Insights into the Effect of Geometrical Parameters in the Mechanical Properties of the Radular Teeth of the Cryptochiton Stelleri – A 3D print Approach

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The Cryptochiton Stelleri is known to have ultra-hard radular teeth that have one of the largest hardness (9-12GPa) and stiffness (90-125GPa) among other biological materials such as Enamel and Abalone shell. The ultrastructure of the teeth is formed by a bundle of highly mineralized rods composed of iron oxides and organic material. The main method to measure the material properties has been through nanoindentation. However there are limitations to nanoindentation of the Chiton's teeth such as limited equipment, costly and time consuming preparation of the samples, and observation of nanoscale features being difficult. In this work, the rod-like microstructure of the Chiton's teeth is modeled through 3D printing technology which are designed to represent the original counterparts and tested with indentation to compare the mechanical properties. The model is designed to mimic the Chiton's teeth by having stiff hexagonal rods made of a polymer with a certain aspect ratio which are surrounded by weak support material. The results show a dependency of mechanical properties measured by indentation to the geometrical design, and shows improvement when having an aspect ratio of ~15. Further variations in aspect ratio and geometrical designs will be studied. Also, the advantages of a rod-like microstructure versus a random orientation are observed in the abrasion resistance of the material.