3D Printing of Living Structural Biocomposites

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Nature has a remarkable ability to create composite materials by combining organic and inorganic elements under benign conditions. Surprisingly, these natural composites often exhibit superior mechanical properties compared to their individual building components. The key to this evolutionary feat lies in nature's unique capability to precisely control the structure and composition of materials. This control is achieved through the compartmentalization of reagents, which can be selectively released in specific locations. Drawing inspiration from nature, we have developed an energy-efficient process that harnesses compartmentalization to fabricate porous composites based on $CaCO_3$, exclusively using materials derived from nature. Remarkably, these composites exhibit compressive strength similar to trabecular bones.

The unique combination of nature-derived materials, 3D printability, and good mechanical properties is achieved through the formulation of these materials: We utilize microgel-based granular inks, which possess inherent 3D printing capabilities. In addition, we leverage the potential of engineered living materials to induce the formation of biominerals by bacteria. By combining these elements, we successfully create biomineral composites with a porous trabecular structure.

The potential applications of this system are vast. It can be utilized in art restoration, providing an innovative solution for repairing damaged artworks. Furthermore, these composites can serve as artificial corals, aiding in the regeneration of marine reefs. With further development, this technology may even enable the repair of fractured or deteriorated mineral-based materials found in natural structures such as certain bone components.

By leveraging the ingenuity of nature and utilizing cutting-edge techniques, we envision a future where our system revolutionizes various fields, offering sustainable and effective solutions for diverse challenges.

