POLYMAT Research Seminars | 25/9 11:30

ABSTRACTS

12:00 | Martino Airoldi

Operando electro-rheology: probing of current-driven morphological transitions, ion heterogeneity, and nonlinear chain dynamics in nanostructured block copolymer electrolytes

Hierarchically self-assembling block copolymer electrolytes constitute a promising class of solid-state ion-conducting materials for next-generation battery technologies. However, under distinct galvanostatic conditions, the complexity of the interplay among ion transport, polymer dynamics, and self-assembled nanostructures means that their electrochemical-mechanical coupling remains insufficiently understood. Accordingly, this work introduces a novel in situ and operando rheo-galvanostatic characterization approach that combines simultaneous rheological and electrochemical measurements of a LiTFSI-doped polystyrene-block-poly(ethylene oxide) diblock copolymer.

In situ measurements enable the correlation of polymer segmental dynamics with electrochemical transport, revealing that polymer-backbone dynamics govern ion motion. The viscoelastic response is analyzed using the topological-entanglement-constrained Rouse model. The implementation of a Stokes–Einstein-based model demonstrates strong agreement between nanoviscosity, reflecting segmental friction, and diffusion properties derived from electrochemical measurements.

Building on these in situ observations, an operando approach enables the simultaneous real-time monitoring of viscoelastic response, morphological evolution, and ion transport under controlled DC polarization. Corroborated by transmission electron microscopy, the results provide a comprehensive view of how increasing galvanostatic perturbations and the associated salt-concentration gradients drive a self-assembled morphological transition from lamellar to gyroid-like and hexagonal structures. Notably, this methodology captures copolymer thermodynamics, enabling the construction of a phase diagram in which current-induced nanomorphologies directly map onto the theoretical phase diagram.

Mechanistic insight into the current-induced morphological evolution of the copolymer is provided by large-amplitude oscillatory shear measurements. Correlation lengths are derived for salt aggregation and interfacial growth, as well as for polymer dynamics arising from DC polarization. The resulting nonlinear response reflects the coupling between evolving ionic-aggregate heterogeneity and polymer dynamics, linking current-driven structural correlations to the intrinsic mechanical nonlinearity of the electrolyte.

12:30 | Ane Llucia Salvador

From rupture to regeneration: bioengineering 3D printed tendon replacements through different approaches

Tendons are highly resilient connective tissues that transmit tensile forces between muscle and bone. Tendon ruptures are common musculoskeletal injuries, yet current clinical treatments often fail to fully restore tissue functionality. The main challenges arise from the complex gradient structure, composition, and mechanical properties of the tendon enthesis.

Tissue-engineering strategies represent a promising alternative. However, the regeneration of full-thickness tendon ruptures remains challenging due to the lack of resilient support materials that promote tissue formation while withstanding physiological loading conditions.

To address this clinical challenge, tissue-engineered substitutes based on 3D (bio)printed elastic and resilient polymeric scaffolds have been developed using two different strategies: 3D-bioprinted, cell-laden hydrogels made from waterborne polyester-urethane bioinks, and 3D-printed poly(lactide-co-caprolactone) scaffolds subsequently seeded with cells.

Mesenchymal stem cells cultured in the 3D-bioprinted, cell-laden hydrogels deposited tendon-characteristic proteins that matured under dynamic mechanical stimulation, demonstrating potential as tendon substitutes. Mesenchymal stem cells cultured in the 3D-printed PLCL scaffolds showed that cell phenotype and deposited matrix composition depended on the printing pattern and fibre spacing.

Overall, these findings demonstrate the potential of 3D-printed constructs for engineering tendon replacements.