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Planar and curved self-assembled polymer multilayers - novel approaches for biomolecule immobilization and release on demand

Polymer-based and composite multilayers have been widely used over the past decade towards biological and non-biological applications. Our research is focused on assembly of 2D and 3D multilayer structures (planar films and capsules) aiming at biological applications. Such tailor-made structures have fine-tuned architecture, controlled thickness from nano to micro, adjusted softness from Pa to GPa, and almost unlimited variety of functional compounds. In this talk I present our recent findings in the mechanism of multilayer assembly, physical-chemical approaches to immobilize biomolecules (proteins, nucleic acids, small drugs, etc) and to release/deliver the biomolecules in controlled manner. The externally triggered release on demand by IR-laser light and cellular studies including extra- and intra-cellular delivery is considered. The developed structures offering localized, remote, and non-invasive release of biomolecules are indispensable for applications in diagnostics, toxicology, tissue engineering, and especially for single cell studies where high precision of biomolecule delivery in space and time is highly desirable.



Figure 1: Schematics showing main physical-chemical aspects studied for polymer multilayers aiming at drug delivery applications

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Recent publications

1. Vikulina A S, Aleed S T, Paulraj T, Vladimirov Y A, Duschl C, von Klitzing R and Volodkin D (2015) Temperature-induced molecular transport through polymer multilayers coated with PNIPAM microgels. PCCP 17:12771-12777.
2. Vikulina A S, Anissimov Y G, Singh P, Prokopovic V Z, Uhlig K, Jaeger M S, von Klitzing R, Duschl C and Volodkin D (2016) Temperature effect on the build-up of exponentially growing polyelectrolyte multilayers. An exponential-to-linear transition point. PCCP 18:7866-7874.
3. Balabushevich N G, de Guereny A V L, Feoktistova N A, Skirtach A G and Volodkin D (2016) Protein-containing multilayer capsules by templating on mesoporous CaCO₃ particles: post- and pre-loading approaches. Macromol Biosci 16:95-105.
4. Prokopovic V Z, Vikulina A S, Sustr D, Duschl C and Volodkin D V (2016) Biodegradation resistant multilayers coated with gold nanoparticles. Towards tailor-made artificial extracellular matrix. ACS Applied Materials & Interfaces 8:24345-24349.
5. Parakhonskiy B V, Yashchenok A M, Möhwald H, Volodkin D and Skirtach A G (2017) Release from polyelectrolyte multilayer capsules in solution and on polymeric surfaces. Adv Mater Interfaces 4:1600273.

Biography

Dmitry Volodkin holds a position of Reader in Materials at Nottingham Trent University (UK) and Heads the group Active Bio-Coatings. He has studied Chemistry at the Lomonosov Moscow State University and further obtained PhD in 2005. Research stays brought him to University of Strasbourg, France and Max-Planck Institute of Colloids and Interfaces; Technical University of Berlin; Fraunhofer Institute for Cell Therapy and Immunology in Germany. His research activities are focused on design of advanced stimuli-responsive biomaterials for applications in tissue engineering, diagnostics, toxicology, drug delivery. His group engineer self-assembled polymer based 2D and 3D structures with tailor-made properties: multilayer films, microcapsules and beads, liposome-polymer composites, polymeric scaffolds, etc. He has published more than 70 peer-reviewed articles/books and received a number of prestigious scientific awards such as Sofja Kovalevskaja Award of Alexander von Humboldt Foundation, Richard-Zsigmondy Prize of German Colloid Society, Alexander von Humboldt Fellowship and Marie Skłodowska-Curie Fellowship.

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