Nanoparticles hitchhiking their way along strands of hair

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In shampoo ads, hair always looks like a shiny, smooth surface. But for physicists peering into microscopes, the hair surface looks much more rugged, as it is made of saw-tooth, ratchet-like scales. In a new theoretical study published in *EPJ E*, Matthias Radtke and Roland Netz have demonstrated that massaging hair can help to apply drug treatment - encapsulated in nanoparticles trapped in the channels formed around individual hairs - to the hair roots. This is because the oscillatory movement of the massaging directs the way these particles are transported.

This phenomenon was previously discovered in experiments on pork skin samples, which were conducted by Jürgen Lademann, dermatologist at the Charité clinic in Berlin, Germany, and his team. It is also relevant at the microscopic scale, in the transport on microtubules taking place in two directions between the cells within our bodies. By constrast, these findings could also help find ways of preventing harmful nanoparticles from being transported along hairs into the wrong places.

In their work, the authors created a model in which a nanoparticle moves between two asymmetric surfaces. Using standard models of random motion, they moved one surface in an oscillatory fashion relative to the other. They demonstrated by virtue of their corrugated surfaces that channels created between individual hairs and the surrounding skin lead to nanoparticles being sucked into hair follicles if the hair is massaged, thanks to a "ratchet" mechanism.

Further, the authors determined optimal transport conditions for different surface structures by varying the driving frequency, particle size, and the amplitude of the corrugated surface. They found that the ratchet effect switches from a flashing to a pushing effect, when the oscillation switches from perpendicular to parallel to the resting surface, respectively. Radtke and Netz also found that nanoparticles' speed and ability to diffuse are greatly enhanced by the parallel oscillatory motion.

More information: Matthias Radtke et al, Ratchet effect for two-dimensional nanoparticle motion in a corrugated oscillating channel, *The European Physical Journal E* (2016). DOI: 10.1140/epje/i2016-16116-4

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