Study on nanoemulsion using various lecithins and oils

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Summary

Nanoemulsions have many specific characters compared with general emulsions in aspect of stability, rheological property, uniformity, high interfacial tension and so on. Therefore we study on nanoemulsions with changing various lecithins and oils using microfluidizer. As lecithins, we used saturated lecithin, unsaturated lecithin and hydrogenated phosphatidylcholine. Caprylic capric triglyceride, Squalane, Macadamia nut oil, Liquid paraffins, Dimethicone, and Cyclomethicone were used as oils. To identify nanoemulsions, we measured paticle size, zeta potential, turbidity and transmission electron microscope.

Introduction

Generally, emulsions can be classified as macroemulsion, miniemulsion and microemulsion. These emulsions have droplet size of 0.1 ~ 100 ㎛. To maintain physical stability of emulsion is very important. Among the rest, emulsion size stability, defined as the ability to maintain initial particle size distribution without undergoing phase separation, is the best. Many factors, for example, components, composition, preparation method and formulation conditions, are known to change the stability of emulsions [1]. It has been a long-standing aim to formulate stable emulsions with small particles since the stabilization of emulsion could be achieved by particle size reduction [2]. In recent years, nanoemulsions are in the spotlight of application in personal and health care products. These systems are stable against creaming or sedimentation as well as against flocculation and coalescence because nanoemulsions have size ranges in the region of 100 ~ 200 nm. Because of thermodynamical stability of microemulsions, these emulsions depend entirely upon concentration of surfactant and oil, while nanoemulsions, as kinetic stability originated from Brownian motion, need low concentration of surfactant [3].

In 1850, Gobley named phospholipid, separated from the yolk of an egg, for lecithin. Lecithin exhibits a very strong hydrophobicity due to two long hydrocarbon chains as well as a strong

hydrophilicity due to the zwitterionic polar head groups that have dipole moments. There is a close balance between hydrophilic and lipophilic properties [4]. Lecithin contains a high percentage of phospholipid and consists of phosphatidylcholine, phosphatidylethanolamine, phosphatidyl-inositol, phosphatidic acid and phosphatidylserine. The properties of lecithin depend on alkyl chain's three dimensional shape, size and degree of saturation. Hydrogenated lecithin is the state of saturated alkyl chain and is superior to general lecithins in aspect of stability of oxidation [5].

The purpose of our study was to prepare nanoemulsions that have many specific characters as stated above and apply them to personal and health care products. To our aim, we used lecithin as emulsifier because it has structure of phospholipid that is all alike living body and also it is great in skin penetration against other synthetic emulsifier. And we made an experiment with various lecithins and oils using microfluidizer. The reason why we used microfluidizer as a high-pressure homogenizer was to achieve a stable nanoemulsion that could be under the control of skin penetration for our skin. To find optimal conditions, a series of experiments was performed on variation of cycle and pressure of microfluidization under the lecithin and oil. The results were summarized in experimental section. With these results, we prepared nanoemulsion in volume of oil, quantity of lecithin, class of oil and type of lecithin under 5 cycles of microfluidization at 800 bar. To make sure nanoemulsions were formed, we measured particle size, zeta potential, turbidity and transmission electron microscope. These results were discussed in experimental section.

Materials and Methods

Equipments

Turbidimeter (2100AN, HACH, USA) was used as measuring instrument of turbidity and Zetasizer 3000HS (MALVERN, UK) was used as measuring instrument of particle size and zeta potential. Microfluidizer (M110F, MICROFLUIDICS, USA) was used as emulsifying instrument. Also transmission electron microscope (TEM) was performed on a JEM1010 electron microscope (JEOL, JAPAN).

