TITLE: Synthesis of amphiphilic block copolymers with complex architectures for preparation of self-assembled polymer-nanopore hybrid membrane structures

Summary: Amphiphilic block copolymers composed of distinct hydrophilic and hydrophobic blocks can spontaneously self-organize in aqueous solutions into ordered structures. The morphology of the formed structures depends primarily on the chemical composition and block lengths of the block copolymer. With an appropriate hydrophilic weight fraction, polymer vesicles (polymersomes) can be prepared. Increasing the molecular weight of the hydrophobic block increases the membrane thickness, which defines the permeability and stability of the polymersome. By modifying polymersomes with biological nanopores, selective permeability of their membrane can be achieved, enabling new technological applications in biomedicine. The main challenge is to design the macromolecular parameters of the block copolymers in a way to achieve the required fluidity, flexibility, stability and thickness of the polymersome membrane to allow the reconstitution of the pore-forming proteins. The goal of doctoral candidate is to design and synthesize new amphiphilic block copolymers that can form stable membrane structures suitable for reconstitution of pore-forming proteins by mimicking the architecture of natural phospholipids and to study their self-assembled membrane structures in water.

Research techniques used: Since the preparation of well-defined block copolymers with complex architectures is challenging, the candidate will need to learn advanced organic and polymer synthesis techniques, including working on a vacuum line to perform water-sensitive reactions. Accurate and correct characterization of the intermediates and final products is also an essential prerequisite for the preparation of well-defined polymers, for which the candidate will use the spectroscopic (FT-IR, NMR), chromatographic (SEC and AF4 with multi-detection system), microscopic (SEM, cryo-EM), light-scattering (DLS) and mass spectrometric (MALDI-TOF MS) techniques.

The reason why the topic is innovative: The new synthetic methods that the candidate will develop will expand the toolbox of polymer synthesis methods and enable the preparation of novel, well-defined polymer systems with complex architecture and unique properties. By studying the self-assembly of prepared block copolymers in water, with a focus on the influence of polymer architecture on membrane thickness and stability, the candidate will contribute to the understanding of the structure-property profile of polymersomes. The results on biopore reconstitution will provide a solid basis for the design of new self-assembled membrane structures suitable for advanced applications such as biosensors, nanoreactors, drug delivery, etc.

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