

Nanoemulsions are suitable for the efficient delivery of active ingredients through the skin. The large surface area of the emulsion system allows for the rapid penetration of actives such as vitamins and antioxidants into the skin (Tadros, 2005). The application of nanoemulsions with lipid or non-soluble materials has produced enhanced skin properties. Incorporation of lipophilic materials such as ceramide, lecithin and vitamin A in nanoemulsions has resulted in an increase in skin hydration (Yilmaz and Borchert, 2006; Zhou *et al.*, 2010). This paper highlights the technology for incorporating palm tocotrienol into a nanoemulsion system.

PALM TOCOTRIENOL NANOEMULSION

Palm tocotrienol nanoemulsion is prepared via a high energy homogenisation method. The high pressures generate a tremendous amount of energy and fluid velocity, resulting in intense turbulence. When the disruptive forces in a homogenisation process exceed the interfacial forces, oil droplets will be broken up into submicron particles in an emulsion or a nanoemulsion system. *Figures 1 and 2* show the preparation steps and the average particle size of a macroemulsion and nanoemulsion, respectively.

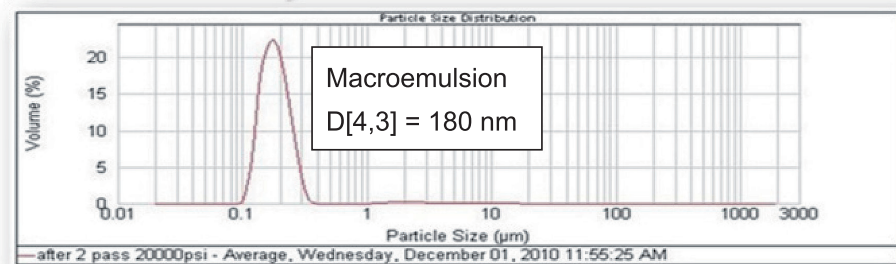
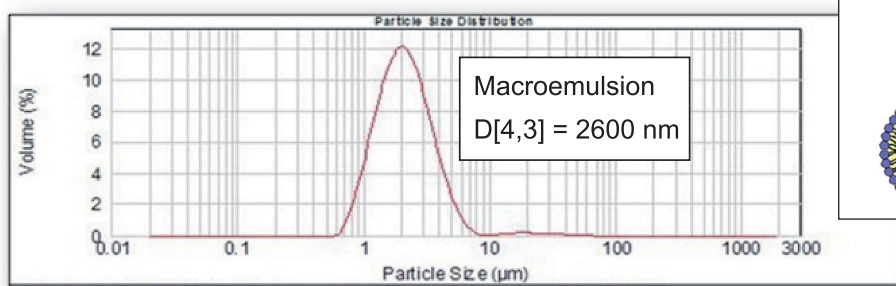


Figure 2. Average particle size of tocotrienol in macroemulsion and tocotrienol in nanoemulsion which has been subjected to high pressure homogenisation.

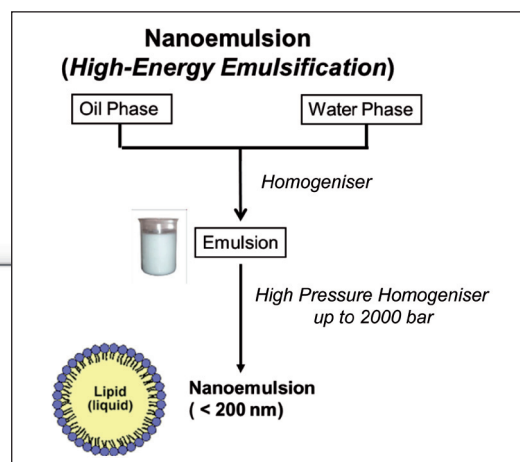


Figure 1. Preparation of nanoemulsion.

PROPERTIES OF PALM TOCOTRIENOL NANOEMULSION

- The tocotrienol nanoemulsion has an average particle size, $D[4,3]$ of 180 nm with monomodal distribution.
- It is stable against Ostwald Ripening at room temperature.
- The tocotrienol nanoemulsion is translucent, and behaves like a Newtonian fluid. Submicron tocotrienol can be incorporated into a gel system.
- Higher percentages of tocotrienol in a nanoemulsion system provide better delivery into the skin than a macroemulsion.

SAFETY ASSESSMENT

In vitro and *in vivo* safety assessments for skin irritation were carried out to ensure that the tocotrienol nanoemulsion does not induce any cutaneous side effects. *In vitro* test results showed no significant irritation potential for the tocotrienol nanoemulsion (Figures 3 and 4). Figure 5 shows the results of an *in vivo* human repeated insult patch test which indicate that the tocotrienol nanoemulsion did not induce any irritant contact dermatitis or allergic dermatitis.

