Hair research for the next millenium
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Small lipid nanoparticles: a new delivery system of lipophilic agents to hair and scalp

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Introduction

The formulation of lipophilic agents in hair care products is unsatisfactory. Conventional oil-in-water emulsions or alcoholic hair tonics which are usually used to deliver lipophilic agents to hair and scalp perform poorly. They leave hair feeling sticky and greasy. In addition, only a low affinity of the substances to hair is observed.

In our laboratory, we have employed a new system to deliver hydrophobic agents to hair and scalp. The system consists of small water dispersible lipid nanoparticles. The vesicles are formed by a monolayer of phospholipids encapsulating a tiny oil core carrying lipophilic agents.

Compared to liposomes (Fig. 1) (optimal carrier for water-soluble drugs), the pay-load of lipophilic substances by nanoparticles is much higher. Nanoparticle preparations are quickly gaining wide recognition in the cosmetic field [1]. They are also used as parenteral emulsions [2] and in a few other pharmaceutical products.

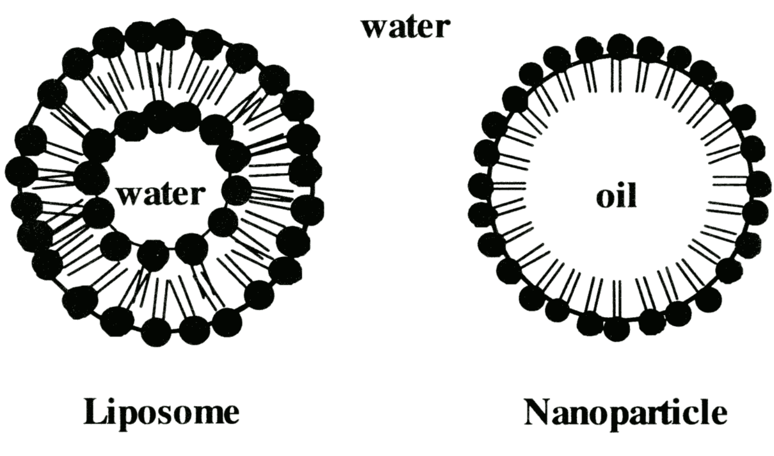

Figure 1. Structural comparison of liposomes and lipid nanoparticles

Materials and methods

Preparation of Nanoparticles

Nanoparticles are prepared by high pressure homogenization using a Microfluidizer® [3]. Phospholipids from soy oil containing the substance of interest and water are mixed to form a predispersion. Multiple cycles through the homogenizer at 1200 bar are performed to obtain a homogeneous preparation of small vesicles.

The composition of nanoparticle preparations can vary: lecithin (1-15%), triglycerides (1-60%), active ingredients (0-40%), water (25-95%) and alcohol (0-20%).

The size of the vesicles can be influenced by the concentration of ethanol or glycerol during the preparation and has a great impact on the properties of the dispersion [4]. Nanoparticles composed of natural phospholipids have a negative surface charge (zetapotential-30 mV). By the addition of the cationic lipid stearylamine, the zetapotential of the vesicles are reversed to +50 mV, resulting in an enhanced affinity of the particles to hair and scalp.

Characterization

The parameters used to characterize lipid nanoparticles are optical appearance, particle size and size distribution, lamellarity, trapped volume and stability (leakage). The optical appearance of nanoparticle preparations is influenced by the size of the vesicles. Preparations of particles with diameters above 150 nm are white, even in diluted dispersions. Preparations containing particles of 100 nm become opaque. A further reduction of the particle size to below 60 nm results in clear transparent dispersions of oil-in-water. The particle size, as well as the particle size distribution can be determined by photon correlation spectroscopy. However, freeze fracture electron microscopy (EM) has been used to characterize the size and shape of the lipid particles exactly. Our calculations regarding the trapped volume of nanoparticle preparations in relation to the lecithin concentration confirmed the assumption that only one monolayer of phospholipids surrounds the oil cores.

