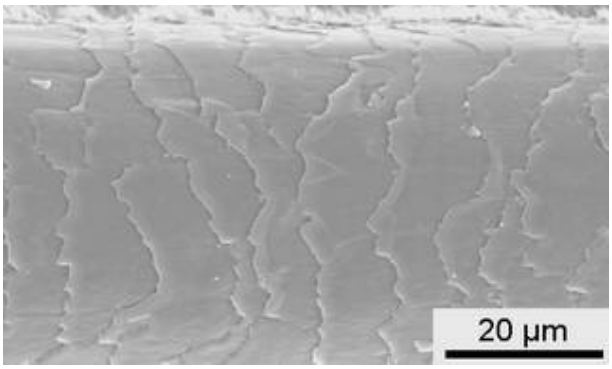
Nanotechnology confronts the 'bad hair day,' tests new conditioner



Ohio State University researchers have just completed the first comprehensive study of human hair on the nanometer level.

Image of hair used in the study.

Special equipment enabled Bharat Bhushan and his colleagues to get an unprecedented close-up look at a rogue's gallery of bad hair days – from chemically overprocessed locks to curls kinked up by humidity.

They used the techniques they developed to test a new high-tech hair conditioner.

Ultimately, the same techniques could be used to improve lipstick, nail polish and other beauty products, said Bhushan , Ohio Eminent Scholar and the Howard D. Winbigler Professor of mechanical engineering at Ohio State .

His specialty is nanotribology – the measurement of very small things, such as the friction between moving parts in microelectronics.

At first, hair seemed like an unlikely study subject, he said. Then he was invited to give a lecture to scientists at Procter & Gamble Co.

“It turns out that, for hair, friction is a major issue,” he said. Everyday activities like washing, drying, combing and brushing all cause hairs to rub against objects and against each other, he explained. Over time, the friction causes wear and tear – two processes that he and his colleagues are very familiar with, though they're normally studying the wear between tiny motors and gears.

“We realized that beauty care was an emerging area for us and we should dive in,” Bhushan said.

He consulted for the company until P&G became an industrial partner in his laboratory, supplying him with samples of healthy and damaged hair. The Ohio State engineers examined hairs under an atomic force microscope (AFM), a tool that let them scratch the surface of hairs and probe inside the hair shaft with a very tiny needle. They published their results in the journal Ultramicroscopy, in a paper now available on the Web.

Among their findings: hair conditioners typically do not evenly cover the entire hair shaft.

P&G recently developed a new formula with additives to make the conditioner coat the hair evenly. In tests, Bhushan found that the new conditioner did coat hair more evenly.

Meanwhile, they examined healthy and damaged hairs under an electron microscope and an AFM, and simulated everyday wear and tear by rubbing hairs together and against polyurethane film to simulate skin.

“We didn't know what we were looking for,” Bhushan said. “People know a lot about hair, but nobody has used an AFM to really study the structure of hair. So we already knew some things, but otherwise we didn't know what to expect.”

Under the electron microscope, individual hairs looked like tree trunks, wrapped in layers of cuticle that resembled bark. In healthy hair, the cuticle edges lay flat against the hair shaft, but as hair gets damaged from chemical treatments or wear and tear, the cuticle edges begin to peel away from the shaft. That much was already known.

The researchers simulated what happens when damaged hair is exposed to humidity; the hairs plump up, and the cuticles stick out even further, leading to frizz. More frizz meant more friction – a fact confirmed by the AFM as researchers dragged a tiny needle across the surface.

Conditioner tends to stick to the cuticle edges, and can make the hair sticky on the nanometer scale. The researchers determined that by poking the hair shaft with the needle, and measuring the force required to pull it away.

They also probed inside hairs to measure the hardness of different layers of the shaft. Hair has a very complex structure, Bhushan said, and these first ultra-precise measurements of interior structure could one day lead to new products that treat hair from the inside.

In the future, he thinks his AFM techniques could be used to develop wear-resistant nail polishes and lipsticks.

Bhushan conducted this work with graduate student Carmen LaTorre and postdoctoral researchers Nianhuan Chen and Guohua Wei, all of Ohio State .

Source: Ohio State University