Medical Xpress

Atomic force microscopy reveals nanoscale dental erosion from beverages

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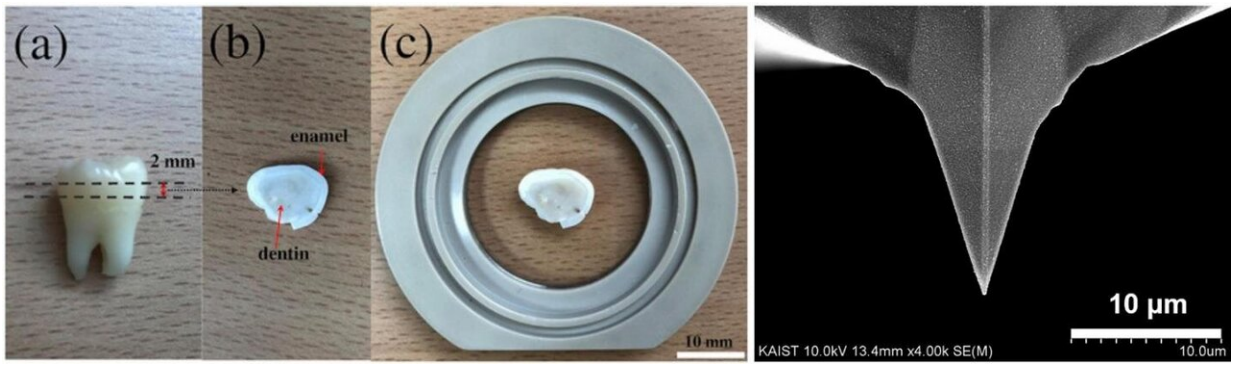


Tooth sample preparation process for atomic force microscopy (a, b, c), and an atomic force microscopy probe image (right). Credit: Professor Seungbum Hong, KAIST

KAIST researchers used atomic force microscopy to quantitatively evaluate how acidic and sugary drinks affect human tooth enamel at the nanoscale level. This novel approach is useful for measuring mechanical and morphological changes that occur over time during enamel erosion induced by beverages.

Enamel is the hard-white substance that forms the outer part of a tooth. It is the hardest substance in the human body, even stronger than bone. Its resilient surface is 96 percent mineral, the highest percentage of any body tissue, making it durable and damage-resistant. The enamel acts as

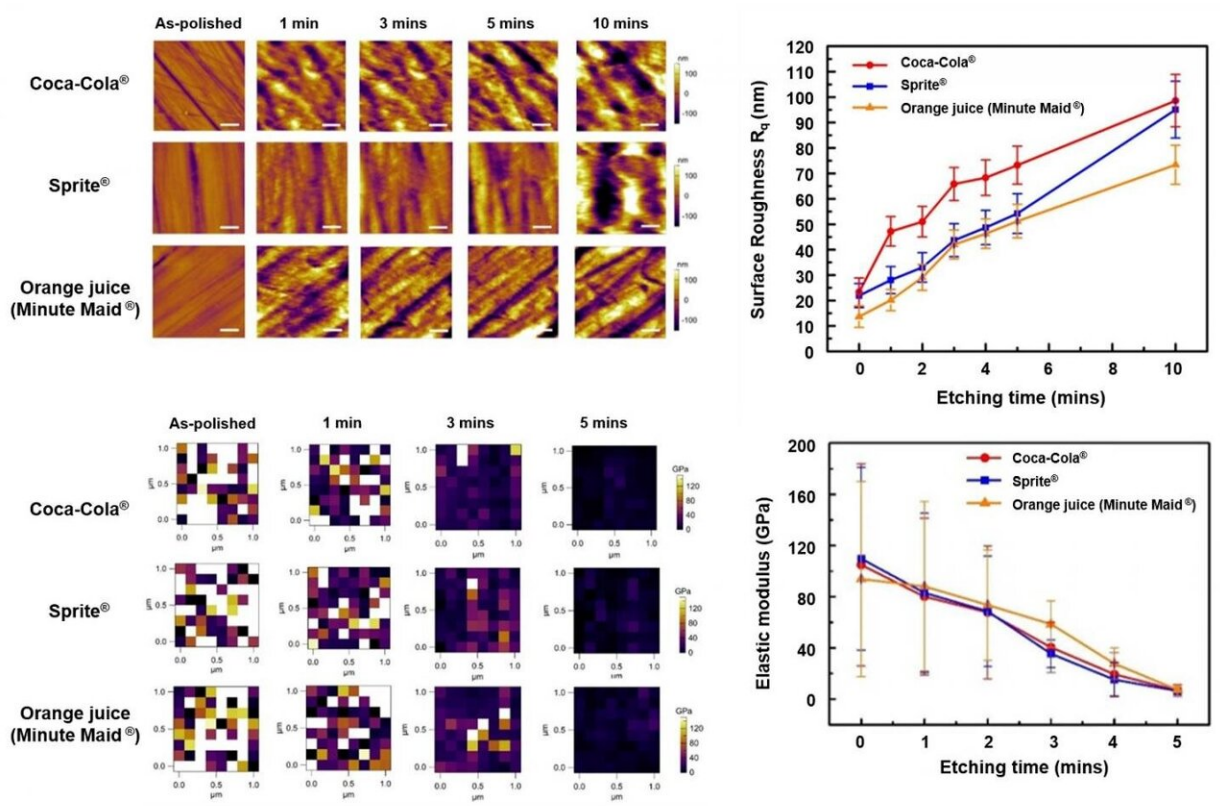
a barrier to protect the soft inner layers of the tooth, but can become susceptible to degradation by acids and sugars.

