length-scales many orders in magnitude, and its ability to characterize structure during a perturbation (e.g. shear), is an ideal method of investigation.

In this work, we study the dilute dispersions of a commercial pig gastric mucin (PGM). Bulk rheology of the aqueous dispersions exhibits a transition from Newtonian to shear thinning response with increase in mucin concentration, indicating the existence of a colloidal sol behavior. Hence, a single mucin particle comprises of an internal network of bottle-brushes, which further aggregates into globular blobs at higher concentrations. Comprehending the corresponding interactions, and possible effect of varied salt/pH conditions is of interest to biological applications. Therefore, extended small angle neutron scattering (USANS, SANS [3-5]) studies were performed in a deuterated solvent, at different mucin concentrations and increasing ionic strength. These measurements were sensitive to the radius of gyration of mucin particles, the electrostatic interactions between particles, and more importantly the electrostatically mediated intra-particle mucin chain correlations that dictate the degree of compaction within the particle.

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Session Classification: Poster session

Track Classification: Peptides, polymers and gels

Contribution ID: **26** Type: **Talk**

Polymer composition profile for controlled thermo-responsive nanoassemblies

Tuesday, May 23, 2023 9:30 AM (20 minutes)

The self-assembly behavior of amphiphiles in a polar solvent is still considered a hot topic for application strategies. Their organization into nanostructured systems has been extensively applied in bio-nanotechnology for various purposes: either mimicking biological components of lipids and proteins or bio-sensing and controlled release in materials science and drug delivery. However, the incorporation of stimulus-responsive scaffolds into the amphiphilic assemblies has introduced new possibilities for the design of advanced devices in nanotechnology applications. Here, we investigated the effect of the spatial distribution of comonomers in physiologically responsive copolymers. Copolymers containing 50% of dimethylacrylamide (DMA) monomer and 50% of N-isopropyl acrylamide (NIPAM) monomer, but with different compositional profiles, ranging from an A-B diblock copolymer to a linear gradient poly(A-grad-B) copolymer, were synthesized and the effect of the balance between molecular weight and distribution profile on the thermo-responsive proprieties was addressed. In this contribution, we explore the effect of comonomer distribution on polymer properties by different experimental techniques, i.e. dynamic light scattering, cryogenic transmission electron microscopy, nuclear magnetic resonance spectroscopy and small angle neutron scattering, and demonstrate that thermo-responsive assemblies can be used for the design of nanotechnological applications like as steric stabilizers of lipid nanoparticles1.

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Session Classification: Peptides, polymers and gels

Track Classification: Peptides, polymers and gels

Contribution ID: **27** Type: **Talk**

SANS Studies on Ionic Complexes with Biopolyelectrolytes as Components and Containing Hydrophobic Domains

Ionic assembly of biopolyelectrolytes with oppositely charged polyelectrolytes or surfactants allows to construct self-assembled colloidal systems, which are very versatile with respect to their structures and properties, such as rheology or solubilisation. This is very important for many practical applications of colloidal formulations, but increasingly requires high biocompatibility of the corresponding systems. Central to understanding the properties of such systems is the knowledge of their mesoscopic structure, as it can nicely be obtained by a combination of small-angle neutron scattering (SANS) and static and dynamic light scattering.
For the formation of such complexes we employed as biopolycation differently modified chitosan and the anionic surfactant alkylethoxycarboxylate, which is also biocompatible. The structures formed by this combination are largely controlled by the self-assembly properties of the surfactant, which is governed by its packing parameter and can be modified by pH. Here, depending on the composition of the systems and pH one can switch from globular aggregates containing compacted micelles to vesicles, whose lamellarity can be controlled. As another alternative the anionic hyaluronic acid has been studied with a variety of different cationic surfactants. In these complexes mostly a network of hyaluronic acid is seen, but it becomes modified by the presence of the surfactant, little affecting the rheology of the system but forming more or less extended regions of surfactant assemblies in this network. In summary the structuring in such systems is driven by the combination of electrostatic and hydrophobic interactions and this interplay leads to structures that vary widely in size and internal structure, depending on for biopolyelectrolytes one has the particular situation of typically having a polysaccharide backbone. This backbone modifies the formed structures and appropriately tailoring the systems one can exert control the colloidal structures and their properties. For understanding them SANS experiments play a crucial role.

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Session Classification: Hybrid biomaterials

Track Classification: Hybrid biomaterials

Contribution ID: **28** Type: **Poster**

Berberine loaded liposome system structure investigated by SANS and SAXS

Tuesday, May 23, 2023 5:20 PM (1h 10m)