Materials

As lecithins, Lecinol S-10 (Hydrogenated soybean lecithin with more than 40 % phosphatidyl choline, Nikkol), HSPC-50 (Hydrogenated soybean lecithin with more than 50 % phosphatidyl choline, Lucas Meyer), S75-3 (Hydrogenated fat-free soybean lecithin with more than 70 % phosphatidyl choline, LIPOID), Lipoid S75 (unsaturated), Lipoid S100-3 (Hydrogenated phosphatidyl choline from soybean lecithin with more than 94 %, LIPOID) and Lipoid S100 (unsaturated) were used. Also as oils, Caprylic capric triglyceride, Squalane, Macadamia nut oil, Liquid paraffins, Dimethicone and Cyclomethicone were used in cosmetic grade.

General Method

The following procedure is representative. To a homogenized solution of water phase was added oil phase which was composed of Lipoid S 75 (3 %), ethanol (15 %), oil (5 %) and additive at 50 ℃. The crude emulsion was pumped through the interaction chamber of a M110F microfluidizer at a pressure of 800 bar. This process was repeated up to five times. The general formulation of nanoemulsion is summarized in Table. Ⅰ.

Results and Discussion

We tried a series of experiment to determine optimal condition. Firstly, Lipoid S75-3 and Lipoid S75 were fixed as lecithins and Caprylic carpric triglyceride was used as oil, we measured particle size and turbidity for investigation of variation as number of microfluidization cycles (Fig. 1).
In this experiment, we observed that particle size and turbidity were reduced generally in increasing of microfluidization cycle but, beyond five times, both particle size and turbidity were not changed dramatically. Also, although Lipoid S75 has less numerical value of particle size and turbidity relatively than Lipoid S75-3 which hydrogenated soybean lecithin, Particle size and turbidity variation of Lipoid S75 was the same tendency as Lipoid S75-3.

Secondly, to find out suitable pressure of microfluidization, we made a further study of nanoemulsion with Lipoid S75 as a lecithin (Fig. 2). As shown in Fig. 2, particle size and turbidity curves were constant over 800 bar. Based on result of Fig. 1 and Fig. 2, we found that optimum conditions of microfluidization were five times and 800 bar.

And then we investigated particle size and turbidity of nanoemulsions as using various lecithins (Fig. 3). In this experiment, Lipoid S75 showed the best result in both particle size and turbidity. Considering diffusion of light as variation of particle size, the fact that turbidity is on the decrease as smaller the particle size may perhaps be natural result. In fact Fig. 3 showed this correlation. Also we have learned that unsaturated lecithins have smaller particle size and turbidity than hydrogenated lecithins.

With these results, we carried out an experiment on particle size distribution of nanoemulsions as a content of Lipoid S75 (Fig. 4). Size distribution of nanoemulsion that was contained a percentage of 1 or 2 remarkable difference from a percentage of 3. In case of over 3 %, there is somewhat difference from 5 % but we thought there is little point in it. Therefore we knew that nanoemulsion contained 3 % lecithin as emulsifier was proper in our system.

We also studied on variation of particle size and turbidity of nanoemulsion as the oil of contents (Fig. 5). In the event of turbidity, as the oil of content has increased from 1 % to 5 %, turbidity has increased step by step. But more than 5 %, turbidity has increased rapidly. In case of particle size, as the oil of content has increased from 1 % to 3%, particle size has showed a sudden change. But particle size has increased up to 5 % rapidly and has increased to 20 % smoothly. Beyond our expectation, the result of particle size variation contrary to the turbidity's from 1 % to 3 %. In

principle, variation of particle size is directly proportional to variation of turbidity. But we have obtained a inverse result in this case. We think this phenomenon happened that the oil of content was too little to form nanoparticle with lecithin and the other structure that has bigger particle size was formed. Therefore we think particle size of 1 % oil of content is not a nanoparticle size. Consequently, we have decided to use oil by a percentage of 5.

