New insight to demineralization

July 7 2008

From toothpaste to technology, noncrystalline or amorphous silica is an active ingredient in a myriad of products that we use in our daily lives. As a minor, but essential component of vertebrate bone, an understanding of silica reactivity in physiological environments is crucial to the development of successful biomedical implants and synthetic materials with bone-like properties.

One ongoing question is why solutions of water containing simple table salt or other electrolyte compounds (as in blood plasma for example) are able to break down noncrystalline silicas at speeds far faster than expected.

Rates of decomposition by processes known as dissolution, or demineralization, are up to 100 times faster when the solutions contain little dissolved silica and suggest a means for controlling the speed of removal. Yet, traditional theory would say that the durability of amorphous solids, such as silica glasses, should change by a simple proportion to the amount of silica present in the dissolving solution.

In the July 7 ??, 2008 Online Early Edition of the *Proceedings of the National Academy of Sciences* (PNAS), Patricia Dove, professor of geosciences in the College of Science at Virginia Tech, and postdoctoral scientists Nizhou Han and Adam Wallace report that amorphous silica can dissolve by a nucleation process that was previously only viewed as possible in crystalline materials. The result is a very large increase in the rate of removal of ions from the surface of silica, which would not be predicted by classical theory.

In collaboration with James De Yoreo at the Molecular Foundry of the Lawrence Berkeley Laboratory, the Virginia Tech researchers demonstrate that structural order is not a requirement for a crystal-based model to describe dissolution when the reacting silica units are defined in terms of their coordination to the surface.

"This finding would seem heretical from the viewpoint of traditional thinking because classical nucleation theory is rooted in the concept that dissolution and growth occur by overcoming a barrier to forming a new phase within an existing phase," said Dove. "Because the transfer of units from a disordered amorphous surface to solution always leaves the surface free energy unchanged, the origin of a comparable energy barrier presents a paradox that is not easy to understand."

Using experimental and theoretical analyses, the paper explains this paradox and the dissolution behavior of silica glasses manufactured by different processes, a natural biologically produced silica, and a synthetic, dispersed or colloidal silica.

Their findings present the basis for understanding how simple modulations in solution chemistry can tune the durability of silica in humid or wet environments. Moreover, the insights suggest a means by which one could use simple, environmentally benign solutions to regulate surface roughness at the nanoscale. "One example would be to add texture to a substrate surface for a biomedical application," said Dove "Or another could be to use a salt solution to clean a silica surface without toxic chemical compounds."

Source: Virginia Tech

https://phys.org/news/2008-07-insight-demineralization.html