Nanocomposite of layered double hydroxide and chitosan polymer for delivery of retinol and Pal-RGD

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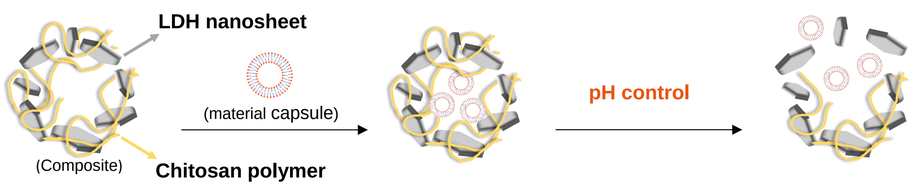
Introduction:



Layered double hydroxide (LDH) has been considered a potential host material in the functional delivery system in many academic and industrial fields. However, natural LDH contains harmful heavy metals, and new LDH synthesis for LDH-polymer composites has low productivity. More importantly, the one-pot synthesis of LDH-polymer composite does not guarantee the uniform LDH and its well-dispersion in a polymer matrix. Additionally, it requires a mass washing step to remove reaction residues. In this study, we investigated the porous nanocomposite of eco-friendly LDH nanosheets and naturally abundant chitosan biopolymer for uptake and selective release of cosmetic niosome vesicles ranging from 50 to 200 nm. Niosome plays an essential role in delivering active ingredients to the skin, leading to improved effectiveness of cosmetics. Although niosome nanoparticles are nontoxic and biodegradable, they have significant disadvantages, including low stability, the possibility of breaking down when in contact with skin, and short lifetimes. Also, they have a limited ability to prevent degradation of active ingredients caused by the penetration of oxygen gas and ultraviolet light. We suggest the use biocompatible LDH and chitosan biopolymer nanocomposites as a stabilizing carrier for colloidal niosome nanoparticles.

Materials & Methods:

