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Nanoemulsions For Cosmetics

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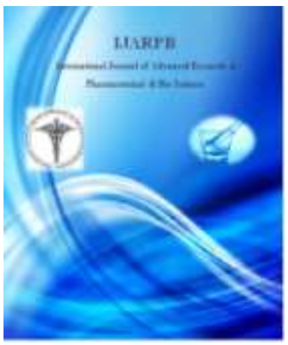

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ABSTRACT

Nanotechnology comprises technological developments on the nanometer scale, usually 0.1-100nm. Nanoemulsions have recently become increasingly important as potential vehicles for the controlled delivery of cosmetics and for the optimized dispersion of active ingredients in particular skin layers. Due to their lipophilic interior, Nanoemulsions are more suitable for the transport of lipophilic compounds than liposomes. Similar to liposomes, they support the skin penetration of active ingredients and thus increase their concentration in the skin. Another advantage is the small-sized droplet with its high surface area allowing effective transport of the active to the skin. Furthermore, nanoemulsions gain increasing interest due to their own bioactive effects. This may reduce the transepidermal water loss (TEWL), indicating that the barrier function of the skin is strenghthened. Nanoemulsions are acceptable in cosmetics because there is no inherent creaming, sedimentation, flocculation, or coalescence that is observed with macroemulsions. Oil-in-water emulsions (O/W emulsions) play an important role in cosmetics: they are fundamental in the formulation of such products as body lotions, skin creams and sunscreens. A relatively recent but fast growing field of application is NanoGel systems and Emulsion-based wet wipes, nanoemulsions that are free from emulsifiers based on polyethylene glycol (PEG). Such blends are highly attractive in the growing market for impregnating emulsions for moisturized tissue. It is relatively recent but fast growing field of application: emulsion-based wet wipes for such applications as baby care and make-up removal.

KEYWORDS: Nanogel systems, Wet wipes, Phase Inversion Temperature, TEWL, PEG-free nanoemusions

INTRODUCTION

The use of nanotechnology in pharmaceuticals and medicine has grown over the last few years. The pharmaceuticals developed on the basis of nanotechnology are termed as "Nanopharmaceuticals". The various nanopharmaceuticals currently being used or in the process of development are[1] Nanoemulsions (NE) (submicron sized emulsions), nanosuspensions (submicron sized suspensions), nanospheres (drug nanoparticle in polymer matrix), nanotubes (sequence of nanoscale C60 atoms arranged in a long chain cylindrical structure), nanoshells (concentric sphere nanoparticles consisting of a dielectric core and a metal shell), nanocapsules (encapsulated drug nanoparticles), lipid nanoparticles (lipid monolayer enclosing a solid lipid core) and dendrimers (nanoscale three-dimentional macromolecules of polymer). NEs are group of dispersed particles for pharmaceutical and biomedical aids and vehicles that show great promise for the future of cosmetics. NEs can be defined as oil-in-water (o/w) emulsions with mean droplet diameters ranging from 50 to 1000nm. Usually, the average droplet size is between 100 and 500nm. The particles can exist as water-in-oil and oil-in-water forms, where the core of the particle is either water or oil, respectively. NEs are made from surfactants approved for human consumption and common food substance that are "Generally Recognised as Safe" (GRAS) by the FDA. These emulsions are easily produced in large quantities by mixing a water-immiscible oil phase into an aqueous phase with a high-stress, a mechanical extrusion process [2].

The NEs are also referred as microemulsions, ultrafine emulsions and submicron emulsions. Phase behavior studies have shown that the size of the droplets is governed by the surfactant phase structure (biocontinuous microemulsion or lamellar) at the inversion point induced by either temperature or composition. Studies on NE formation by the phase inversion temperature (PIT) method have shown a relationship between minimum droplet size and complete solubilization of the oil in a microemulsion biocontinuous phase independently of whether the initial phase equilibrium is single or multiphase. Nanoemulsions are submicron sized emulsions that are under extensive investigation as drug carriers for improving the delivery of therapeutic agents. They are by far the most advanced nanoparticle systems for the cosmetics. It helps to give skin care formulations a good skin feel, an increasingly important characteristic for formulators.

NEs posses various advantages such as [3]

NEs have a much higher surface area and free energy than macroemulsions that make them an effective transport system.

- NEs do not show the problems of inherent creaming, flocculation, coalescence, and sedimentation, which are commonly associated with macroemulsions.
- NEs can be formulated in variety of formulations such as foams, creams, liquids and sprays.
- NEs are non-toxic and non-irritant, hence can be easily applied to skin and mucous membranes.
- NEs are formulated with surfactants, which are approved for human

consumption (GRAS), they can be taken by enteric route.