Next, we applied various oils to our nanoemulsion system (Table. Ⅱ). As shown in table Ⅱ, the value of zeta potential have showed less than –50 mV in all case of oil. The stability of a particle dispersion will depend upon the balance of the repulsive and attractive forces that exist between particles as they approach one another. The magnitude of the measured zeta potential is an indication of the repulsive force that is present and can be used to predict the long-term stability of the product. The general dividing line between stable and unstable suspensions is generally taken at either +30 or –30 mV. Particles with zeta potentials more positive than +30 mV or more negative than –30 mV are normally considered stable. Thus we found our nanoemulsions have state of electrical stability. In the event of turbidity and particle size, we have obtained a good result in case of Caprylic capric triglyceride and Dimethicone. Unexpectedly, when we used cyclomethicone as oil, in spite of low turbidity compared with other oils, particle size was bigger than other cases. We think it is same as experiment of Fig. 5 and we will make further experiment on this result in detail.

Anyway, we kept nanoemulsions that was manufactured by our optimum conditions in incubator at 45 ℃ and 5 ℃. After three weeks, we measured particle size and zeta potential again (Fig. 6) and we could confirm no variation, approximately. Also we could identify nanoemulsion that was made by Lipoid S75-3 by transmission electron microscope clearly (Fig. 7).

Conclusions

we could found out effect of nanoemulsion as kinds of lecithin, oil, pressure of microfluidizer, cycle of microfluidization and so on. Also we could have identify nanoemulsion by particle size, zeta potential and tranmission electron microscope.

In summary,

1) Generally, hydrogenated lecithins have less numerical value than unsaturated lecithins in particle size and turbidity.
2) As content of lecithin increased and oil decreased, particle size and turbidity decreased.
3) In case of using various oils, particle size has decreased as followed.

   Cyclomethincone > Macadamia nut oil > Squalane > Liquid Paraffin > Dimethicone > Caprylic capric triglyceride.

Consequently, we have manufactured nanoemusion by our optimum conditions, although it has made a difference as lecithins and oils.

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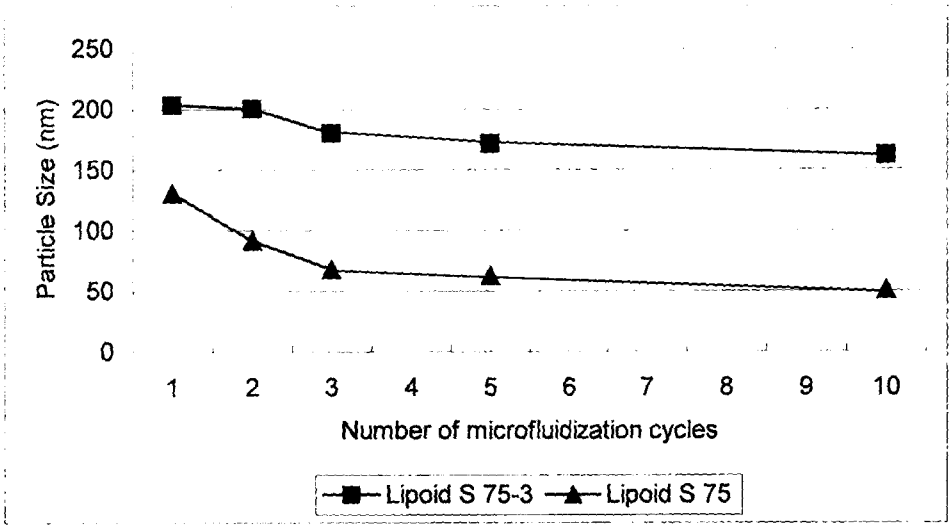
Table. Ⅰ. General Formulation of Nanoemulsion

Part	Ingredient	% by weight
Lipid Phase	Lecithin	1 ~ 5
	Ethanol	15.0
	DEA-cetyl phosphate	Qs
	Oil	1 ~ 20
Aqueous Phase	Additive	Qs
	Water	To 100

Table. Ⅱ. Analytical Data of nanoemulsions as a function of oils

Ingredient	Turbidity (NTU)	Zeta Potential(mV)	Particle Size (nm)
Liquid Paraffins	2890	-76.3	96.3
Squalane	4040	-71.4	103.5
Macadamia Nut Oil	4710	-66.7	110.1
Dimethicone	344	-60.4	80.6
Cyclomethicone	797	-65.7	177.2
Caprylic/Capric Triglyceride	292	-61.1	62.4

