Insights into the Immobilization of Enzymes onto Hybrid Hairy Particles for Interfacial Catalysis

Claudia Marschelke[1,2], Anke Matura[3], Martin Müller[1], Ivan Raguzin[1], and Alla Synytska[1,2]

[1] *Leibniz Institute of Polymer Research Dresden, Institute of Physical Chemistry and Polymer Physics, Dresden, Germany*
[2] *Dresden University of Technology, Institute of Physical Chemistry of Polymeric Materials, Dresden, Germany*
[3] *Dresden University of Technology, Institute of Biochemistry, Dresden, Germany*

The design of colloidal core-shell particles with advanced architectures and controlled chemical functionalities is highly demanding for discovering responsive and adaptive multifunctional materials. The tunable design of the polymeric shell interface, realized by the polymer brush approach, provides an excellent base for the immobilization of catalytically active species, such as enzymes [1] and metal nanoparticles [2], which may enhance their structural and catalytic stability in different environmental conditions, reducing product inhibition and facilitating their recovery, Although it is of prime importance to control the interface architecture, there is still a lack of systematic investigations concerning the impact of the particles' properties on the designed interface, as well as on the immobilization of biomolecules.

Herein, we propose the immobilization of enzymes onto core-shell particles as an application for interfacial catalysis that would benefit from the unique properties and architecture of these particles. We report on the synthesis of hybrid hairy particles with controllable size (Fig. 1 a,b), grafting density, polymer chain length, chemical functionality, and responsiveness. Thus, we control the interfacial properties of the carrier material, such as swelling, charge, and adhesion, as investigated by (cryo-)TEM, electrokinetics and AFM force distance measurements. Further, we discuss the correlation between the controlled design of polymeric interface and its impact on the immobilization efficiency and enzymatic structure of laccase from *Trametes versicolor*, as well as occurring changes in the surface morphology, charge and adhesion performance of the final polymer-enzyme layer (Fig. 1c).

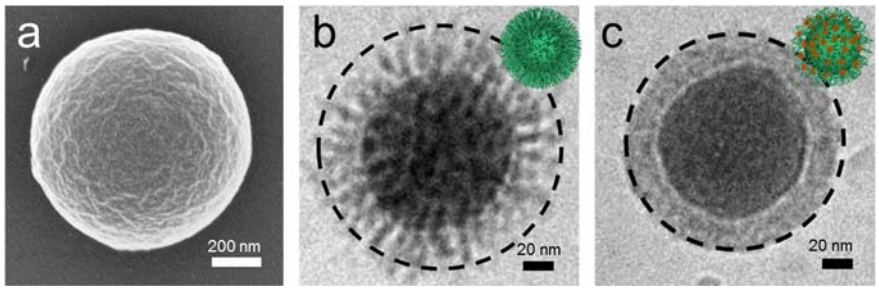

Figure 1. (a) Representative SEM image of a 1 µm hybrid hairy core-shell particle; cryo-TEM images of (b) a 100 nm hybrid hairy particle without any catalytic species, and (c) with immobilized laccase from *Trametes versicolor.* Insets show schematic illustrations.

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[2] A. Kirillova, C. Schliebe, G. Stoychev, A. Jakob, H. Lang, and A. Synytska, *ACS Appl. Mater. Interfaces* **7** (2015), 21218.

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