Substituting ivory with a 3D printable material

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Ivory was a popular material for numerous religious, art and every-day objects because of its aesthetic looks and convenient workability. Since the introduction of the ivory trading ban by the Convention on International Trade in Endangered Species (CITES) in 1989 many natural and synthetic materials were used to substitute ivory. These materials should represent especially the aesthetic characteristics of ivory by means of the color, translucency and haptics. This also includes the appearance of the so-called Schreger lines, which are visible at the cross-section of an elephant or mammoth tusk and particularly difficult to reproduce. Typically, an ivory substitute material is only available in bulk and, therefore, needs to be carved into shape. To restore sometimes very complex and delicate artefacts, it is reasonable to develop a resource-friendly substitute that can be built by additive manufacturing.

The technique used here derived from stereolithography, where a photosensitive resin is polymerized layer by layer with a UV laser. Calcium phosphate particles are added to the resin, similar to the morphology of ivory that consists of an organic matrix with embedded hydroxy apatite platelets. The solids loading was adjusted to fit the translucency of ivory, which was around 55 wt.%. At this content, also the Young's modulus of about 8 GPa and the density of about 1.79 g/cm^3 are comparable to the values for ivory found in literature. Small quantities of yellow and red color pigments were added to the mixture to modify the basic color.

A surface texture was applied onto the modeled artefacts that mimics the appearance of the Schreger lines. The printing layer thickness for the material testing specimens was 100 µm, whereas, for the recreation of the cultural artifacts the printed layers were only 25 µm thick to enhance the accuracy. With further staining and polishing of the surface, an optical imitation of natural ivory was achievable. This new solution for substituting ivory shows, therefore, promising results and advantages over already existing substitute materials.