Abstract

Topical drug delivery with nanoparticles: Science fiction or reality?

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The requirements on nanoparticles for use in dermatology are very different. While nanoparticles widely applied in sunscreens, like TiO_2 and ZnO, shall remain on the skin surface or in the upper cell layers of the stratum corneum, nanoparticles intended for drug delivery shall penetrate through the skin barrier to the target structures in the living cells.

At the Charité - Universitätsmedizin Berlin various laser scanning microscopy methods are used to investigate the penetration and storage of nanoparticles in the skin, hair follicles being in the focus of attention. Human hair follicles are ideal target structures for drug delivery. Hosting both the stem and dendritic cells, they are surrounded by a dense network of blood vessels. Investigating nanoparticles of different size and materials, it was found that particles of approximately 600nm diameter penetrate most efficiently into the hair follicles and can be stored there for maximally 10 days. Their retention time in the hair follicles exceeds that in the stratum corneum by almost one order of magnitude.

No experiment had shown, however, that particles of 40nm-1µm in diameter penetrated from the hair follicle into the living tissue if the skin barrier was intact. This is plausible as the hair follicle has its own barrier. The moving hair is assumed to act as a gearing pump under in vivo conditions, pushing the particles deeply into the hair follicles.

Only if the barrier was disturbed artificially or by illness, nanoparticles of 40nm in diameter had penetrated into the living tissue. For more than 20 years, academic and industrial research has been intensely focusing on the utilization of nanoparticles for drug delivery through the intact skin. However, a commercial product providing this effect is still missing. Taking into consideration that non-particulate substances poorly penetrate into the hair follicles, but once arrived there are capable of passing through the follicular barrier unto the living cells, whereas particulate substances do penetrate well into the hair follicles but cannot pass the follicular barrier, the triggered release of substances from nanoparticles in the hair follicle presents a promising field of research. Thereby nanoparticles are loaded with drugs which penetrate into the hair follicles nearby the target structures. Once the release of the drug from the nanoparticle has been triggered by a signal like pH ore temperature, the drug penetrates the last microns through the follicular barrier without assistance.

Another method is the application of nanocrystals of the drug. These crystals should have the optimal size of about 600nm. They are released in the hair follicle after penetration. With this method the penetration efficacy of the drug can increased by one order of magnitude.