Fig. 1. Variation of particle size and turbidity as number of microfluidization cycles



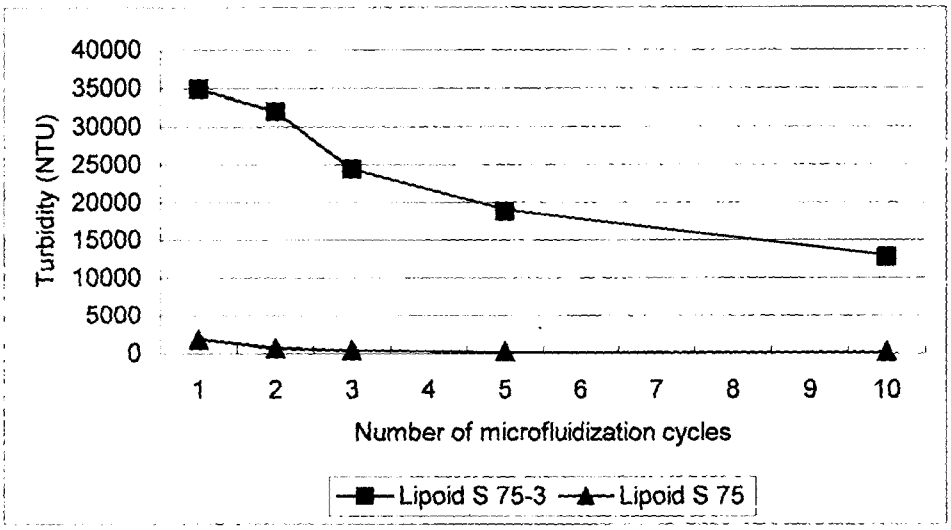
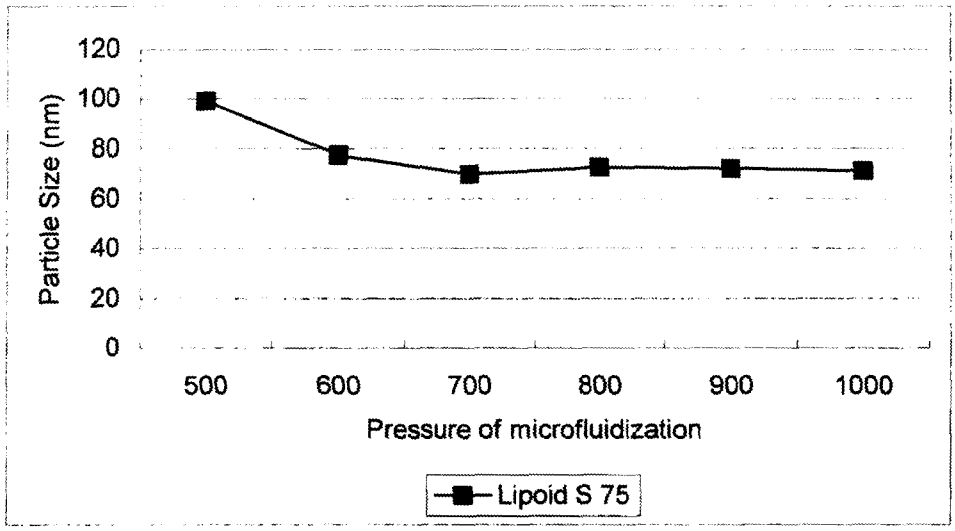


Fig. 2. Variation of particle size and turbidity as pressure of microfluidization