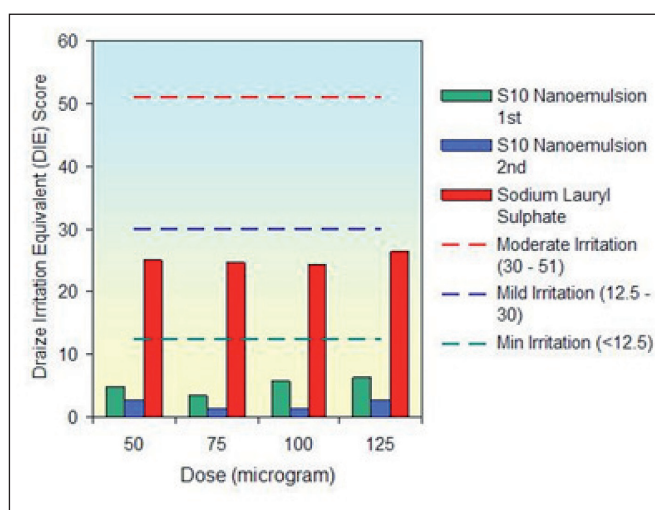


Figure 3. *In vitro* ocular irritation assay for tocotrienol nanoemulsion.

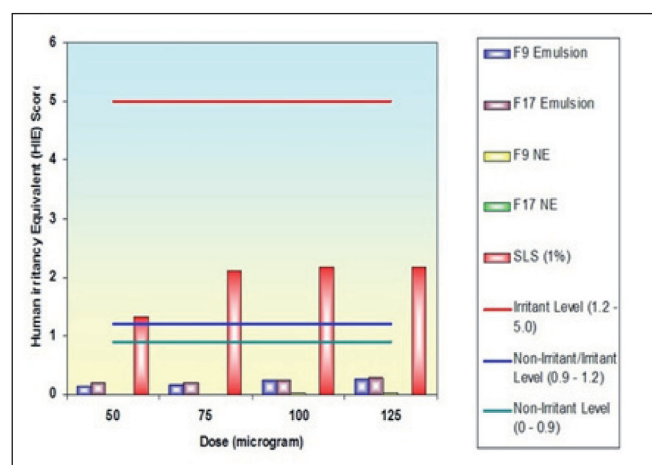


Figure 4. *In vitro* dermal irritation assay for tocotrienol nanoemulsion.

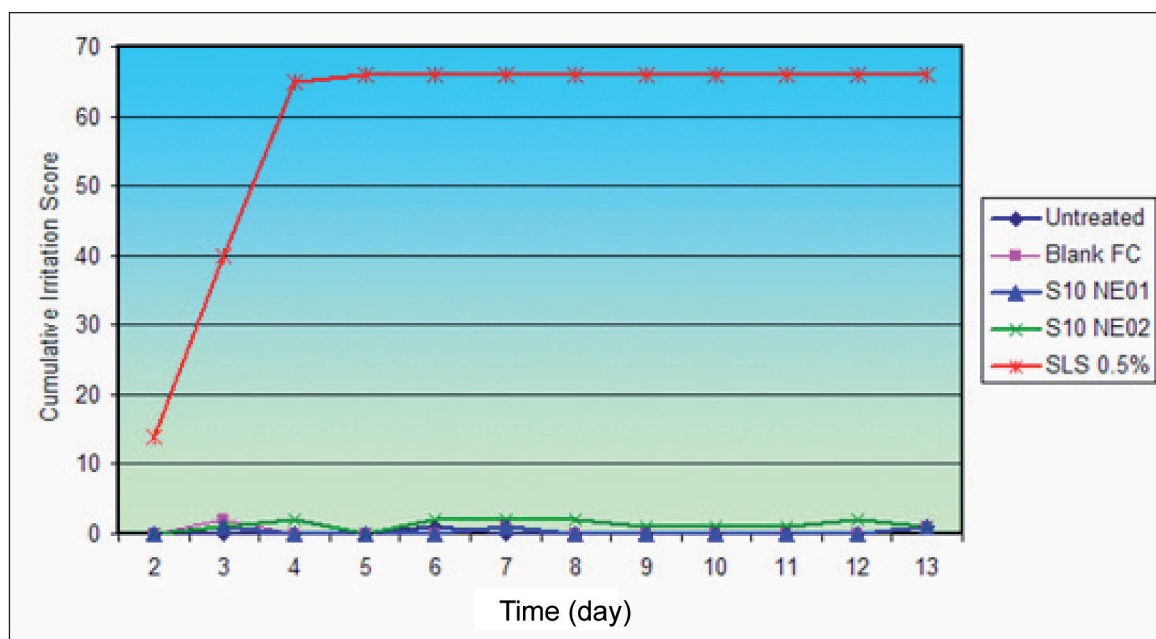


Figure 5. Results of human repeated insult patch test for tocotrienol nanoemulsion.

EFFICACY EVALUATION

For the determination of the effectiveness of the product, skin hydration measurements and the *in vitro* Sun Protection Factor (SPF) test were carried out on the tocotrienol nanoemulsion in comparison with tocotrienol in a macroemulsion system. Figure 6 shows the test areas for untreated, mac-

roemulsion- and nanoemulsion-treated. Tocotrienol in a macroemulsion showed a 29% increase in skin hydration compared to the maximum of 54% for the tocotrienol nanoemulsion (Figure 7). Figure 8 indicates that the tocotrienol nanoemulsion protected the skin better than the macroemulsion against ultraviolet light.