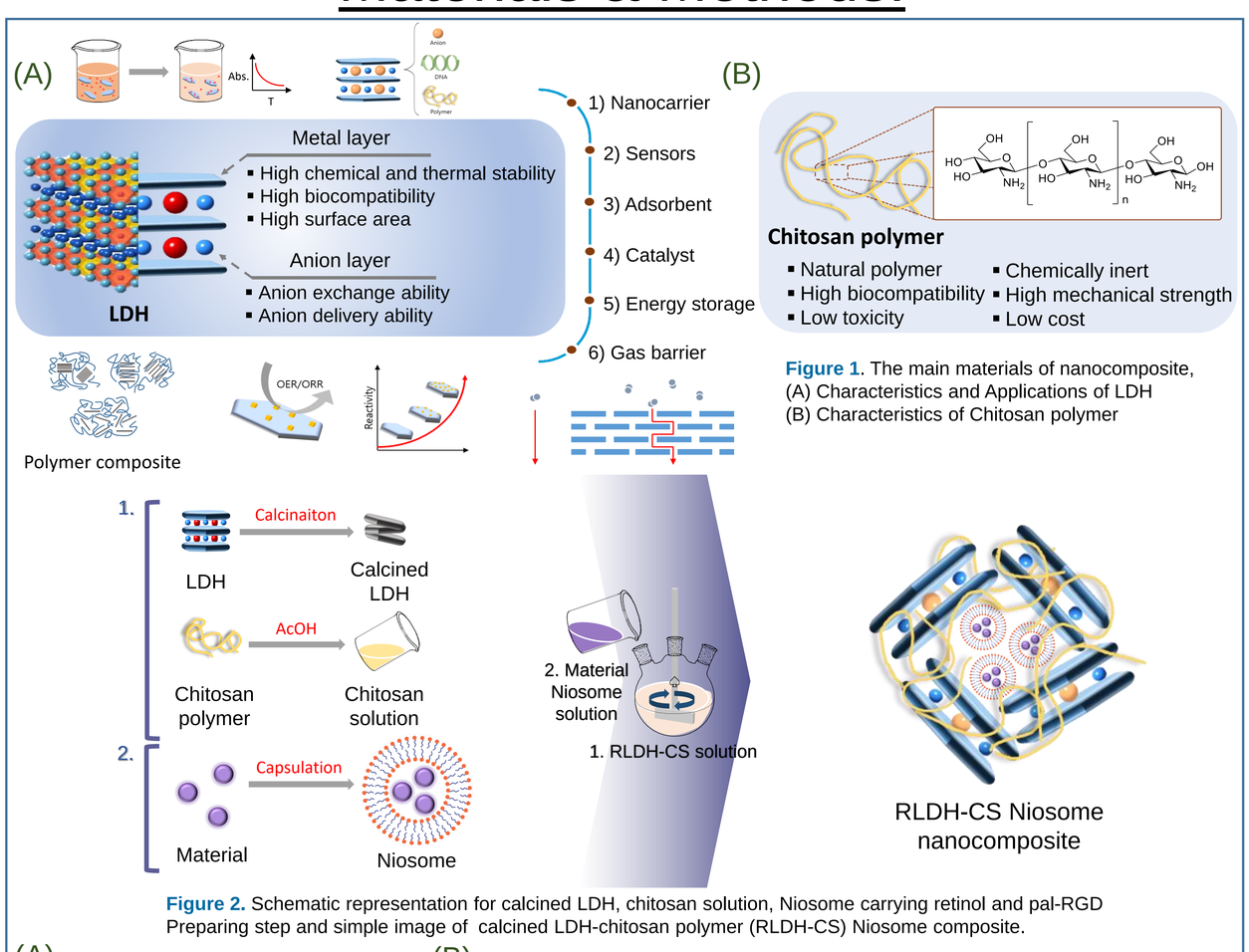
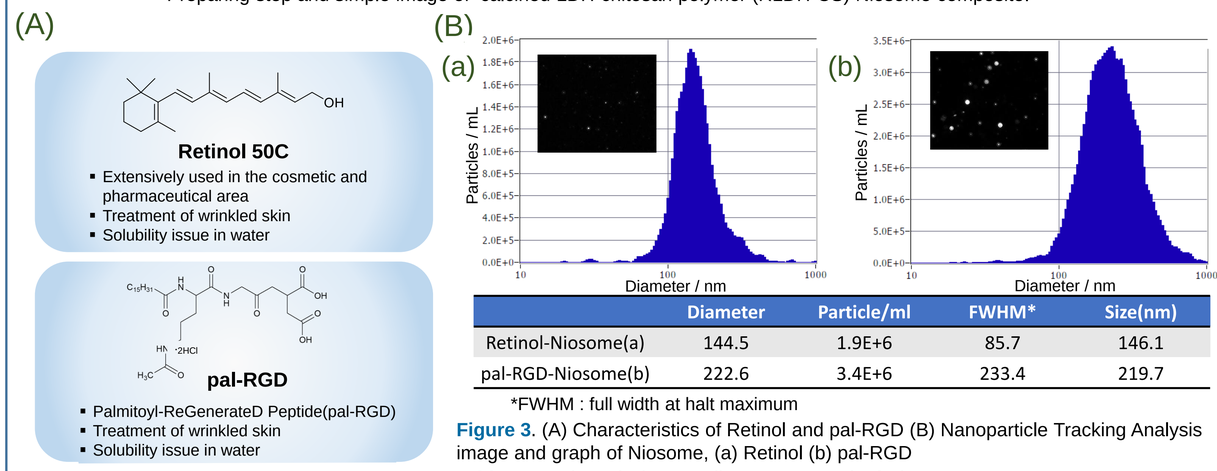


Figure 1. The main materials of nanocomposite, (A) Characteristics and Applications of LDH (B) Characteristics of Chitosan polymer

Figure 2. Schematic representation for calcined LDH, chitosan solution, Niosome carrying retinol and pal-RGD Preparing step and simple image of calcined LDH-chitosan polymer (RLDH-CS) Niosome composite.



