Luminescent Silicon Diatom Replicas: Self-Reporting and Degradable Drug Carriers with Biologically Derived Shape for Sustained Delivery of Therapeutics

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Abstract:

Current development of drug microcarriers is mainly based on spherical shapes, which are not biologically favorable geometries for complex interactions with biological systems. Scalable synthesis of drug carriers with nonspherical and anisotropic shapes featuring sustained drug-releasing performances, biocompatibility, degradability, and sensing capabilities is challenging. These challenges are addressed in this work by employing Nature's optimized designs obtained from low-cost diatomaceous earth mineral derived from single-cell algae diatoms. Silica diatoms with unique shapes and 3D microcapsule morphology are converted into silicon diatom replicas with identical structure by a magnesiothermic reduction process. The results reveal that prepared silicon diatoms have a set of unique properties including favorable microcapsule structure with high surface area and micro/mesoporosity providing high drug loading, fast biodegradability, and intrinsic luminescence, which make them highly suitable for low-cost production of advanced drug microcarriers. Their sustained drug release >30 days combined with self-reporting function based on silicon luminescence properties using nonluminescent and luminescent drugs for intravitreal drug therapy is successfully demonstrated. These silicon diatoms offer promising potential toward scalable production of low-cost and advanced microcarriers for broad medical therapies, including theranostics and microrobotic guided drug delivery devices.

Keywords:

hierarchical porous structures, luminescence, ocular drug delivery, self-reporting, silicon diatoms replicas

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