Surfactant-Based Polyelectrolyte Multicore Nanocarriers for Hydrophobic Cargo Delivery

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The delivery of hydrophobic compounds remains a fundamental challenge in colloid and interface science due to their poor solubility and limited stability in aqueous environments. Here, we report the design of polyelectrolyte multicore nanocarriers fabricated via a layer-by-layer (LbL) assembly approach, exploiting electrostatic interactions between micellar templates and oppositely charged polyelectrolytes [1]. The proposed system is based on the complexation of surfactant micelles with oppositely charged polyelectrolytes, followed by the deposition of functional multilayers, leading to the formation of stable multicore colloidal systems. This architecture enables the incorporation of hydrophobic cargo within micellar domains distributed throughout the polyelectrolyte matrix. The resulting nanocarriers exhibit sizes in the nanometer range (~200 nm), controlled surface charge, and high colloidal stability governed by electrostatic interactions. Moreover, the outer layer of the multilayer shell can be further functionalized (e.g., by PEGylation) to introduce steric stabilization and enhance their potential as drug delivery systems based on the enhanced permeability and retention (EPR) effect. To evaluate encapsulation efficiency and functionality, two model hydrophobic compounds were employed: coumarin 6 as a fluorescent probe and paclitaxel as a model anticancer drug. The micelle-assisted loading strategy enables efficient incorporation of hydrophobic molecules, while the multilayer shell provides structural integrity and modulates interactions with the surrounding medium. Biological studies confirm that the encapsulated cargo retains its activity, while the nanocarrier itself remains non-toxic. These findings highlight the potential of multicore micelle–polyelectrolyte assemblies as a versatile platform in colloid and interface science for designing tunable delivery systems based on self-organization, interfacial interactions, and multilayer structuring.

Keywords:
nanocapsules, nanocarriers, miecelles, taxanes, EPR effect

References:

[1] Szwed, M.; Michlewska, S.; Kania, K.; Szczęch, M.; Marczak, A.; Szczepanowicz, K. New SDS-Based Polyelectrolyte Multicore Nanocarriers for Paclitaxel Delivery—Synthesis, Characterization, and Activity against Breast Cancer Cells. *Cells* **2023** , *12* , 2052. https://doi.org/10.3390/cells12162052

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