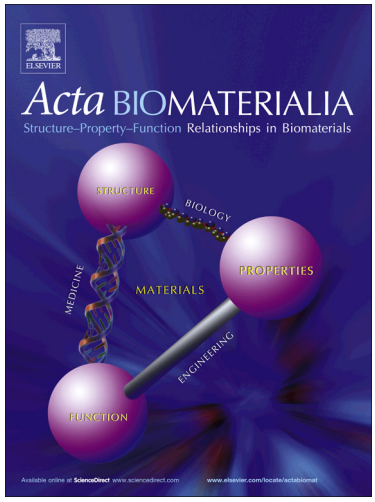

Full length article

A comparative study of bio-inspired protective scales using 3D printing and mechanical testing

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A comparative study of bio-inspired protective scales using 3D printing and mechanical testing

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Abstract.

Flexible natural armors from fish, alligators or armadillo are attracting an increasing amount of attention for their unique combinations of hardness, flexibility and light weight. The extreme contrast of stiffness between hard scales and surrounding soft tissues gives rise to unusual and attractive mechanisms, which now serve as models for the design of bio-inspired armors. Despite this growing interest, there is little guideline for the choice of materials, optimum thickness, size, shape and arrangement for the protective scales. In this work, we explore how the geometry and arrangement of hard scales can be tailored to promote scale-scale interactions. We use 3D printing to fabricate arrays of scales with increasingly complex geometries and arrangements, from simple squares with no overlap to complex ganoid-scales with overlaps and interlocking features. We performed puncture tests and flexural tests on each of the 3D printed materials, and we report the puncture resistance – compliance characteristics of each design on an Ashby chart. The interactions between the scales can significantly increase the resistance to puncture, and these interactions can be maximized by tuning the geometry and arrangement of the scales. Interestingly, the designs that offer the best combinations of puncture resistance and flexural compliance are similar to the geometry and arrangement of natural teleost and ganoid scales,