In the recent years, plant extract became more and more used, worldwide in allopathic treatment of different types of disease associated symptoms. Several studies showed that plant extracts containing a certain alkaloid, known as berberine, has different beneficial effects such as antitumoral effect (Andreicuț et all, 2019; Milata et all, 2019). Other effect of these berberine based plant extract, are antioxidant and anti-inflammatory (Andreicuț et all, 2018).
Liposomes are concentrical bistratified vesicles, in which the liquid phase is fully locked in a double lipidic layer, mainly made of synthetic or natural phospholipids. One liposome can be synthesized in different forms, such as unilamellar and multilamellar vesicles (Shukla et. All, 2018).
Since berberine is an instable alkaloid (Duong et. all, 2021) and vegetal extracts of interest for our study (Berberis vulgaris, Mahonia aquifolium and Phellodendron amurese) have a considerable amount of berberine, we can assume that enclosing them into liposomes would offer them a more chemical stabile form, compared with the use of these extracts as they are (in a freeway). The vegetal extracts were obtained through cold percolation method (Pârvu et. all, 2013), with plant parts collected from „Alexandru Borza"Bothanical Garden, Babeș-Bolyai University, Cluj-Napoca, Romania.
For obtaining more information about our systems, such as form and structure, we have considered using small angle X-ray and neutron scattering (SAXS and SANS) methods. Our systems were composed from unilamellar vesicles (ULV), multilamellar vesicles (MLV) and our vegetal extracts of interest: Berberis vulgaris, Mahonia aquifolium and Phellodendron amurese. The vesicles were obtained from Dimyristoylphosphatidylcholine –DMPC. SANS measurements were performed at the YuMO neutron spectrometer at the IBR-2 reactor, Frank Laboratory of Neutron Physics and SAXS measurements were performed at BioSAXS instrument, BM29 beamline, European Synchrotron Radiation Facility.
From the obtained data we can say that our systems have demonstrated a stabilizing effect of the vegetal extracts, but in the case of Mahonia aquifolium this effect was more visible. We can also say that tempeature does not influence the stability or the structure of the systems. Also with the obtained data we can make theoretical models for our systems, to see their form and structure more clear.

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Session Classification: Poster session

Track Classification: Lipids and membranes

Contribution ID: **29** Type: **Talk**

SANS from foams

Tuesday, May 23, 2023 11:40 AM (20 minutes)

Foams are a complex material with a rich structural hierarchy. Aqueous foams in particular change their structure over time due to processes like gravitational drainage, Ostwald ripening and coalescence. Because of this complex structure, modelling SANS curves obtained from foams is challenging. Here, a newly developed model, describing SANS data of foams, is presented. The model takes into account the geometry of the foam bubbles and is based on an incoherent superposition of reflectivity curves, arising from the foam films, and a small-angle scattering (SAS) contribution from the Plateau borders. We present results obtained from foams stabilized by (i) a standard cationic surfactant ($C_{14}TAB$) and (ii) temperature responsive pNIPAM-microgels - both with different water contents, i.e. drainage states, that provides information about the thickness. The approach points the way to the investigation of protein (β-lactoglobulin, casein, bovine serum albumin) stabilised foams, for which we will present preliminary thin film pressure balance results.

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Session Classification: Hybrid biomaterials

Track Classification: Hybrid biomaterials

Contribution ID: **30** Type: **Talk**

Redefining our understanding of drug loaded polymer micelles using neutron, synthesis and molecular modelling

Monday, May 22, 2023 4:40 PM (20 minutes)

Over the last decades, our understanding of drug loaded micelles was simple. The core dissolves and protects the drugs, the micelle corona ensures stealth properties and ensures colloidal stability. Using a wide variety of analytical tools, including neutron scattering, NMR spectroscopy, synthetic variations and in silico molecular modeling, we have found conclusive evidence that this simplistic view does not reflect experimental realities. Accordingly, we suggest to significantly overhaul our view, models and cartoons of drug loaded to reflect on updated vision, wherein the hydrophilic corona is actively engaged in drug interactions and thereby critical for drug solubilization, biodistribution and therapeutic efficacy.

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Presenter: LUXENHOFER, Robert (University of Helsinki)

Session Classification: Nanomedicine

Track Classification: Nanomedicine

Contribution ID: **31** Type: **Talk**

Mapping of a Mouse Brain Slice using Neutrons

Tuesday, May 23, 2023 2:10 PM (20 minutes)

To elucidate the function of the brain, one needs to understand in detail the structural organization of the connectomes, i.e., the spatial architecture of the nerve fibers in the brain [1]. Various imaging techniques such as diffusion MRI, OCT, 3D PLI, etc., have been extensively used to address this issue [2-4]. Recently, X-ray have been used to study the nerve fibers in a brain slice [5]. In this case, neutrons are used to scan an entire brain section of a reeler mouse at small angle scattering geometry [6]. Interesting scattering patterns are obtained from the different parts of the section. The orientation and distribution of the nerve fibers in the brain and their degree of orientation are extracted from the scattering anisotropy. The assembly and orientation of the myelin sheaths in the brain section are estimated simultaneously from the myelin diffraction peaks. These neutron scattering results are validated with the fiber orientation map (FOM) of 3D polarized light imaging (3D-PLI). Further insights into scattering-based imaging techniques for mapping nerve fibers in a brain are discussed.

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Session Classification: Lipids and membranes

Track Classification: Lipids and membranes

Contribution ID: **32** Type: **Talk**

Complementary approaches to obtaining thermodynamic parameters from protein ligand systems: challenges and opportunities and a case for neutrons

Thursday, May 25, 2023 11:20 AM (20 minutes)

Protein ligand interactions play an important role in biology and in order to influence this process in a targeted way increased understanding is necessary. The binding process is heavily influenced by its thermodynamic parameters. While the overall change in enthalpy can be easily measured using isothermal titration calorimetry (ITC) and the change in entropy and Gibbs free enthalpy then calculated this does not provide information about the individual components of these contributions. This presentation aims to discuss how the different components that are responsible for the total change in entropy can be isolated using different complementary techniques, as well as what the challenges faced for each method are and how they might be overcome or mitigated. All discussions will be based on the system of streptavidin and biotin which will be used as a model system. Upon protein ligand binding, changes of conformational entropy occur in protein and hydration layer, as well as internal dynamics. In this study the binding of biotin to the tetramer streptavidin was investigated using quasi-elastic neutron scattering (QENS), as well as Thermal Diffusion Forced Rayleigh Scattering (TDFRS) and ITC. This specific interaction is enthalpy driven, with an opposing entropic component. An experimental investigation of the components of the entropy change, specifically the change in conformational entropy, indicates a change in conformational entropy strongly opposed to the binding. The adverse change in entropy therefore has to be compensated, with the strongest candidate being a supportive change in the entropy of the surrounding hydration layer. It is also of note that while the change in conformational entropy upon saturation with biotin is on the same order of magnitude as that of protein folding, no significant structural changes take place during the binding process.

