Protein-Mimetic Heterograft Polymers as Model Systems for Controlled Complexation with Oppositely Charged Biomacromolecules

Purushottam Dubey [a] *and Paula Malo de Molina* [a]

[a] *Centro de Física de Materiales (CSIC-EHU), P Manuel Lardizabal 5, Donostia E-20018, Spain*

p.malodemolina@ehu.eus

Amphiphilic random heterograft polymers mimic key protein features such as folding, transport, and catalysis [1] . Their synthesis is straightforward, based on copolymerizing hydrophilic, hydrophobic, and charged monomers, enabling a wide design space. When interactions are balanced, these polymers remain folded and resist aggregation, allowing folding and association to be decoupled [2] . This opens the way to investigate how protein-like polymers behave in complex environments, particularly during polyelectrolyte complexation and coacervation.

Here, we investigate the complexation behavior of positively charged heterograft polymers based on poly(DMAEMA-ran-LMA-ran-OEGMA)* with two model polyanions of increasing biological relevance: poly(glutamic acid) and RNA. These polymers in their isolated state adopt a compact, intramolecularly structured conformations in water and display only a weak expansion upon increasing charge, as revealed by SAXS, consistent with protein-like folding behavior. By varying the relative content of charged (DMAEMA) and neutral hydrophilic (OEGMA) units, together with pH, we tune the effective charge of the polymer and its electrostatic interactions with the polyanion. To capture the resulting phase behavior, we construct phase diagrams of the binary polycation–polyanion systems as a function of pH and composition (polycation/polyanion ratio), revealing marked differences in the phase separation regions depending on polymer composition and the nature of the polyanion. Close to the phase boundaries, we identify slightly turbid yet stable regimes where well-defined complexes are formed. These structures are further characterized by SAXS and DLS, providing insight into the role of polymer composition and charge in governing polymer–polyanion complexation across multiple length scales.

*DMAEMA: dimethylaminoethylmethacrylate; LMA: laurylmethacrylate; OEGMA: oligoethyleneglycolmethacrylate

Keywords:

Amphiphilic random heteropolymers, Polyelectrolyte complexation, Biomimetic polymers

References:

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