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Protein loading into vaterite $CaCO_3$ crystals by co-synthesis

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$CaCO_3$-based co-synthesis (or co-precipitation) is actively used for encapsulation of fragile biomolecules, for instance encapsulation into multilayer capsules and other carriers to be used for drug delivery, tissue engineering, biotechnology.1,2 Molecules of interest can effectively be incorporated into the mesoporous vaterite $CaCO_3$ crystals (Fig. 1) by adding them during the crystal synthesis at mild conditions (principle of the co-synthesis).3-5 This work explores the ability of various proteins to be incorporated into the crystals. The following model proteins have been tested for their loading into the crystals by co-synthesis: bovine serum albumin, lysozyme, α-lactalbumin, catalase, cytochrome C, insulin. The proteins can be loaded inside the crystals at extremely high amounts (adsorption capacity of the crystals of up to 600 mg of protein per 1 g of crystals) and giving a value of Gibbs free energy of about -30 kJ/mol. The research here aims to identify a correlation between physical-chemical properties of the proteins (molecular mass, sign of charge) with the thermodynamic parameters of the protein loading such as equilibrium constant and Gibbs free energy. The findings of the study allow to understand the mechanism of the protein loading into the crystals.

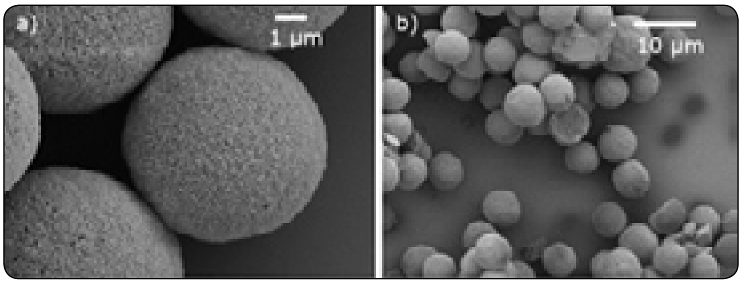

Fig. 1. Scanning electron microscopy images of vaterite $CaCO_3$ crystals at magnification x10,000 (a) and x2,000 (b).

Recent Publications:

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3. Balabushevich, N. G.; de Guerenu, A. V. L.; Feoktistova, N. A.; Skirtach, A. G.; Volodkin, D. Protein-Containing Multilayer Capsules by Templating on Mesoporous $CaCO_3$ Particles: POST- and PRE-Loading Approaches. Macromolecular Bioscience 2016, 16 (1), 95-105.
4. Balabushevich, N. G.; de Guerenu, A. V. L.; Feoktistova, N. A.; Volodkin, D. Protein loading into porous $CaCO_3$ microspheres: adsorption equilibrium and bioactivity retention. PCCP, 2015, 17 (4), 2523-2530.
5. 5. Vikulina, A. S.; Feoktistova, N. A.; Balabushevich, N. G.; Skirtach, A. G.; Volodkin, D., The mechanism of catalase loading into porous vaterite $CaCO_3$ crystals by co-synthesis. PCCP, 2018, 20, 8822-8831

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.

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