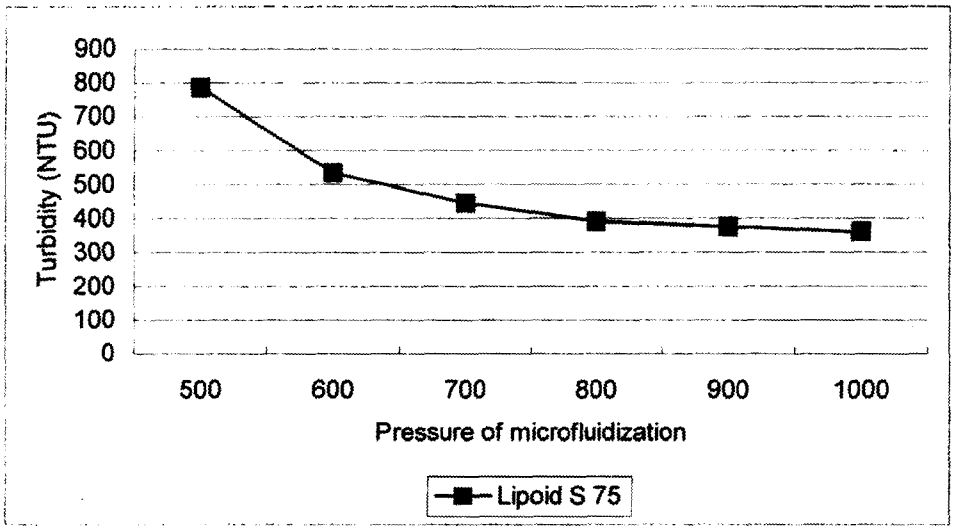


Fig. 3. Variation of particle size and turbidity as various lecithins

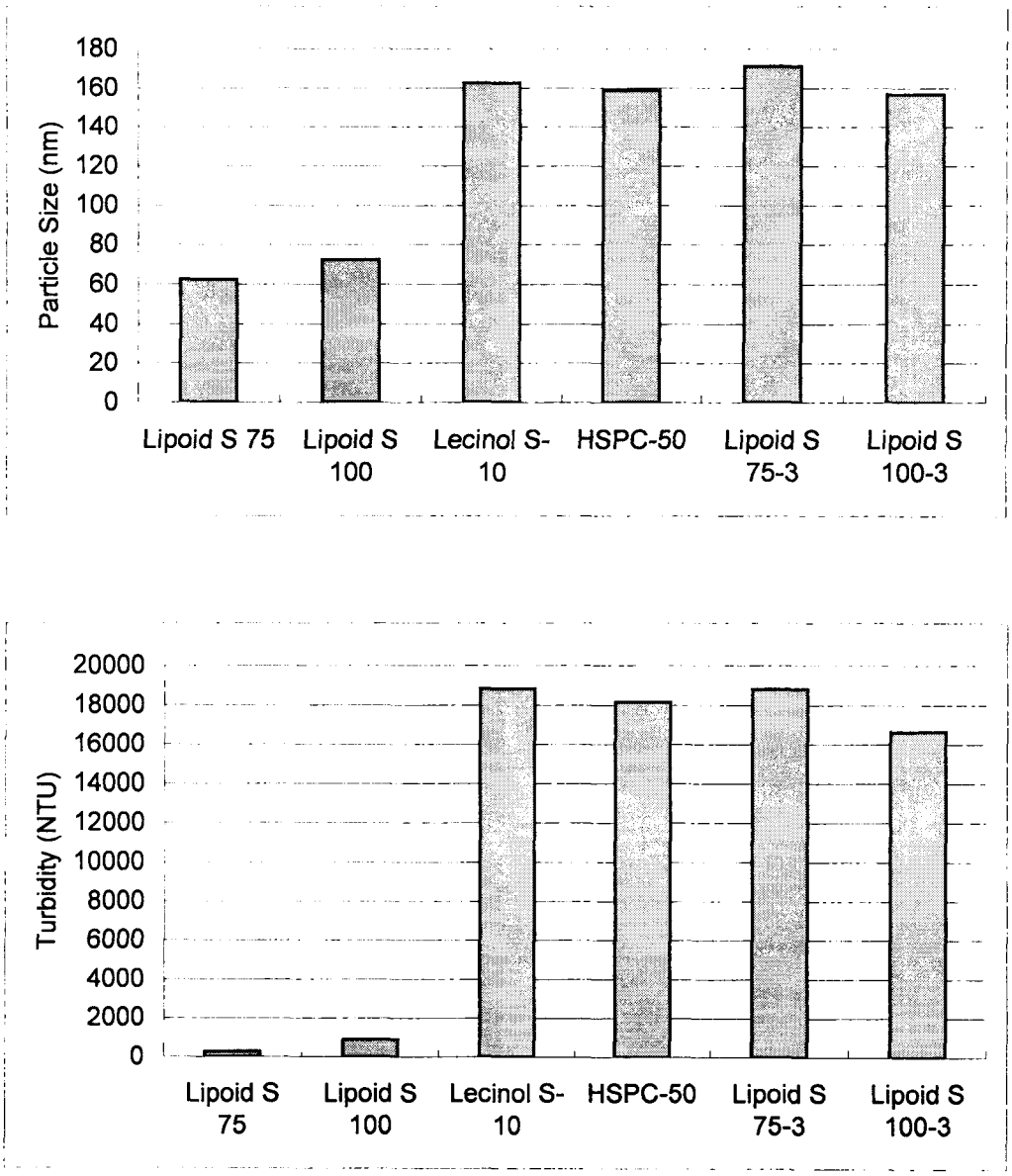