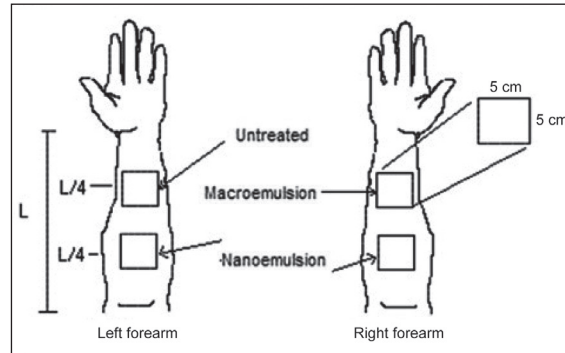


Figure 6. Test areas for skin hydration measurements.

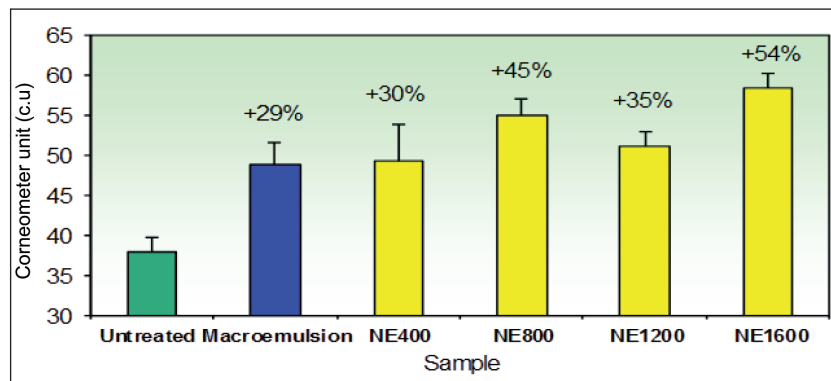


Figure 7. Skin hydration measurements for untreated area, and areas treated with tocotrienol in macroemulsion and with tocotrienol in nanoemulsion (NE) at various pressures (400, 800, 1200 and 1600 bar).

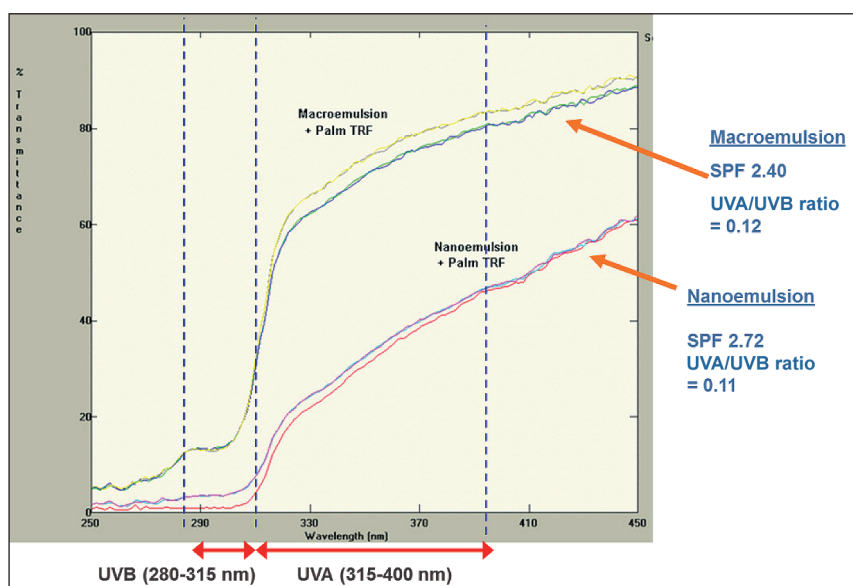


Figure 8. *In vitro* sun protection factor of tocotrienol macroemulsion against tocotrienol nanoemulsion.

ECONOMIC ANALYSIS

Cosmetics utilising nanotechnology are relatively new in this region. The current market price of cosmetics with nanomaterials varies between RM 40 and RM 200 per 30 g of cream. For a 3000-kg production output per year, the projected cash flow is as follows:

Estimated capital expenditure (CAPEX) : RM 260 000

Estimated operational cost (1st year) : RM 430 000

Cash flow @ 30% price margin

Internal Rate of Return (IRR) : 54%

Return (IRR)

Net Present Value (NPV) @ 20% : RM 120 000

Payback period : 3 years



Figure 9. Palm tocotrienol nanoemulsion.

The estimated raw material cost and projected palm tocotrienol nanoemulsion price are RM 180/kg and RM 234/kg, respectively.

CONCLUSION

A nanoemulsion system has very small particle size which enables better skin penetration and delivery of palm tocotrienol than traditional emulsions. The nano product is safe, and with enhanced delivery, its application results in higher skin hydration with a better sun protection property. The technology is suitable for cosmetic manufacturing companies as the process can be integrated into the existing production lines.

REFERENCES

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YILMAZ, E and BORCHERT, H (2006). Effect of lipid-containing, positively charged nanoemulsions on skin hydration, elasticity and erythema - An *in vivo* study. *Int. J. Pharm.* 307, (2): 232-238.

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