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Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **33** Type: **Invited talk**

Structure and dynamics during hydrophobic collapse of elastin-like polypeptides

Wednesday, May 24, 2023 10:40 AM (40 minutes)

Elastin-like polypeptides (ELPs) are versatile responsive biopolymers used in a range of biomedical applications such as drug delivery, protein purification and tissue engineering in the last decade. ELPs mimic a hydrophobic amino acid repeat segments of elastin which is a key protein of the extracellular matrix, and provides elastic properties to biological tissues –such as lung and ligaments –with extraordinary long-term stability and resilience. Elastin and ELPs undergo a hydrophobic collapse upon crossing a lower critical solution temperature (LCST), which can cause both compaction of individual chains, and the formation of ELP condensates. Although key to the elasticity of elastin and the stimulus-response of ELPs, a comprehensive mechanistic characterization of the collapse in terms of dynamical and structural evolution is so far missing.
We report on an integrative research program combining dynamic and static scattering techniques with computer simulations. To study the interaction between amino acid segments, we first study a short ELP chain of 18 amino acids. From dynamic light scattering (DLS), we obtain a clear signature of chain assembly, which is also supported by an increasing size using small-angle neutron scattering (SANS). Computer simulation show that these short ELPs collapse only mildly, but show a temperature-induced attraction and form transient complexes [1]. Interestingly, the chains remain extended in simulations, while at the same time the complexes appear more compact after collapse based on the scattering signature. Finally, the chain dynamics explored by quasi-elastic neutron scattering (QENS) shows no strong dynamic transition, evidencing very dynamic, fluid-like assemblies.
Experimental signatures for longer ELP chains show a more diverse behavior with significant effects both on structure and dynamics as seen from QENS, SANS and DLS. Despite stronger chain collapse, we still obtain a high dynamic flexibility, rejecting earlier explanations for the hydrophobic collapse based on the formation of specific secondary structures. Finally, we use time-resolved small-angle X-ray scattering after a temperature jump induced by an IR laser to follow the millisecond structural evolution of hydrophobic collapse and formation of condensates, which shows a complex behavior.

[1] TI Morozova, NA García, O Matsarskaia, F Roosen-Runge, J-L Barrat: Structural and Dynamical Properties of Elastin-Like Peptides near Their Lower Critical Solution Temperature, Biomacromolecules 2023, in press, doi:10.1021/acs.biomac.3c00124

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Presenter: ROOSEN-RUNGE, Felix (Malmö University)

Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **34** Type: **Poster**

Enzymes in Microemulsions or Where does an enzyme reside in a sponge?

Tuesday, May 23, 2023 5:20 PM (1h 10m)

The substrates of enzymes are often insoluble in water. Protein molecules, however, are usually hydrophilic. Nature overcomes this problem by compartmentalization of the cytoplasm and by generating huge interfaces between polar and apolar regions inside the different relevant organelles. For biotechnological applications an approach mimicking this compartment formation has already been successfully employed . This is the use of microemulsions being thermodynamically stable mixtures of water and oil forming nanoscale compartments stabilized by surfactants and sometimes co-surfactants.
Enzymes within a microemulsion can on the one hand be affected in their structure and function by the complex environment of the microemulsion and on the other hand, with their presence, alter the phase structure of the microemulsion and the properties of the amphiphilic interface.
We were curious how a combination of laboratory and scattering techniques makes it possible to shed light on this complex situation. We discuss the cases of two enzymes inside bicontinuous microemusions as examples: the lipase from Candida antarctica B (CalB) and the diisopropyl fluorophosphatase (DFPase) from the squid Loligo vulgaris. The time-averaged structure was determined from SANS measurements and on the nanosecond time scales the fluctuations of the amphiphilic film were probed with NSE. The results show, that adsorption/desorption mechanisms of CalB at the surfactant monolayer lead to a stiffening of the interface while in the case of DFPase the interface remains unaffected.
The approach we suggest makes it possible to comprehensively investigate the biotechnological usability of enzymes in microemulsions.

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Presenter: HOLDERER, Olaf

Session Classification: Poster session

Track Classification: Lipids and membranes

Contribution ID: **35** Type: **Poster**

KWS-1 - the versatile SANS instrument for biomaterials

Tuesday, May 23, 2023 5:20 PM (1h 10m)

The method of small-angle neutron scattering (SANS) is highly versatile. Using deuteration many hydrogen containing materials can be highlighted against the residual matrix. This is also highly beneficial for biomaterials. Either synthetic polymers or deuterium grown proteins and lipids from bacteria are embedded in highly complex biology mimicking environments such that their specific function can be analyzed. Several examples will be presented to show the strength of SANS.