Fig. 4. Particle size distribution of nanoemulsions as a function of contents of lecithin

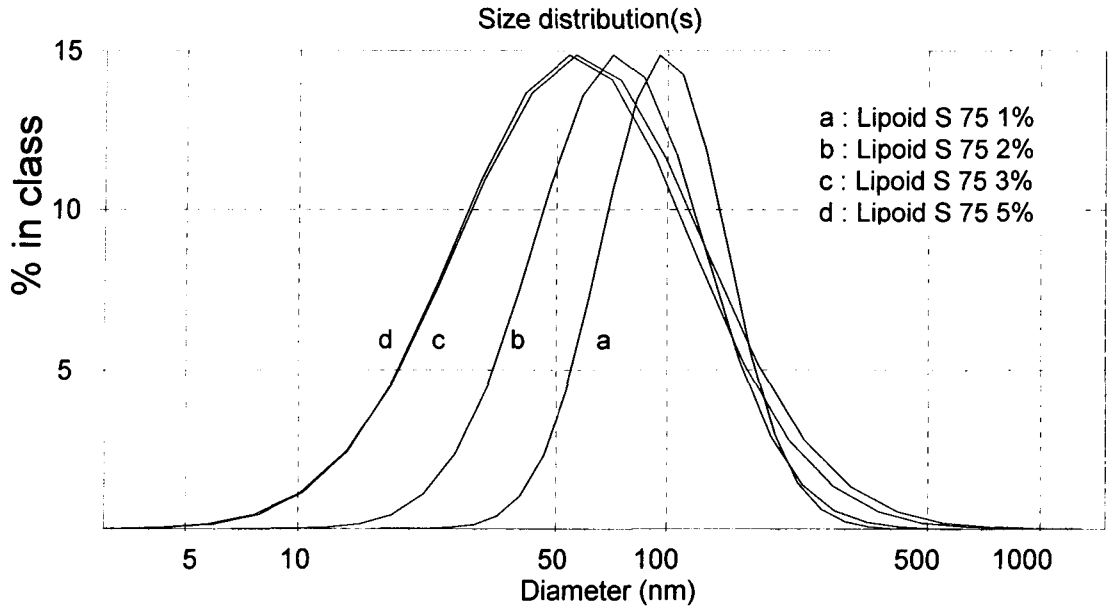
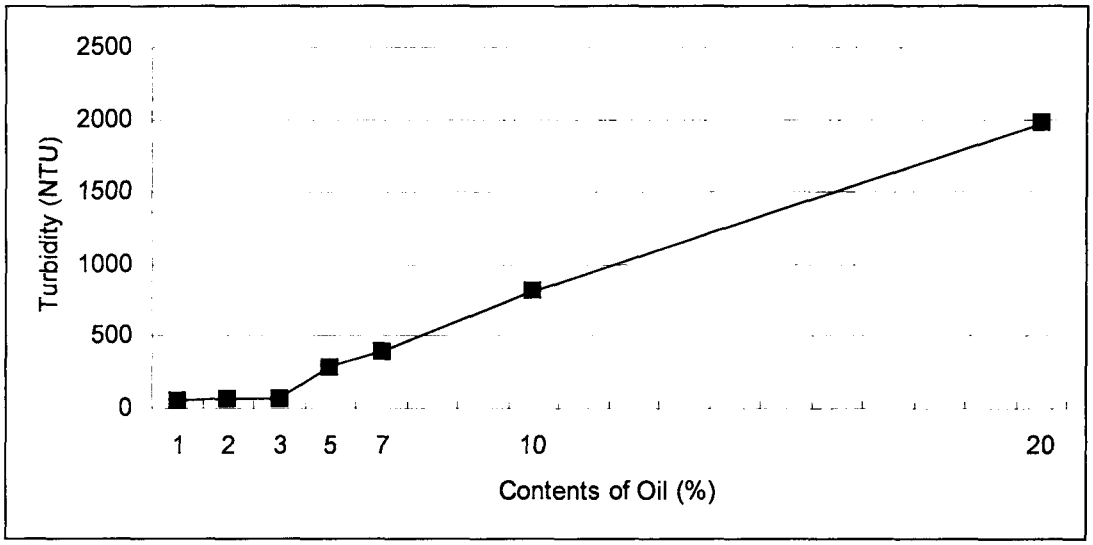


