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Abstract Formulary

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Title: 3D Printing additive-free, gelled nano inks for the rational design of functional aerogels of complex geometry

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ABSTRACT (Space limited to 2200 characters)

The limited shape tunability of conventionally casted nanoparticle-aerogels hinders a multiscale processing scheme for the elegant integration of colloidal nanomaterials into a macroscopic, functional aerogel device. Here, we present a 3D printing methodology for the fabrication of hierarchically structured TiO2 nanoparticle-based aerogels with full control of the nano-, micro-, and macroscopic length scales.[1] To maintain the nanoscopic characteristics of the nano-building blocks in a 3D-printed architecture, a well-designed ink formulation and printing process are decisive. We show that 3D printing within an alkaline liquid bath enables ink formulation without the need for any rheologic additive. Moreover, we demonstrate that the 3D-printed TiO2 aerogels feature an interconnected mesoporous network with pore sizes of about 20 nm and a large specific surface area of up to 539 m^2g^{-1}. Thus, the 3D printing protocol retains key structural characteristics of conventionally casted aerogels while offering unparalleled designability on the micrometer scale. In general, diverse nanomaterials can be processed into inks and 3D-printed giving access to multifunctional aerogels. To exemplify, we load the TiO2 gels with plasmonic Au-nanorods to facilitate photothermal heating. By 3D printing, we optimize the microstructure of the strongly light-absorbing, photothermal Au-nanorod/TiO2 aerogel to improve light penetration by a factor of four and to achieve homogenous heating on a macroscopic scale. This greatly improves the scalability of conventionally unstructured aerogels and enables a new generation of photothermal devices for solar steam generation, thermochemical heat storage, or photocatalysis. Ultimately, the intersection of nano-building blocks and 3D printing creates a new paradigm to design functional hierarchical architectures and devices with complex geometries.

Reference:

[1] M. Rebber, M. Trommler, I. Lokteva, S. Ehteram, A. Schropp, S. König, M. Fröba, D. Koziej, *Adv. Funct. Mater.* **2022**, 2112914.