Penetration and storage of nanoparticles in the skin

J. Lademann, H. Richter, W. Sterry, A. Patzelt

Charité – Universitätsmedizin Berlin, Clinic for Dermatology, Venerology and Allergology, Department Skin Physiology, Berlin

The requirements on nanoparticles in cosmetics and medicine are very different in most cases. One the one hand, nanoparticles such as TiO_2 and ZnO, which are widely applied in sunscreens, should be localised on the skin surface in the upper cell layers of the stratum corneum, while during drug delivery they should penetrate the skin barrier in order to reach the target structures in living cells.

The Clinic for Dermatology, Venerology and Allergology of the Charité utilises various methods to investigate the penetration and storage of nanoparticles in the skin, with hair follicles being in the focus of attention. Ideally suited as target structures for drug delivery, hair follicles are surrounded by a dense network of blood vessels and characterized by a high concentration of both stem and dendritic cells.

Investigations of nanoparticles of different size and materials showed that particles with a diameter of circa 600 nm penetrate into the hair follicles particularly efficiently and can be stored there for a period of maximally 10 days. This means that the retention time in the hair follicle is almost one order of magnitude longer than in the stratum corneum.

The particularly efficient penetration of the particles with a diameter of circa 600 nm is due to the surface structure of the skin. The dandruff has a mean thickness of circa 600 nm and forms a “zigzag” structure on the hair surface. Obviously, this makes the moving hair acting like some sort of a gear pump and stimulates the transport process.
The investigations did not show, however, that any particles with diameters between 40 nm and 1µm penetrated from the hair follicle into living tissue if the barrier was intact. This is plausible as the hair follicle, too, has a barrier structure of its own. Only in the event of artificial barrier damage a penetration of nanoparticles of 40 nm in diameter into living tissue structures could be observed.

Consequently, a penetration through the intact skin barrier can be excluded for the investigated particle systems. But, on the other hand, nanoparticles are well suited to delivering drugs into the hair follicles for subsequent release.