Fig. 5. Variation of particle size and turbidity as oil of content



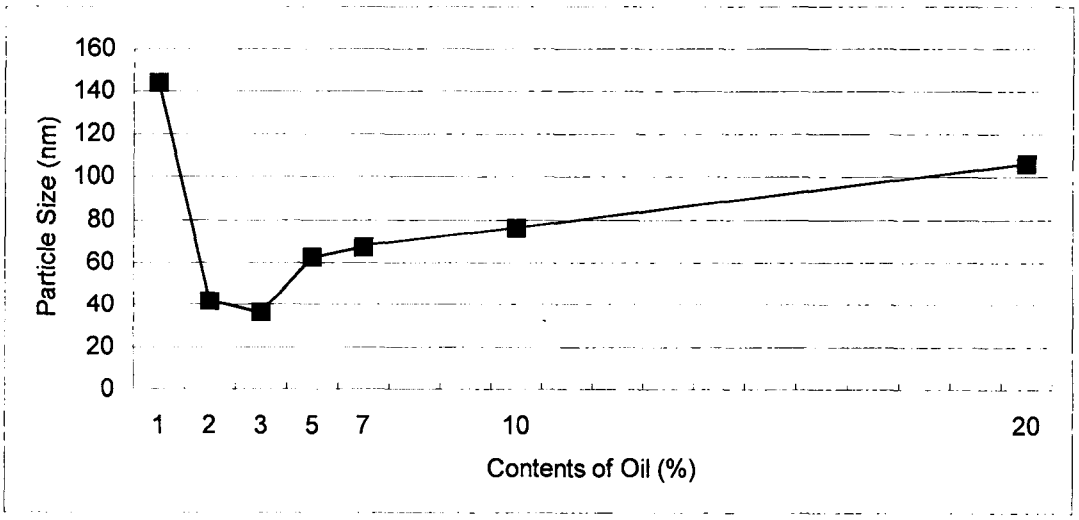
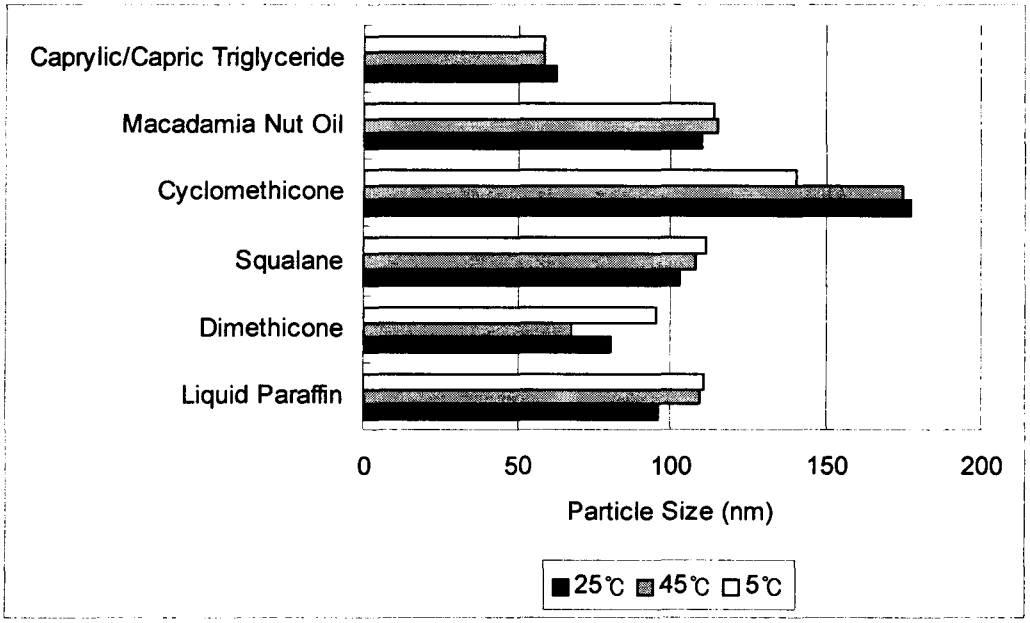