Nanoparticles are stable at room temperature for several months without changes in the mean size of the particles. Leakage tests with encapsulated Safranin T (a lipophilic cation [5]) showed a very slow release from the vesicles. Yet the barrier function of the phospholipid shell is less important than the partition coefficient of the encapsulated agent between the oil and the water phase.

Results

Small nanoparticles carrying different active agents of cosmetic or pharmaceutical interest can be prepared using the sophisticated technology of microfluidization. Lipophilic ingredients become water-dispersible by their complete encapsulation in the oil core of small vesicles. Preparations of the particles can easily be sterilized by heat treatment or filtration. Active ingredients like vitamins, sunscreens, fragrances and essential oils have been incorporated in consumer products without additional surfactants or solubilizers. Phospholipids from soy are well tolerated emulsifiers which have a high affinity to the skin [6]. To target these particles to hair, the phospholipid shell can be dotted with cationic molecules resulting in nanoparticles with a positive zetapotential (Table 1). In our *in vitro* experiments (Fig. 2), using UV filters as active agents, we showed that these positively charged particles have a one hundred fold higher affinity to hair compared to untreated negatively charged nanoparticles.

Table 1.
Preparation of anionic and cationic nanoparticles containing a sunscreen.
Uvinul T 150® is a totally water insoluble UV-B filter with an extremely high extinction coefficient. The preparation of positively and negatively charged nanoparticles containing this sunscreen results in convenient formulations for hair and skin care products.

Product	Zetapotential	Particle size
Nano-Lipobelle® UV-F4 2% Lecithin, 6% Uvinul T 150®	-32.5 mV	148.3 nm
Nano-Lipobelle® UV-F9 ditto +0.5% Stearylamine	+49.9 mV	117.5 nm

Conclusions

Lipid nanoparticles are an ideal carrier system for the transport and the protection of lipophilic substances for topical applications in cosmetics and dermatology. The preparations have a low viscosity and are not greasy. In addition, nanoparticles have a high affinity to the skin and enhance the bioavailability of the encapsulated agents. Thus the topical treatment of the scalp is of special interest due to an already high percutaneous absorption rate [7]. With the preparation of positively charged nanoparticles, a highly improved targeting to hair can be obtained.

To summarize, nanoparticles offer new promising possibilities for the utilization of lipophilic agents in advanced hair care preparations.

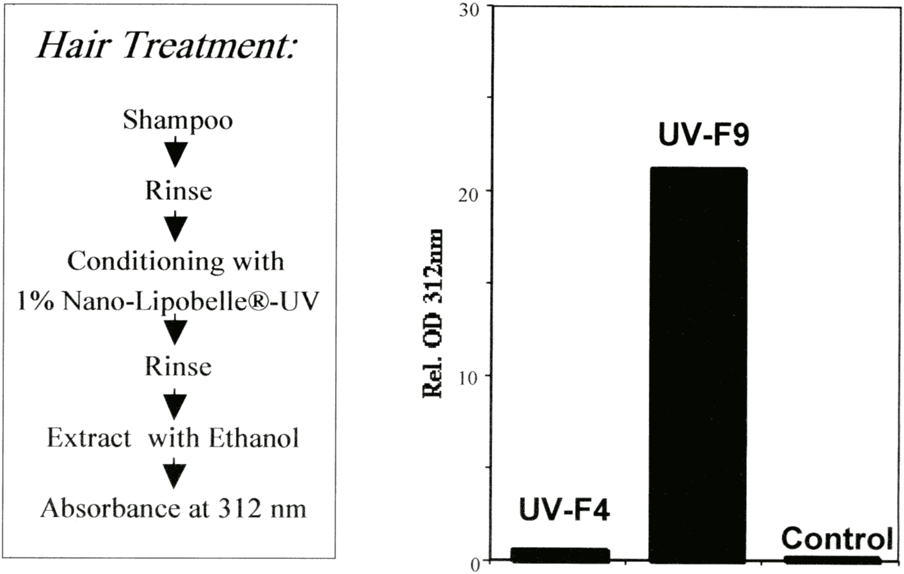

Figure 2. Hair treatment with UV-filters encapsulated in positively and negatively charged nanoparticles

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