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Polymer and Colloid Highlights

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Going Nano for Batteries and Drug Delivery

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Nanoscale particles can be engineered for a panoply of potential applications, two of which will be highlighted here. The first one is the use of nanoparticles in the context of Li-ion batteries where they may serve as cathode materials. The classically used mixed metal oxides, *e.g.* $LiCoO_2$, are typically prepared by solid-state reactions requiring high temperatures (>800 °C) and long reaction times, which lead to micron scale particles. In such large grains, the insertion and extraction of lithium ions into and from the crystallites is slow and incomplete. With precursors in which the metal ions are preorganized, it is possible to dramatically reduce the reaction time and temperature to obtain nanoscale $LiCoO_2$.[1] Depending on the molecular precursor, the size of those nanoparticles can be tuned. Another approach to a new nanoscale cathode material with an olivine structure, $LiMnPO_4$, uses surfactants under different conditions to influence the size and shape of the corresponding nanoparticles.[2] The advantage of such low particle sizes of the active cathode material is the shortened lithium ion diffusion pathway as compared to micron scale grains (Fig. 1). For $LiCoO_2$, the lithium ion diffusivity was improved by a factor of up to 100 using the nanoscale material produced *via* the precursor method.[3] On the anode side, a common problem is the formation of cracks due to the large swelling and shrinking effect of *e.g.* Sn as active material. Upon encapsulation of Sn-nanoparticles inside of a carbon shell, forming nanorattles, the Sn-particles can swell upon Li^+ insertion inside of their capsule without breaking the latter (Fig. 2).[3]

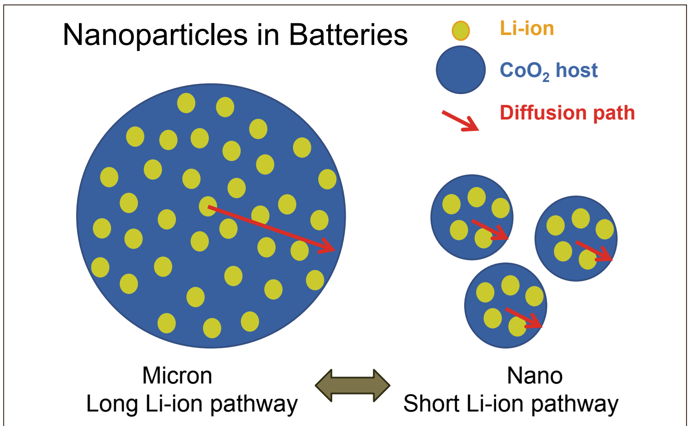

Fig. 1. Advantages of using nanoparticles in battery electrodes.

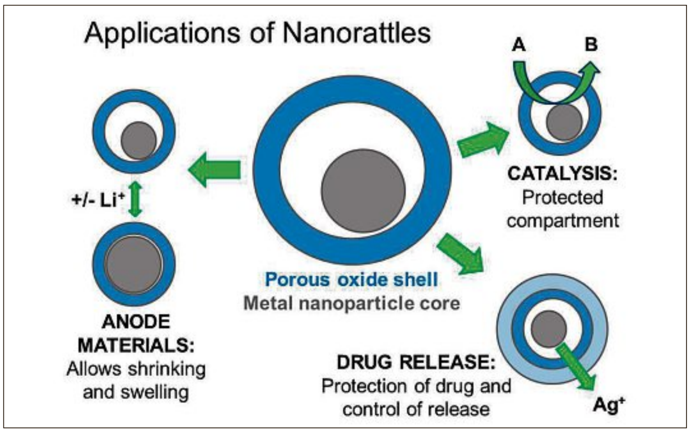

Fig. 2. Applications and advantages of nanorattles.

Such nanorattles are also in the focus of the second application, the controlled delivery of antimicrobial drugs such as silver ions (Fig. 2). While ionic silver compounds are used up within several weeks in, for example, an antimicrobial implant coating,[4] metallic silver nanoparticles are longer lasting under similar conditions. However, they are more difficult to handle, to attach and to protect from degradation. More advantageous is the encapsulation of the metal nanoparticles to form nanorattles. Double encapsulation with a second shell of TiO_2 around a shell of CeO_2 was shown to prolong the silver ion release to several years.[5] Silver-filled SiO_2 nanorattles show excellent properties in terms of their biocompatibility. Such silver nanorattles can be made by different methods, in different sizes ranging from 20 nm to 200 nm, they can be functionalized for attachment to a surface or for cell targeting, and they are useful in other areas as well such as catalysis.[6]

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