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Presenter: FRIELINGHAUS, Henrich (JCNS)

Session Classification: Poster session

Track Classification: Biomimetics and alive systems

Contribution ID: **36** Type: **Talk**

Pressure effect on protein cluster formation induced by multivalent ions

Thursday, May 25, 2023 11:40 AM (20 minutes)

A thorough understanding of protein interactions in aqueous solutions is crucial for many areas of research in soft matter and biology. For example, a strong interprotein attraction can lead to protein aggregation, which is observed in several pathologies such as cataract and neurodegenerative diseases.
We have shown that a patchy particle model can describe the phase behavior of a system of acidic globular proteins such as bovine serum albumin (BSA) in the presence of multivalent salts such as yttrium chloride (YCl_3). The resulting phase diagram of the studied system as a function of salt concentration and temperature is quite complex, showing reentrant condensation, metastable liquid-liquid phase separation (LLPS), cluster formation and crystallization. In particular, a lower critical solution temperature (LCST) is observed which suggests that hydration plays an essential role in the ion-mediated protein interactions.
This hydration effect is also visible by changing the solvent from normal water (H_2O) to heavy water (D_2O). It leads to an increasing attraction potential between the proteins and instead of LLPS the formation of clusters is observed. By neutron spectroscopy a slowing down of the short-time self-diffusion of the protein as a function of the number of yttrium ions per protein is observed. The effect is enhanced by increasing the temperature of the sample.
Using temperature as a control parameter has some disadvantages because temperature influences both the thermal energy and the density of the system. Furthermore, only a small temperature range is available for studying proteins since high temperatures lead to denaturation. As opposed to temperature, pressure influences only the density and can be considered to have milder effects. Here we will present the first results from pressure dependent neutron spectroscopy experiments. In contrast to the previous studies [1-3] at and above room temperature we found, that the slowing down of the short-time self-diffusion is less pronounced. This behavior of the short-time self-diffusion will be discussed with the help of pressure dependant SAXS measurements.
[1] M. Grimaldo, et al., J. Phys. Chem. Lett. 6 (2015), 2577-2582.
[2] C. Beck, et al., Soft Matter 17 (2021), 8506-8516.
[3] M. Grimaldo, et al., Quart.Rev.Biophys 52 (2019), e7.

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Presenter: WOLF, Marcell (TUM)

Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **37** Type: **Poster**

Self-assembly of alternating amphiphilic copolymers

Tuesday, May 23, 2023 5:20 PM (1h 10m)

The self-assembly of amphiphilic copolymers with alternating hydrophobic and hydrophilic blocks has garnered much attention in recent years due to the wide range of nanostructures they can form, including micelles, vesicles, and gels. In this particular study, we focus on investigating the phase behavior of in-house synthesized Alternating Amphiphilic Copolymers (CnEGm) [1] in water using small-angle X-ray scattering (SAXS). Our findings demonstrate that the phase behavior of these copolymers is influenced by several factors, such as the length of the hydrophobic Cn- and the hydrophilic blocks EGm-blocks, as well as the overall molecular weight of the polymer. Additionally, we show that external parameters such as temperature, pH, and concentration can be used to control the phase behavior of these copolymers. Furthermore, we observe that the highly ordered structure of the gel formed by this polymer has not been previously reported, highlighting the importance of exploring the structure of this polymer for potential future applications.

[1] Kostyurina, E.; De Mel, J. U.; Vasilyeva, A.; Kruteva, M.; Frielinghaus, H.; Dulle, M.; Barnsley, L.; Förster, S.; Schneider, G. J.; Biehl, R.; Allgaier, J. Controlled LCST Behavior and Structure Formation of Alternating Amphiphilic Copolymers in water. Macromolecules 2022, 55, 1552–1565.

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Presenter: SHARMA, Tulika (Forschungszentrum Juelich, Germny)

Session Classification: Poster session

Track Classification: Peptides, polymers and gels

Contribution ID: **38** Type: **Invited talk**

Tracking solution structures by scattering and modeling

Wednesday, May 24, 2023 9:30 AM (40 minutes)

Small-angle neutron scattering (SANS), combined with ab initio modeling or coarse-grain simulations, has proven to be an essential technique for obtaining structural information on proteins when classical high-resolution methods (e.g. NMR, radiocrystallography) are not possible. SANS is a low resolution technique but has the advantage of being used in solution. Above all, the "contrast matching"method, only possible with SANS, is often the only one capable of removing certain obstacles and answer relevant questions in structural biology.
SANS is particularly suited to the study of membrane proteins by literally "turning off"the signal from the membrane and thus specifically probing the structure of the protein. I will illustrate this feature in two studies of membrane proteins:
(i) Structural changes of dystrophin, a filamentous peripheral membrane protein supporting the plasma membrane of muscle cells. Its absence due to genetic mutations leads to the severe Duchenne muscular dystrophy. Most of dystrophin consists of a central domain, made of 24 coiled-coil repeats. We probed by SANS, using stealth phospholipid bicelles, the solution structure of the R1-3 fragment, which is known to interact with membrane lipids.
(ii) The structural investigation of TSPO translocator protein, a ubiquitous and functionally important membrane protein of about 18 kDa, used as a marker in many brain diseases in humans. For mammalian TSPO, no crystals have yet been obtained and high-resolution structure determination remains challenging. We study the structure of mouse TSPO (mTSPO) in different amphiphilic environments, from detergents and lipid/detergent mixtures to more biomimetic environments such as nanodiscs.