- NEs do not damage healthy human and animal cells, hence are suitable for human and veterinary therapeutic purposes.

Methods of Preparation of Nanoemusions [4-7]

High pressure homogeniozation: This technique makes use of high-pressure homogenizer/piston homogenizer to produce NEs of extremely low particle size (upto 1nm).

Microfluidization: Microfluidizaion is a patented mixing technology, which makes use of a device called microfluidizer. This device uses a high pressure positive displacement pump (500-20000 psi), which forces the product through the interaction chamber, which consists of small channels called “microchanels”. The product flows through the microchanels onto an impingement area resulting in very fine particles of sub-micron range. The two solutions (aqueous phase and oily phase) are combined together and processed in an inline homogenizer to yield a coarse emulsion. The coarse emulsion is into a microfluidizer where it is further processed to obtain a stable nanoemuslion. The coarse emulsion is passed through an interaction chamber of the microfluidizer repeatedly until desired particle size is obtained. The bulk emulsion is then filtered through a filter under nitrogen to remove large droplets resulting in a uniform nanoemulsion.

Other method used for the NE preparation is the phase inversion temperature technique.

Components of Nanoemulsion

Main three components of nanoemulsions are as follows:

1. Oil (Table 1)
2. Surfactant/Co-Surfactant (Table 2)
3. Aqueous Phase (Table 3)

Table1: List of oils used in nanoemusions

S.No.	Name	Chemical Name
1	Captex 355	Glyceryl Tricaorylate/ Caprate
2	Captex 200	Propylene Dicaprylate/ Dicaprate Glycol
3	Captex 8000	Glyceryl Tricaprylate (Tricaprylin)
4	Witepsol	90:10 % w/w C12 Glyceride tri: diesters
5	Myritol 318	C8/C10 triglycerides
6	Isopropyl myristate	Myristic acid isopropyl ester

Table 2: List of Surfactants used in Nanoemulsions

S.No.	Solubilizing agents, surfactants, emulsifying agents, adsorption enhancers
1	Capryol 90
2	Gelucire 44/14, 50/13
3	Cremophore RH 40
4	Imwitor 191, 308(1), 380, 742, 780K, 928, 988
5	Labrafil M 1944 CS, M2125 CS
6	Lauroglycol 90
7	PEG MW > 4000
8	Plurol Oleique CC 497
9	Poloxamer 124 and 188
10	Softigen 701, 767
11	Tagat TO
12	Tween 80

Table 3: List of Co-Surfactant Used in Nanoemulsions

S.No.	Co Surfactant
1	Transcuto IP
2	Glycerin, Ethylene Glycol
3	Propylene Glycol
4	Ethanol
5	Propanol

Factors to be considered during preparation of nanoemulsion

Three important conditions:

- Surfactants must be carefully chosen so that an ultra low interfacial tension ($< 10^{-3}$ mN/m) can be attained at the oil/water interface which is a prime requirement to produce nanoemusions.
- Concentration of surfactant must be high enough to provide the number of surfactant molecules needed to stabilize the microdroplets to be produced by an ultra low interfacial tension.
- The interface must be flexible or fluid enough to promote the formation of Nanoemulsions.

Applications of Nanoemulsions in Cosmetics

NEs have recently become increasingly important as potential vehicles for the controlled delivery of cosmetics and for the optimized dispersion of active ingredients in particular skin layers. Due to their lipophilic interior, NEs are more suitable for the transport of lipophilic compounds than liposomes. Similar to liposomes, they support the skin penetration of active ingredients and thus increase their concentration in the skin. Another advantage is the small sized droplet with its high surface area allowing effective transport of the active to the skin. Furthermore, NEs gain increasing interest due to their own bioactive effects. This may reduce the trans-epidermal water loss (TEWL), indicating that the barrier function of the skin is strengthened. NEs are acceptable in cosmetics because there are no inherent creaming, sedimentation, flocculation, or coalescence that are observed with macroemulsions. The incorporation of potentially irritating surfactants can often be avoided by using high energy equipment during manufacturing. [8]

NanoGel

One of the example includes New Jersey -based TRI-K Industries and its patent company Kemira have launched a new Nano-based gel aimed at enhancing the efficacy of a wide range of skin care products. Kemira Nanogel is said to be a unique nanoemulsion carrier system that has been designed around easy formulation, combined with the added benefits brought about by its nanotechnology properties.

