

Multilayer biopolymer-based capsules made using vaterite CaCO₃ crystals

Volodkin Dmitry, Jack Campbell and Vikulina Anna
Nottingham Trent University, UK

Polymer-based multilayer capsules are new types of effective drug delivery carriers. The capsules assembled using decomposable and porous CaCO₃ vaterite crystals can be loaded with biomolecules at mild conditions. These crystals can then effectively release biomolecules such as proteins and peptides, small drugs, like antibiotics, nucleic acids, etc.1-4 Protection and controlled release of the biomolecules are the main advantages of the capsules; this can be achieved by adjusting the capsule structure by a varying the number of layers deposited, and the appropriate choice of the chemical nature of the polymer used.2-4 Despite there being a number of synthetic polymers that have been employed to assemble the capsules, there is a gap in the understanding of the capsule assembly mechanism for biopolymers. This is indispensable for the formulation of capsules to be utilised for biologically relevant applications. This work aims to fabricate capsules from biopolymers typically used for bio-applications in drug delivery and tissue engineering. The examples of the utilised biopolymers include polyanions (chondroitin sulfate, hyaluronic acid, dextran sulfate, and heparin) and polycations (poly-L-lysine, dextran amine, collagen, and protamine). The following pairs of biopolymers are the most attractive in terms of capsule integrity: heparin/poly-L-lysine (Fig. 1) and heparin/protamine. Not only the stability, but also protein retention in the formed capsules, capsule shrinkage, and the fusion between capsules are investigated. Interestingly, the occupation of the vaterite crystal pores with polymer(s) during capsule fabrication is responsible for the observed capsule shrinkage and fusion phenomena. The findings of this study would open new routes for applications of multilayer capsules in the field of controlled drug delivery.

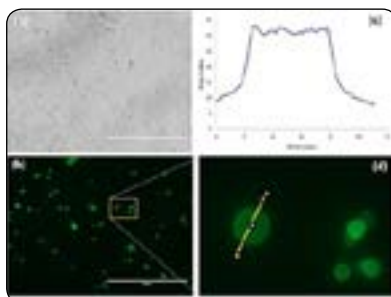


Fig. 1. Optical (a) and corresponding fluorescence (b) images, with the corresponding fluorescence profile (c) of BSA encapsulated within (heparin/poly-L-lysine)₂/heparin capsules. (d) - enlarged area from the image (b). Scale bar is 100 μm.

Recent Publications:

1. Volodkin, D.; Skirtach, A.; Möhwald, H., Bioapplications of light-sensitive polymer films and capsules assembled using the layer-by-layer technique. *Polym Int* 2012, 61 (5), 673-679. Review
2. Volodkin, D. CaCO₃ templated micro-beads and -capsules for bioapplications. *Adv Colloid Interface Sci* 2014, 206, 437-454.
3. Feoktistova, N., J. Rose, V.Z. Prokopović, A.S. Vikulina, A. Skirtach, and D. Volodkin, Controlling the Vaterite CaCO₃ Crystal Pores. *Design of Tailor-Made Polymer Based Microcapsules by Hard Templating*. *Langmuir*, 2016, 32(17), 4229-4238.
4. Parakhonskiy, B. V.; Yashchenok, A. M.; Möhwald, H.; Volodkin, D.; Skirtach, A. G. Release from Polyelectrolyte Multilayer Capsules in Solution and on Polymeric Surfaces. *Advanced Materials Interfaces* 2017, 4(1), 1600273.

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Biography

Volodkin Dmitry is Associate Professor at Nottingham Trent University and heads the group "Active-Bio-Coatings". He has studied Chemistry at the Lomonosov Moscow State University in Russia. Research stays brought him to France (University of Strasbourg) and Germany (Max-Planck Institute of Colloids and Interfaces, Technical University of Berlin, Fraunhofer Institute for Cell Therapy and Immunology). 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. Dmitry Volodkin 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 Price of German Colloid Society, Alexander von Humboldt Fellowship, Marie Skłodowska-Curie Fellowship.

dmitry.volodkin@ntu.ac.uk

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