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Presenter: COMBET, Sophie (LLB)

Session Classification: AI for biomaterials

Track Classification: AI for biomaterials

Contribution ID: **39** Type: **Poster**

Establishment of the SEC-SANS option at KWS-2 in MLZ

Tuesday, May 23, 2023 5:20 PM (1h 10m)

This contribution introduces the newly established sample environment at the small-angle neutron scattering (SANS) diffractometer KWS-2 at the neutron source Heinz Maier-Leibnitz (MLZ, Garching, Germany): the in-situ size exclusion chromatography (SEC) directly followed by SANS measurements, the SEC-SANS setup. The motivation is the growing demand from users interested in bio-molecular samples where the single-particle structure is the investigation target. However, many of such systems are prone to form aggregates, which then coexist with the interested single ones. Thus, an in-situ separation is necessary shortly before SANS data collection, for the sake of obtaining the scattering of individual particles.
The main features of the SEC-SANS setup at KWS-2 include: (1) Dual-pump that allows simultaneous elute and rinse of two columns (2) Auto-sampler that allows programmed injection of samples in desired series (3) Both UV and RI detectors (4) Switching valve installed before the purified sample flowing into the SANS cell (5) A second UV-vis setup installed to detect the purified samples flowing into the SANS cell, and (6) Possibility to perform SEC-SANS-MALS measurement, to determine molecular weight independently.

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Session Classification: Poster session

Track Classification: Proteins

Contribution ID: **40** Type: **Poster**

Exploring dynamic processes in biological systems with SPHERES

Tuesday, May 23, 2023 5:20 PM (1h 10m)

The neutron backscattering spectrometer SPHERES (SPectrometer for High Energy RESolution) at MLZ is a third generation backscattering spectrometer with focusing optics and phase-space transform (PST) chopper. It covers a dynamic range of ± 31μeV with a high resolution of about 0.66μeV and a good signal-to-noise ratio. The instrument performance has been improved over the recent years by different measures. The intensity has been more than doubled by the upgrade of the PST chopper and the focusing guide. The signal-to-noise ratio can be significantly improved by employing the new background chopper.
SPHERES enables investigations on a broad range of scientific topics. It is in particular sensitive to the incoherent scattering from hydrogen and allows to access dynamic processes up to a timescale of a few ns. Therefore it is well suited to study dynamic processes in various biological systems. Selective deuteration allows for example to follow the mobility of the different components in a polymer-protein hybrid (G.Schirò et al., Phys. Rev. Lett. 126, 088102 (2021)) or to measure internal protein motions (A. Stadler et al., J. Phys. Chem. B 123, 7372 (2019)).

Primary author: ZAMPONI, Michaela (Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at Heinz Maier-Leibnitz Zentrum)

Presenter: ZAMPONI, Michaela (Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at Heinz Maier-Leibnitz Zentrum)

Session Classification: Poster session

Track Classification: Proteins

Contribution ID: **41** Type: **Poster**

To pump or not to pump: Combining several scattering and optical absorption methods following the formation of biomaterials.

Tuesday, May 23, 2023 5:20 PM (1h 10m)

In this contribution we discuss the use of a circulating liquid sample pumped by a peristaltic pump through the cuvettes of different scattering or absorption techniques in order to follow processes in biomaterials formation in time. The tested techniques are UV-Visible spectroscopy, Circular Dichroism, infrared spectroscopy or static light scattering, further more we used small angle x-ray or neutron scattering. As a test sample we investigated the formation of amyloid like structures in insulin at pH 2. Using the amide I band, infrared (IR-) spectroscopy can give information on the fold of the protein and also allows to follow aggregation phenomena. Small angle neutron scattering reports on the global structure of proteins in solution and can give information on the shape of growing aggregates or folded proteins in solution. This is why the two techniques deliver complementary information on the observed process. Since the process of amyloid formation is not very reproducible, the results of different techniques cannot be correlated to each other when they are measured one after the other on different samples. Even if one prepares the sample with great care, the lag phase of the amyloid formation is known to be not very predictable.
Furthermore, we would like to explore the capabilities of infrared spectroscopy based on quantum cascade lasers (QCLs) in combination with other techniques. The advantages of QCLs are superior Gaussian beam characteristics and a higher spectral density as compared to the glow bar infrared light sources of the Fourier-transform infrared spectrometer (FTIR). This allows to measure good quality IR spectra within one second. Their disadvantage is the more complicated pulsed mode of operation and the limited spectral width they can cover.
As a first scientific sample, the effect of a pH drop on protein aggregation and amyloid like structure formation in insulin is investigated. Insulin was dissolved in a phosphate buffer, where the pH was adjusted to 2. At room temperature the sample was pumped through varying combinations of flow through cells of the FTIR spectrometer, the QCL, the UV-Visible spectrophotometer and the static light scattering device. Thereby we could follow the amyloid like structure formation on the very same sample using many different techniques in series.
Implications for the requirements on the samples and the processes involved will be discussed in order to widen the application of the used techniques for following the formation of biomaterials in other sample systems.

