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Ultrasmall mesoporous organosilica nanoparticles: morphology modulations and redox-responsive biodegradability for tumor-specific drug delivery

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Abstract

Beyond mesoporous silica nanoparticles (MSNs), mesoporous organosilica nanoparticles (MONs) have been becoming an even more attractive alternative to the traditional organic or inorganic nanomaterials in biomedical applications, especially for drug delivery, due to its high surface area, stable physicochemical properties, low toxicity, high biocompatibility, and particularly the devisable features decided by the incorporated organic fragments. However, it is still challenging to fabricate uniform ultrasmall MONs with tunable composition, morphology and fine biodegradability. Herein, we report, on the large-scale fabrication of monodispersed and molecularly organic-inorganic hybrid MONs with framework-incorporated physiologically active thioether bonds, controllable nanostructure, composition and morphology, which provides the material foundation for exploring the versatile biomedical applications of organosilica nanosystems. The hybrid MONs of less than 50 nm in particle size exhibit the unique reduction-responsive biodegradation behavior, and the biodegradation rate is significantly higher than that of traditional mesoporous silica nanoparticles with pure inorganic Si-O-Si framework. The reductive microenvironment-triggered biodegradation of MONs induces the concurrent reduction-responsive anticancer drug releasing from MONs, enabling tumor-specific drug delivery. Importantly, these biocompatible and biodegradable MONs exhibit significantly improved drug-delivery efficiency and enhanced tumor-suppressing effect for combating cancer. Based on the facile and large-scale fabrication of MONs with controllable key structure/composition/morphology parameters, unique tumor microenvironment-responsive biodegradation behavior and high performance for drug delivery, the MONs therefore show more promising potentials for clinical translation as compared to traditional MSNs.

Keywords: Mesoporous organosilica, biodegradation, drug delivery, nanomedicine, cancer therapy