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Electrically-assisted delivery of cosmeceuticals into the skin: Transport mechanisms and dermatological applications

[1]Yogeshvar N. Kalia PhD, [2]Jean Luc Levy MD, [3]Francesco Garcia PhD, [4]Juan Carlos Font PhD

[1]University of Geneva, Geneva, Switzerland
[2]Centre Laser Dermatologique, Marseille, France
[3]Bodyestetic Laboratories, Barcelona, Spain

The skin is a complex organ with many biological functions; not only does it maintain a strict control over transepidermal water loss but it also protects the organism against the external environment and the entry of exogenous substances. Although the skin is a convenient site for the administration of both locally and systemically acting molecules, the stratum corneum's excellent barrier function limits the number of molecules that can be delivered by this route. Iontophoresis, which involves the application of a small electric potential, can increase transdermal delivery by several orders of magnitude by reversibly increasing skin permeability. It is particularly suited to the delivery of polar and charged molecules that cannot be administered by conventional means and it has been used for the local and systemic delivery of small molecules and medium-sized peptides. There are two principal iontophoretic transport mechanisms: (i) electromigration, which depends on the applied potential to drive charged molecules across the stratum corneum – the rate of transport is proportional to the molecule's electric mobility and (ii) electroosmosis, which involves a potential-induced solvent flow in the anode-to-cathode direction due to the skin's net negative charge at physiological pH; this enables the delivery of neutral molecules. In this study, we investigated the effect of iontophoresis on the cumulative delivery in vitro of sodium ascorbyl phosphate (anion) and caffeine (neutral) both of which are commonly used cosmeceutical agents. The results showed that transdermal iontophoresis resulted in ~7-fold and ~15-fold increases in the amount of ascorbic acid recovered from the skin after 20 and 60 minute current applications as compared to passive controls (0.74 ± 0.27 vs. 0.1 ± 0.04 μg/mg and 1.64 ± 0.82 vs. 0.11 ± 0.08 μg/mg, for the 20 and 60 minute applications, respectively). Furthermore, in the case of caffeine, a short 20 minute current application resulted in a 2-fold increase in permeation as compared to the control (71.6 ± 26.7 vs. 34.7 ± 7.9 ng/mg, respectively). The data demonstrate the role of the two complementary transport mechanisms in increasing cutaneous bioavailability; this should correspond to improved efficacy and a potential reduction in treatment time.