Primary authors: STADLER, Andreas (FZ Jülich); RADULESCU, Aurel (Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at MLZ); FITTER, Joerg; DADFAR, Seyed Mohammad Mahdi; SCHRADER, Tobias

Presenter: SCHRADER, Tobias

Session Classification: Poster session

Track Classification: Peptides, polymers and gels

Contribution ID: **42** Type: **Talk**

Injectable hydrogels from thermoresponsive tri- and tetrablock terpolymers

Tuesday, May 23, 2023 9:50 AM (20 minutes)

Lower critical solution temperature (LCST) polymers have attracted great interest for 3D bioprinting, as they are water-soluble and form solutions at room temperature, while they form a hydrogel at body temperature [1]. The hydrogel properties depend strongly on the architecture of polymers and their concentration. Poly(ethylene glycol) (PEG) based thermoresponsive polymers are particularly promising, because PEG is a hydrophilic, biocompatible and FDA-approved polymer. Here, we address an ABC triblock terpolymer and a BABC tetrablock terpolymer consisting of the hydrophilic oligo(ethylene glycol) methyl ether methacrylate with an average Mn of 300 g/mol (OEGMA, A), hydrophobic *n*-butyl methacrylate (BuMA, B) and thermoresponsive di(ethylene glycol) methyl ether methacrylate (DEGMA, C). Dynamic light scattering (DLS) on dilute micellar solutions shows that for both, ABC and BABC, the hydrodynamic radii of the micelles increase strongly above 25 ℃, and the solutions feature a cloud point at 31-34 ℃. By small-angle neutron scattering (SANS) on 15 wt% polymer solutions, the structural changes at the origin of the gel formation were identified: While the triblock terpolymers ABC form spherical core-shell micelles, that transform into cylinders at high temperatures, the spherical core-shell micelles formed by the BABC tetrablock terpolymers remain spherical and form loose aggregates at higher temperatures, that become more compact upon further heating. Thus, for the two architectures, the hydrogel formation proceeds via vastly different mechanisms.

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Session Classification: Peptides, polymers and gels

Track Classification: Peptides, polymers and gels

Contribution ID: **43** Type: **Invited talk**

Structure and rheology of nanocellulose interfacial layers controlling digestion

Thursday, May 25, 2023 8:30 AM (40 minutes)

The use of particles such as nanocelluloses, i.e. cellulose nanocrystals (CNC) and nanofibrils (CNF) received increasing attention for the Pickering stabilization of fluid interfaces [1]. The adsorption of nanocellulose and nanocellulose-protein composites at oil-water or air-water interfaces facilitates the formation of stable and biocompatible emulsions and foams but depends heavily on the particles'surface properties. In this contribution, we review the structure of differently designed adsorption layers by neutron reflectivity and interfacial rheology measurements as a function of physico-chemical boundaries conditions (pH, salts, enzymes) [2, 3], surface properties of the cellulose crystals (natural, methylation, esterification) [4, 5], and protein or polysaccharide addition [6]. Native unmodified CNC (hydrophilic, negatively charged, and anisotropic nanoparticles) showed negligible viscoelasticity that could be increased by charge screening due to a shift from repulsive to attractive CNC interactions. Methylated CNCs formed dense monolayers with higher dynamic moduli compared to native CNCs and could be thermo-gelled into multilayers. The esterified CNCs formed aggregated clusters at the interface, resulting in a Maxwellian frequency behavior with distinctive relaxation times, a rarely observed phenomenon for interfacial layers. Scattering length density profiles obtained from neutron reflectivity measurements are used to elucidate the thickness and roughness of the adsorption layer, and in case of nanocellulose-protein composites, their spatial composition. Supported by in vivo digestion experiments in humans we rationalize the design principles of nanocellulose-stabilized emulsions and foams for food and drug delivery vehicles [7-9].

[1] Bertsch P, Fischer P: Adsorption and interfacial structure of nanocelluloses at fluid interfaces, Advances in Colloid and Interface Science 276 (2020) 102089
[2] Bertsch P, Fischer P: Interfacial rheology of charged anisotropic cellulose nanocrystals at the air-water interface, Langmuir 35 (2019) 7937.
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[8] Scheuble N, Schaffner J, Schumacher M, Windhab EJ, Liu D, Parker HL, Steingoetter A, Fischer P: Tailoring emulsions for controlled lipid release: Establishing in vitro-in vivo correlation for digestion of lipids, ACS Appl. Mater. Interfaces 10 (2018) 17571.
[9] Bertsch P, Steingoetter A, Arnold M, Scheuble N, Bergfreund J, Fedele S, Liu D, Parker HL, Langhans W, Rehfeld JF, Fischer P: Lipid emulsion interfacial design modulates human in vivo digestion and satiation hormone response, Food & Function 13 (2022) 9010.

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Presenter: FISCHER, Peter (ETH Zurich)

Session Classification: Food

Track Classification: Food

Contribution ID: **44** Type: **Invited talk**

Application of X-ray and neutron scattering within development of RNA nanopharmaceuticals

Monday, May 22, 2023 3:40 PM (40 minutes)

The recent success of messenger RNA (mRNA) nanoparticles for vaccination against Covid-19 has highlighted the great potential of nanoparticulate pharmaceutical products for application in a wide variety of indications, including cancer.
Nanoparticles can be formed from different materials, including lipids (liposomes, lipid nanoparticles) polymers, as well as inorganic materials or hybrid formats. All of them are characterized by their colloidal nature, and their intrinsic complexity poses great challenges within pharmaceutical development.
Extended physicochemical characterization, including advanced techniques such as SAXS/SANS measurements, can contribute to the understanding of structural and functional coherencies inside these systems and provide a basis for successful development into clinical practice.
In this presentation, taking selected RNA nanoparticle formats as examples, key characteristics are described, and options to control and improve physicochemical parameters related to activity are outlined.