NanoGel technology provides a simple process and system to create submicron emulsions from an easy-to-use, oil-in-water concentrate. The formula is particularly suited to minimizing transepidermal water loss, enhanced skin production, and penetration of active ingredients. These characteristics suggest it would be particularly useful for sun care products as well as moisturizing and anti-aging creams_ particular areas where nanotechnology is already being incorporated into a host of products currently on the market. Likewise, it is also highlighted that it helps to give skin care formulations a good skin feel, an increasingly important characteristics of formulators.

PEG- free Nanoemulsions for Cosmetics[9]

Another example includes manufacturing and processing of low-viscosity oil-in-water nanoemulsions that are free from emulsifiers based on polyethylene glycol (PEG). Such blends are highly attractive in the growing market for impregnating emulsions for moisturized tissue. It is relatively recent but fast growing field of application : emulsion-based wet wipes for such applications as baby care and make-up removal. The key components in these products are low viscosity O/W emulsions with good storage stability. Classical emulsions have typical particle radii of between 0.5 and 10 micrometers which causes their typical white appearance, and usually show viscosities of over 1,000 mPas. They are kinetically stable, and can be manufactured with help of a homogenizer. Because their particles are relatively large, however, comparable viscosity systems are unstable and cream up.

Alternatively, O/W microemulsions are easy to produce because of their thermodynamic stability. They are translucent, and their typical particle radii range between 10 and 40 nanometers. Microemulsions form spontaneously on mixing, and the order in which the components are added makes no difference. However, microemulsion formation usually requires large quantities of emulsifiers and surfactants. In terms of their properties, "nanoemulsions" are positioned between microemulsion and traditional emulsions. Their typical particle radii range between 30 and 100 nanometers which causes their typical blue-shinning experience. At these small particle sizes, the Brownian motion prevents creaming, and as a result, nanoemulsions often have a long-term good stability. Like classical emulsions, nanoemulsions are kinetically stable. They are typically not easy-to-produce as they require either high-pressure homogenisers or very specific manufacturing processes.

We have now overcome this disadvantage with the development of a low-energy emulsion process for the manufacturing of nanoemulsions. In this process, a phase with extremely low surface tension is passed. In this phase the transitional phase inversion occurs at the affinity of the emulsifier towards the oil and water phase changes continuously. To put it in graphic terms, the curvature of the surface changes from W/O (concave) to O/W (convex) in this process. As it changes, the emulsion goes through a microemulsion-like phase in which the surface is not curved (figure 1).

The conventional process for manufacturing finely dispersed O/W emulsions with a transitional phase inversion is the Phase Inversion Temperature Method, in which the phase transition is obtained by cooling. O/W nanoemulsions manufactured by this method are long term stable and are used for a number of cosmetic applications (e.g. wet wipes, sprayable emulsions). Phase Inversion Temperature emulsions utilize the temperature-dependent hydrophilicity of the ethoxylated emulsifiers.

PEG-free Alternatives to Phase Inversion Temperature Emulsions needed

The use of ethoxylated emulsifiers, however is seen more and more as a disadvantage. Because consumers increasingly prefer natural ingredients in cosmetics, the industry is extremely interested in PEG- free emulsions. And this is just what Evonik has now made possible: the manufacturer of nanoemulsions without homogenisers, without energy input for heating/cooling steps and without ethoxylates. An oil phase based on this new technology platform typically consists of three components: PEG free emulsifiers (10% to 30%), cosmetic oils (50% to 90%), and co-surfactants (1% to 20%). Co-surfactants are surface active. However, unlike surfactants, they do not form micelles in water, and therefore do not tend to self-aggregate. If water is added to this kind of liquid and clear oil phase, a microemulsion-like phase is passed and a low-viscosity O/W nanoemulsion with good long-term stability is obtained.

In the tests conducted on these wipes, the viscosity of the wipe system depends heavily on the water content. In the microemulsion like phase, there is a significant reduction in viscosity, which indicates extremely low- interfacial tension at this point. Similar to phase inversion temperature emulsion system, this kind of minimum viscosity is typical for the point of phase inversion from W/O to O/W. Because this inversion point occurs at a certain water concentration, the new process is called a Phase Inversion Concentration Technology. These PICT emulsions system require no stirring or heating. Even the order in which the oil and water are added has no impact on the result. The emulsion mixture and co-surfactant content, however, must be presicely adjusted with the oil phase to be emulsified.

In the Tego wipe system, the surface active phenoxylethanol, which is often used as preservative in the cosmetic industry, plays the role of the cosurfactant. The researchers assume that the water solubility of the phenoxyethanol is decisive for the occurrence of a microemulsion like phase: with increasing water concentration , the cosurfactant increasingly migrates out of the surface film and into the water phase, which assists the phase inversion. The phase inversion is also promoted by a co-emulsifier, such as dilauryl citrate, that becomes more hydrophilic with increasing water concentration.