Enamel erosion occurs when the tooth enamel is overexposed to excessive consumption of acidic and sugary food and drinks. The loss of enamel, if left untreated, can lead to various tooth conditions including stains, fractures, sensitivity, and translucence. Once tooth enamel is damaged, it cannot be brought back. Therefore, thorough studies on how enamel erosion starts and develops, especially at the initial stages, are of high scientific and clinical relevance for dental health maintenance.

A research team led by Professor Seungbum Hong from the Department of Materials Science and Engineering at KAIST reported a new method of applying atomic force microscopy (AFM) techniques to study the nanoscale characterization of this early stage of enamel erosion. This study was introduced in the *Journal of the Mechanical Behavior of Biomedical Materials* (JMBBM) on June 29.

AFM is a very-high-resolution type of scanning probe microscopy (SPM), with demonstrated resolution on the order of fractions of a nanometer (nm) that is equal to one billionth of a meter. AFM generates images by scanning a small cantilever over the surface of a sample, and this can precisely measure the structure and mechanical properties of the sample, such as surface roughness and elastic modulus.

The co-lead authors of the study, Dr. Panpan Li and Dr. Chungik Oh, chose three commercially available popular beverages, Coca-Cola, Sprite, and Minute Maid orange juice, and immersed tooth enamel in these drinks over time to analyze their impacts on human teeth and monitor the etching process on tooth enamel.



Changes in surface roughness (top) and modulus of elasticity (bottom) of tooth enamel exposed to popular beverages imaged by atomic force microscopy. Credit: Professor Seungbum Hong, KAIST

Five healthy human molars were obtained from volunteers between age 20 and 35 who visited the KAIST Clinic. After extraction, the teeth were preserved in distilled water before the experiment. The drinks were purchased and opened right before the immersion experiment, and the team utilized AFM to measure the surface topography and elastic modulus map.

The researchers observed that the surface roughness of the tooth enamel increased significantly as the immersion time increased, while the elastic

modulus of the enamel surface decreased drastically. It was demonstrated that the enamel surface roughened five times more when it was immersed in beverages for 10 minutes, and that the elastic modulus of tooth enamel was five times lower after five minutes in the drinks.

Additionally, the research team found preferential etching in scratched tooth enamel. Brushing your teeth too hard and toothpastes with polishing particles that are advertised to remove dental biofilms can cause scratches on the enamel surface, which can be preferential sites for etching, the study revealed.

Professor Hong said, "Our study shows that AFM is a suitable technique to characterize variations in the morphology and mechanical properties of dental erosion quantitatively at the nanoscale level."

More information: Panpan Li et al, Nanoscale effects of beverages on enamel surface of human teeth: An atomic force microscopy study, *Journal of the Mechanical Behavior of Biomedical Materials* (2020). DOI: 10.1016/j.jmbbm.2020.103930

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