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Presenter: HAAS, Heinrich (Johannes Gutenberg Universität Mainz)

Session Classification: Nanomedicine

Track Classification: Nanomedicine

Contribution ID: **45** Type: **Talk**

Interaction of nanoparticles with lipid films: the role of symmetry and shape anisotropy

Tuesday, May 23, 2023 2:30 PM (20 minutes)

Nanoparticles are nowadays widely used in biology and have quickly emerged as essential to modern medicine. When nanomaterials come into contact with biological membrane, their interaction with biomacromolacules and biological barriers will determine their bioactivity, biological fate and cytotoxicity. It goes without saying that understanding the interaction between nanomaterial and biological interfaces is vital to bridge the gap between design/synthesis/engineering of nanoparticles and their full translation into end-use applications. In this context, the role of symmetry/shape anisotropy of both the nanomaterials and biological interfaces in their mutual interaction, is a relatively unaddressed issue.
Here we present the findings about the interaction of gold nanoparticles (NPs) of different shape, i.e. nanospheres and nanorods, with biomimetic membranes of different symmetry, i.e. lamellar (of 2D symmetry), and cubic (of 3D symmetry) membranes.
Through the combination of structural scattering techniques (in particular Neutron Reflectometry), we observed that, on a nanometric lengthscale, the structural stability of the membrane towards NPs is dependent on the topological characteristic of the lipid assembly and of the NPs, with higher symmetry related to higher stability. Moreover, Confocal Microscopy analyses highlight, on a micrometric lengthscale, that cubic and lamellar phases interact with NPs according to two distinct mechanisms, related to the different structures of lipid assemblies.
This study represents a first attempt to systematically study the role of membrane symmetry on the interaction with NPs; the results will contribute to improve the fundamental knowledge on nano-bio interfaces and, more in general, will provide new insights on the biological function of lipid polymorphism in interfacial membranes as a response strategy.

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Session Classification: Lipids and membranes

Track Classification: Lipids and membranes

Contribution ID: **46** Type: **Talk**

Bridging Direct and Reciprocal Space: Using Molecular Dynamics Simulations and Scattering Experiments to Study Biological Membranes

Biological membranes are primarily composed of phospholipid-based bilayers, which serve as their fundamental structural elements. In this study, we present an approach that combines experimental neutron scattering data with molecular dynamics (MD) simulations to investigate phospholipid membrane systems. Neutron and X-ray reflectometry measurements are determined by the scattering length density profile in real space. However, this profile is often challenging to retrieve unambiguously from the data alone. MD simulations predict these density profiles, but they require experimental validation. By cross-validating scattering data and MD results, we can simultaneously address both issues. We'll present the strengths and weaknesses of each technique. The complementarity between scattering methods and MD simulations is remarkable, as it not only bridges the gap between direct and reciprocal space, but also provides unique insights into each other's limitations. To facilitate these insights, we have created a new software program named Made2Reflect, which directly calculates neutron and X-ray small-angle scattering and reflectivity patterns from MD simulation trajectories.

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Session Classification: AI for biomaterials

Track Classification: AI for biomaterials

Contribution ID: **47** Type: **Talk**

Probabilistic classification of 2D Small-Angle Scattering Patterns

Wednesday, May 24, 2023 9:10 AM (20 minutes)

X-ray and neutron scattering are widely used powerful techniques for probing the physical structure of materials at the molecular and supramolecular scale. With the simultaneous advent of high-speed detectors, previously unimaginable time-resolved in situ and high throughput photon and neutron experiments have become possible, with the subsequent explosion of data volumes. Data analysis is becoming the most serious bottleneck on the way from experiment to scientific insight and final publication. We aim to provide rapid machine learning-based data classification to (i) guide decisions during the course of an experiment and to (ii) guide users as to which models are most appropriate for subsequent data analysis.

The main challenge of AI-assisted data analysis is that simulated and experimental data come from different distributions. Thus, in general case, model trained on simulated data will highly probably have a poor performance on the experimental data. We developed a methodology where the small-angle scattering patterns or 2D detector data are first transformed from (qx,qy) into (r,phi)-coordinates to become independent of the specific beam position on the detector and the specific detector pixel array format. The subsequent Fourier transform transforms the data from (r,phi)- to a real-space representation in Carthesian (x,y) coordinates. This makes use of Friedel's law and the Fourier shift theorem for a reduced presentation of the data. It is thus possible to operate with one training set for different instruments and different detectors. We used a broad range of experimental and simulated 2D-scattering data for spheres, ellipsoids, isotropic and oriented cylinders, as well as ordered lattice structures consisting of spheres, cylinders or lamellae of different degree of positional and orientational order and polydispersity.

In the present work we compare performance of probabilistic classification using variational inference neural networks for different data representations. We show, that the transformed data can be better classified compared to the original 2D-detector data, enabling a reliable fast classification of scattering patterns with the possibility for a subsequent automatized data analysis with the selected models.

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Session Classification: AI for biomaterials

Track Classification: AI for biomaterials

Contribution ID: **48** Type: **Invited talk**

Protein interactions with PEG

Wednesday, May 24, 2023 11:20 AM (40 minutes)

Protein-polymer interactions are a key point to understand and improve the activity of proteins and polymer in many bio related applications. Polyethylene glycol (PEG) is a widely used bio compatible polymer with applications reaching from antifouling, over crystallization helper to PEGylation of therapeutic drugs. Neutron scattering is an ideal method to examine protein PEG interactions because of the possibility to match PEG to D2O.
I present here examples how protein-PEG systems can be examined by SANS/SAXS combined with neutron spinecho spectroscopy (NSE) to determine interactions between PEG and proteins on nanometer length scale and a timescale up to hundred nanoseconds.
Matched hd-PEG can be used to examine the tracer diffusion of proteins in crowded environment. Matched maleimide-PEG allows to examine domain dynamics changes due to the bound maleimide-PEG. Combined SAXS/SANS analysis allows to examine hydration water and PEG protein interaction.