Fig. 6. Variation of particle size and zeta potential as a function of temperature



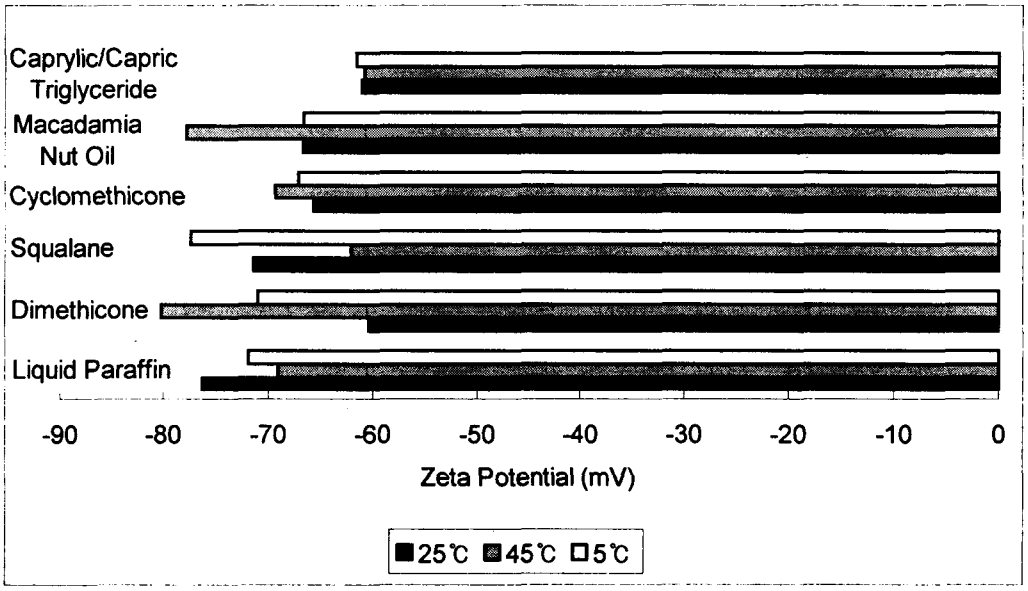


Fig. 7. TEM (transmission electron microscope) of nanoemulsion emulsified saturated lecithin (Lipoid S 75-3) (Mag X 10,000)