Likewise, it is also highlighted that it helps to give skin care formulations a good skin feel, an increasingly important characteristic for formulators. Nanoemulsions have attracted considerable attention in recent years for application in personal care products as potential vehicles for the controlled delivery of cosmetics and the optimized dispersion of active ingredients in particular skin layers.[10]

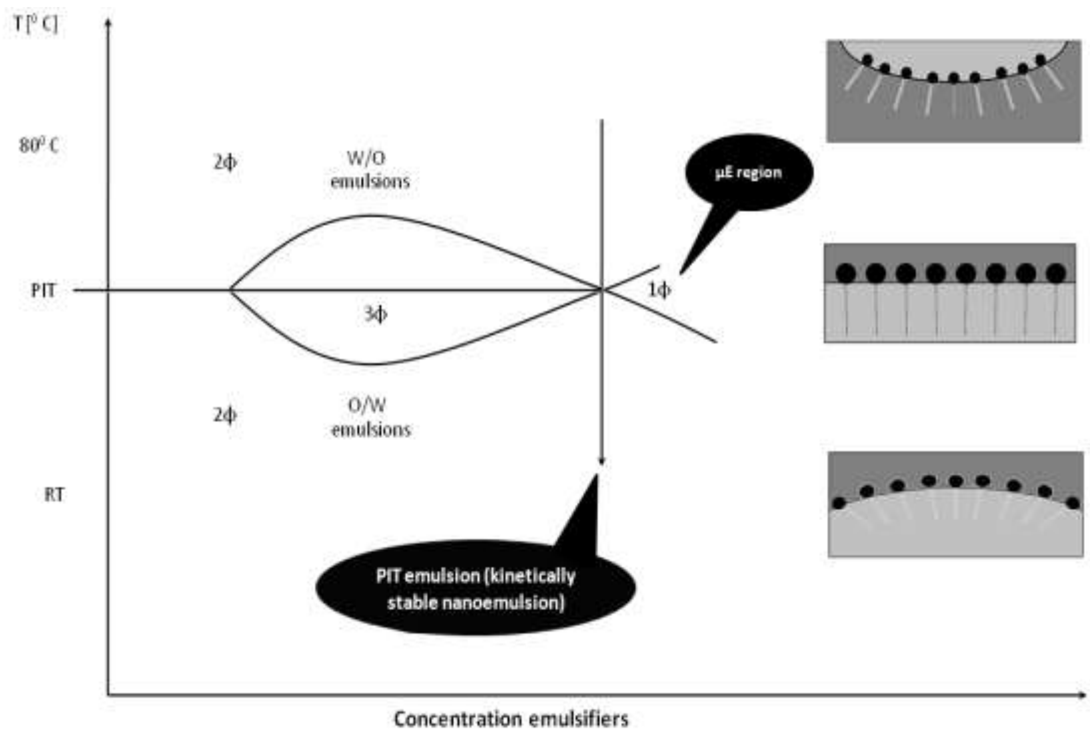

Figure1: With PIT method (the phase inversion temperature method) the affinity of the emulsifier for the two phases changes at the oil and water interface, depending on the temperature. When a w/o emulsion is cooled, a transitional phase inversion occurs that results in low-viscosity, finely-dispersed o/w nanoemulsions with good storage stability.

Patented Nanoemulsions[11]

1. Patent Name: NE based on phosphoric acid fatty acid esters and its uses in cosmetics, dermatological, pharmaceutical and/or ophthalmological fields. Assignee: L'Oreal (Paris, FR). US Patent Number: 6,274,150.
2. Patent Name: NE based on ethylene oxide and propylene oxide block copolymers and its uses in the cosmetics, dermatological and/or ophthalmological fields. Assignee: L'Oreal (Paris, FR). US Patent Number: 6,464,990.

Conclusion

A great advancement had been reported in case of nanoemulsion used for cosmetics. Scientists had invented PEG- free emulsions because consumers increasingly prefer natural ingredients in cosmetics. The new process is called a Phase Inversion Concentration Technology which require no stirring or heating. Tego Wipe System represents the best example for this kind of technology which are long term stable emulsions with very fine particle size. These cosmetic wet wipes are particularly useful for make-up removal, face care, body care & baby care products. It is also highlighted that it helps to give skin care formulations a good skin feel, an increasingly important characteristic for formulators. Nanoemulsions have attracted considerable attention in recent years for application in personal care products as potential vehicles for the controlled delivery of cosmetics and the optimized dispersion of active ingredients in particular skin layers.

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