Various influences on the formation of silica-encapsulated liposome particles and their functional cosmetic application

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Various influences on the formation of silica-encapsulated liposome particles and their functional cosmetic application

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Abstract
This work reports the various influences on the formation of silica-encapsulated liposome particles such as the used concentration of silica precursor and lecithin, and reaction temperature, and used solvent, and demonstration of cosmetic application with natural hemp-seed extracts as an anti-oxidant material for controlled release formulation. The obtained SLPs from various conditions were characterized by SEM, particle size analyzer, and FT-IR spectrophotometer to confirm the morphology and particle size. Furthermore, the cosmetic formulation of SLPs was demonstrated with controlled release of natural hemp-seed extracts.

Keywords: Silica, Encapsulation, liposomes, Cosmetic, Hemp-seed, Controlled release

1. Introduction
The encapsulation of active ingredients of the liposome vesicles is usually performed in the hydrophobic regions using an impregnation process [1]. The liposome drug delivery systems have been found promising for better and more effective drug delivery, and have provided much more appropriate and systematic drug delivery for clinical medicines and cosmetics [2]. The utilization of liposome for delivery of active ingredient compounds has been mentioned [3-5]; however, their use in cosmetic or drug delivery formulations are not efficacious. To overcome these disadvantages of the using liposomes, we prepared the silica encapsulated liposome particles by sol-gel encapsulation with tetraethyl orthosilicate (TEOS) on the hydrophilic regions of lecithin molecules.

In this work, we achieved the various influences on the formation of silica-encapsulated liposome particles such as the used concentration of silica precursor and lecithin, and reaction temperature, and used solvent, and demonstration of cosmetic application with natural hemp-seed extracts as an anti-oxidant material for controlled release formulation.

2. Materials and methods
2.1. Preparation of silica-encapsulated liposome particles
1 g of hydrogenated lecithin was dissolved in deionized water in 98 mL at 80°C. The lecithin was fully dissolved in the solvent under stirring (500 rpm) at 80°C for more than 4 hrs. Then, TEOS was drop wisely in the suspension, and the reaction was conducted under stirring at room temperature. The supernatant by centrifugation was removed and the final pellet was dried at room temperature in vacuum dryer overnight.
2.2. Instrumental analysis
The morphology of each samples was observed by scanning electron microscopy (SEM; SM-300, Topcon Co., Tokyo, Japan) at an acceleration voltage of 20 kV and energy dispersive X-ray spectroscopy (EDS, Thermo Electron Corporation). The specimens were sputter coated with gold in order to prevent charging on a carbon tape. Particles size distribution was determined by dynamic light scattering instrument (DLS, Photal DLS-8000, Otsuka Electronics Co., Tokyo, Japan) with a wavelength of 632.8 nm during 48 h. Fourier transform infrared spectroscopy (FT-IR) analysis was performed using using KBr pellets (JASCO V-460 FT-IR plus model, Jasco Co., Tokyo, Japan). Thermogravimetric analysis (TGA; SDT Q900, TA instruments Inc., USA) was performed in nitrogen (N\textsubscript{2}) atmosphere from 30 to 700°C at a heating rate of 10°C/min.

3. Results and discussion
Silica-encapsulated liposome particles (SLPs) were successfully prepared by encapsulation of silica with TEOS on the hydrophilic region of aqueous lecithin as shown in Fig. 1.

![Scheme of the silica encapsulated phospholipids particles by sol-gel reaction with TEOS in coupling on hydrophilic region of aqueous liposome](image1.png)

**Fig. 1.** Scheme of the silica encapsulated phospholipids particles by sol-gel reaction with TEOS in coupling on hydrophilic region of aqueous liposome

SEM images demonstrate that the silicified liposomes obtained are largely dispersed at a ratio 3:2 of solvent, comparable to the sizes of source liposomes in Fig. 2. The precipitation of silica on the surface of the liposomes resulted in the formation of a spherical structure, according to SEM. A more spherical shape was observed for the silica-coated liposomes at a ratio 3:2 of solvent than others, suggesting a possible external structural reinforcement of the lipid bilayer by the silica shell.

![SEM images of silica encapsulated phospholipids particles as a function of ethanol concentration](image2.png)

**Fig. 2.** SEM images of silica encapsulated phospholipids particles as a function of ethanol concentration (a) 0 wt.%, (b) 20 wt.%, (c) 40 wt %, and (d) 60 wt.%, respectively
To identify the functional groups of SLPs, FT-IR analysis was carried out (Fig. 3). The FT-IR spectrum of SLPs showed differences in the functional groups of –OH/-CH₂, C=O and Si-O-Si. The broad band of the adsorbed water, Si–OH group at 3367.1 cm⁻¹ was observed. The peaks located at 2925.5 confirmed the presence of C-H. The peak at 1742.4 is attributed to C=O. The dominant peak observed at 1218.8 and 1067.4 cm⁻¹ correspond to Si-O-Si vibration.

The loaded and release of natural hemp-seed extracts were depended on the pore confinement of silica matrix in the SLPs. The hemp-seed extracts release profile was showed the sustained release pattern (Fig. 4), in which this result was attributed to the steric impediment by the silica layers because the porous matrices of the silica encapsulated phospholipids particles had a more complicated structure. Release profiles showed the sustainable release pattern with maximum release of 2,300 gmL⁻¹/g per gram of silica-encapsulated liposome particles.

Fig. 3. FT-IR patterns of silicified-liposomes with different concentration of TEOS

Fig. 4. Hemp-seed extracts release profile from silica encapsulated phospholipids particles
4. Conclusions
In conclusion, spherical silicified liposomes were successfully prepared by silicification with TEOS as a silica source of hydrophilic region of lecithin liposomes. The hemp-seed extracts entrapment capacity and release profile of silicified liposomes were successfully evaluated. By 10 the silicified liposomes showed the maximum release of 2,300 gmL$^{-1}$/g of hemp-seed extracts per gram of SLPs.

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