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Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **49** Type: **Talk**

Studying the bone-implant interface in 3D using X-ray scattering and imaging

Magnesium (Mg)-based implants are in the focus for orthopedic applications, due to their biocompatibility and biodegradability. Depending on the alloy, the degradation behavior and integration into the bone will differ. To elucidate this complex interplay which affects all hierarchical levels of bone, synchrotron radiation-based scattering and imaging techniques are used. Specifically, we have studied implants made of pure Mg, a rare-earth containing Mg-alloy (WE43) and titanium (Ti) implanted in rat bone using 3D X-ray diffraction tomography (XRD-CT) and high-resolution X-ray absorption tomography (μCT). Thus, we were able to observe differences in the volume loss and degradation rate of the implant, as well as the bone growth and its crystalline ultrastructure. The crystallite size and crystal lattice spacing of the bone surrounding pure Mg are lower than surrounding WE43, which is inversely related to their degradation rates. The information resulting from the X-ray scattering and imaging experiments is pivotal to establish and calibrate computational models of implant degradation and bone growth, in order to predict the behavior of implants that will be developed. In the future, complementary neutron-based characterization techniques could be used to enable in situ mechanical testing without impacting its mechanical properties due to radiation damage.

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Session Classification: Nanomedicine

Track Classification: Nanomedicine

Contribution ID: **51** Type: **Invited talk**

Neutron macromolecular protein crystallography – shedding light on the structure-function relationship in proteins and enzymes

Thursday, May 25, 2023 10:20 AM (40 minutes)

Proteins play a crucial role in many biological processes. For example, all chemical reactions in living cells are accelerated by many orders of magnitude by enzymes, which are proteins that are responsible for catalyzing selectively one specific chemical reaction. Proton transfer is a fundamental mechanism at the core of many enzyme-catalyzed reactions. That is why the knowledge of protonation states and H-bonding networks in the active center of enzymes is essential to understand their ligand specificity and reaction mechanism. In addition, information about orientation of water molecules and the protonation state of ligands in the active center can further aid in revealing the underlying reaction mechanism. This knowledge is often the starting point for developing tailor-made inhibitors for so-called drug-target enzymes.

Neutron single crystal diffraction provides an experimental method for the direct location of hydrogen atoms in biological macromolecules. This talk will use selected examples from the neutron single crystal diffractometer BIODIFF at the Heinz Maier-Leibnitz Zentrum to show how neutrons can help to gain information about reaction mechanisms in enzymes.

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Presenter: Dr OSTERMANN, Andreas (Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München)

Session Classification: Proteins

Track Classification: Proteins

Contribution ID: **52** Type: **not specified**

Welcome Address

Monday, May 22, 2023 1:30 PM (20 minutes)

Presenter: Prof. MÜLLER-BUSCHBAUM, Peter

Contribution ID: **53** Type: **Talk**

Molecular understanding of the structure and dynamics of supramolecular polymers

Tuesday, May 23, 2023 11:20 AM (20 minutes)

Supramolecular polymers, in which noncovalent interactions, like hydrogen bonds, keep the repeating units together, offer exciting prospects for materials with novel properties because the interactions are reversible. This is the case of diaminotriazine (DAT) and thymine-1-acetic acid (THY) (one of the nucleobases in DNA functional groups) that form heteromolecular interactions, and 2-ureido-4[1H]-pyrimidinone (UPY), building homomolecular association motives, respectively, The self-assembly of such supramolecular associations based polymers, in bulk and diluted state, have been investigated by means of neutron and X-ray scattering, rheology and dielectric relaxation spectroscopy.[1,2,3] The polymers consist of poly(alkylene oxide)s of differing polarity, i.e, of poly(propylene oxide) (PPO) and poly(ethylene oxide) (PEO).[3,4] In this talk, results on the correlation between polymer polarity, association strength of the functional end groups, and concentration on their structure and dynamics are highlighted.

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Presenter: BRÁS WÜRSCHIG, Ana (University of Cologne)

Session Classification: Hybrid biomaterials

Track Classification: Hybrid biomaterials

Contribution ID: **55** Type: **Talk**

Studying the bone-implant interface in 3D using X-ray scattering and imaging

Wednesday, May 24, 2023 8:30 AM (40 minutes)

Magnesium (Mg)-based implants are in the focus for orthopedic applications, due to their biocompatibility and biodegradability. Depending on the alloy, the degradation behavior and integration into the bone will differ. To elucidate this complex interplay which affects all hierarchical levels of bone, synchrotron radiation-based scattering and imaging techniques are used. Specifically, we have studied implants made of pure Mg, a rare-earth containing Mg-alloy (WE43) and titanium (Ti) implanted in rat bone using 3D X-ray diffraction tomography (XRD-CT) and high-resolution X-ray absorption tomography (μCT). Thus, we were able to observe differences in the volume loss and degradation rate of the implant, as well as the bone growth and its crystalline ultrastructure. The crystallite size and crystal lattice spacing of the bone surrounding pure Mg are lower than surrounding WE43, which is inversely related to their degradation rates. The information resulting from the X-ray scattering and imaging experiments is pivotal to establish and calibrate computational models of implant degradation and bone growth, in order to predict the behavior of implants that will be developed. In the future, complementary neutron-based characterization techniques could be used to enable in situ mechanical testing without impacting its mechanical properties due to radiation damage.

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Session Classification: AI for biomaterials