Researchers find shark teeth made of natural fluoride

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(Phys.org) -- German researchers studying shark teeth have found at least two species that have fluorinated calcium phosphate - mineral fluoroapatite, as a main component, one of the main ingredients in toothpaste, which partly explains why sharks don't ever get cavities. The researchers looked at *Isurus oxyrinchus* and *Galeocerdo cuvier* (mako and tiger sharks) and found, as they explain in their paper published in the *Journal of Structural Biology*, after very close examination, that the outer coating of the shark teeth contained one hundred percent fluoride.

To gain a better understanding of how sharks manage to keep their teeth in such pristine condition, the team looked at two species that eat in very different ways. Mako sharks rip off flesh when feeding as opposed to

tiger sharks who use their teeth to slice neatly through their meal. Under close observation using regular and scanning electron microscopes, the team was able to determine the exact makeup of the ingredients of the shark's teeth. Besides the hard crystal enamel structure that makes up the outside of the teeth, they found an inner organic dentin made of proteins which was more elastic, similar to that of human teeth. They note also the well known fact that sharks are able to replace teeth that are lost many times throughout their life cycle. The result they say, is a nearly perfect design, allowing sharks to rely on their teeth to keep them fed.

Teeth coated with fluoroapatites are known to be less water soluble than hydroxyapatite which is what humans and most other mammals have coating their teeth, which should help teeth that have them remain more stable in underwater environments and thus less prone to attacks by various bacteria which can lead to decay.

The researchers also conducted hardness tests, and found that despite the shark teeth being made of a naturally harder mineral, they were not harder than human teeth; this because the crystal structure of human teeth has a pattern arrangement more suited to hardness. They noted that teeth in general tend to have such dual structures to keep them from shattering when encountering hard objects.

More information: Structure, composition, and mechanical properties of shark teeth, *Journal of Structural Biology*, Volume 178, Issue 3, June 2012, Pages 290–299.

Abstract
The teeth of two different shark species (Isurus oxyrinchus and Galeocerdo cuvier) and a geological fluoroapatite single crystal were structurally and chemically characterized. In contrast to dentin, enameloid showed sharp diffraction peaks which indicated a high crystallinity of the enameloid. The lattice parameters of enameloid were

close to those of the geological fluoroapatite single crystal. The inorganic part of shark teeth consisted of fluoroapatite with a fluoride content in the enameloid of 3.1 wt.%, i.e., close to the fluoride content of the geological fluoroapatite single crystal (3.64 wt.%). Scanning electron micrographs showed that the crystals in enameloid were highly ordered with a special topological orientation (perpendicular towards the outside surface and parallel towards the center). By thermogravimetry, water, organic matrix, and biomineral in dentin and enameloid of both shark species were determined. Dentin had a higher content of water, organic matrix, and carbonate than enameloid but contained less fluoride. Nanoindentation and Vicker's microhardness tests showed that the enameloid of the shark teeth was approximately six times harder than the dentin. The hardness of shark teeth and human teeth was comparable, both for dentin and enamel/enameloid. In contrast, the geological fluoroapatite single crystal was much harder than both kinds of teeth due to the absence of an organic matrix. In summary, the different biological functions of the shark teeth ("tearing" for Isurus and "cutting" for Galeocerdo) are controlled by the different geometry and not by the chemical or crystallographic composition.

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