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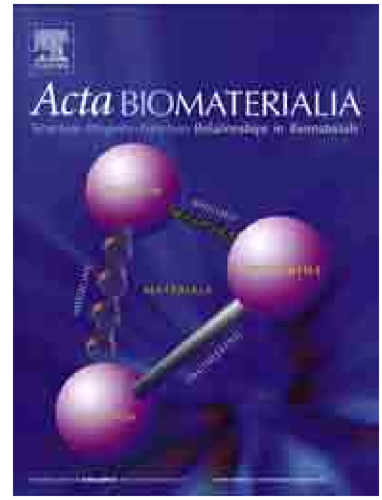

3D-Printing Porosity: A New Approach to Creating Elevated Porosity Materials and Structures

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3D-Printing Porosity: A New Approach to Creating Elevated Porosity Materials and Structures

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Abstract: (200 words)

We introduce a new process that enables the ability to 3D-print high porosity materials and structures by combining the newly introduced 3D-Painting process with traditional salt-leaching. The synthesis and resulting properties of three 3D-printable inks comprised of varying volume ratios (25:75, 50:50, 70:30) of $CuSO_4$ salt and polylactide-co-glycolide (PLGA), as well as their as-printed and salt-leached counterparts, are discussed. The resulting materials are comprised entirely of PLGA (F-PLGA), but exhibit porosities proportional to the original $CuSO_4$ content. The three distinct F-PLGA materials exhibit average porosities of 66.6-94.4%, elastic moduli of 112.6-2.7 MPa, and absorbency of 195.7-742.2%. Studies with adult human mesenchymal stem cells (hMSCs) demonstrated that elevated porosity substantially promotes cell adhesion, viability, and proliferation. F-PLGA can also act as carriers for weak, naturally or synthetically-derived hydrogels. Finally, we show that this process can be extended to other materials including graphene, metals, and ceramics.

Statement of Significance

Porosity plays an essential role in the performance and function of biomaterials, tissue engineering, and clinical medicine. For the same material chemistry, the level of porosity can dictate if it is cell, tissue, or organ friendly; with low porosity materials being far less favorable than high porosity materials. Despite its importance, it has been difficult to create three-dimensionally printed structures that are comprised of materials that have extremely high levels of internal porosity yet are surgically friendly (able to handle and utilize during surgical operations). In this work, we extend a new materials-centric approach to 3D-printing, *3D-Painting*, to 3D-printing structures made almost entirely out of water-soluble salt. The structures are then washed in a specific way that not only extracts the salt but causes the structures to increase in size. With the salt removed, the resulting medical polymer structures are almost entirely porous and contain very little solid material, but the maintain their 3D-printed form and are highly compatible with adult human stem cells, are mechanically robust enough to use in surgical manipulations, and can be filled with and act as carriers for biologically active liquids and gels. We can also extend this process to three-dimensionally printing other porous materials, such as graphene, metals, and even ceramics.