	Diameter	Particle/ml	FWHM*	Size(nm)
Retinol-Niosome(a)	144.5	1.9E+6	85.7	146.1
pal-RGD-Niosome(b)	222.6	3.4E+6	233.4	219.7

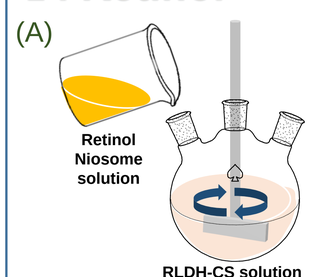
*FWHM : full width at halt maximum

Figure 3. (A) Characteristics of Retinol and pal-RGD (B) Nanoparticle Tracking Analysis image and graph of Niosome, (a) Retinol (b) pal-RGD

Table 1. Peak analysis according to NTA result of Niosome

Results & Discussion:

Ⅰ. Retinol



(003)	2θ(degree)	FWHM*	Tickness(nm) **
LDH	11.62	0.15706	56.67
RLDH-CS	11.5	0.53422	17.22
RLDH-CS Niosome	12	3.4016	2.43

*FWHM : full width at halt maximum, **scherrer equation T=K·λ/FWHM·cosθ

Table 2. Analysis of (003) peak from XRD pattern

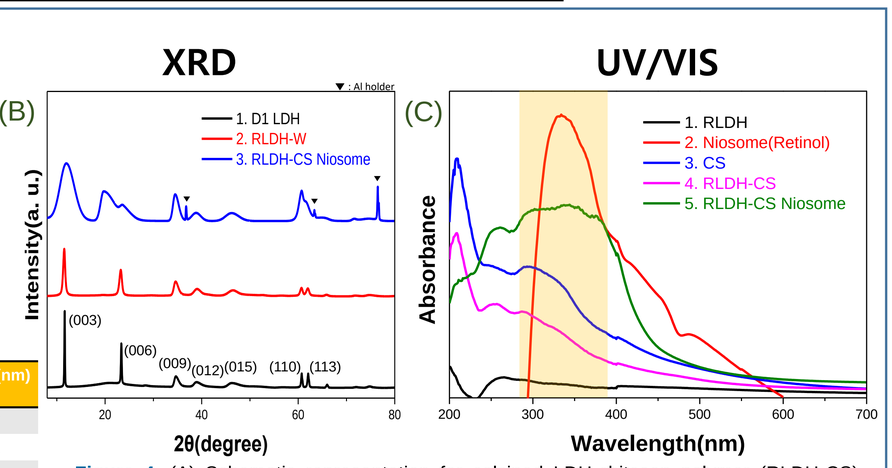
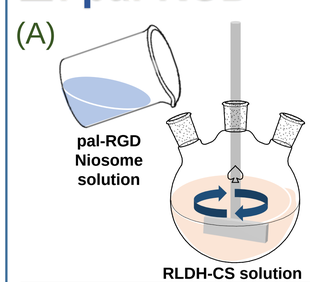


Figure 4. (A) Schematic representation for calcined LDH-chitosan polymer (RLDH-CS) Niosome composite manufacturing process. Niosome is carrying retinol. (B) XRD pattern of LDH, RLDH-W and RLDH-CS Niosome nanocomposite. (003) peak of RLDH-CS Niosome nanocomposite and broadened as compared with LDH and RLDH-W. (C) UV/vis absorption spectroscopy of LDH, chitosan polymer, niosome, RLDH-CS nanocomposite and RLDH-CS Niosome nanocomposite. Absorbance was measured using an integrating sphere.

Ⅱ. pal-RGD



(003)	2θ(degree)	FWHM*	Tickness(nm) **
LDH	11.62	0.15706	56.67
RLDH-CS	11.50	0.53422	17.22
RLDH-CS Niosome	12.02	2.4386	3.37

*FWHM : full width at halt maximum, **scherrer equation T=K·λ/FWHM·cosθ

Table 3. Analysis of (003) peak from XRD pattern

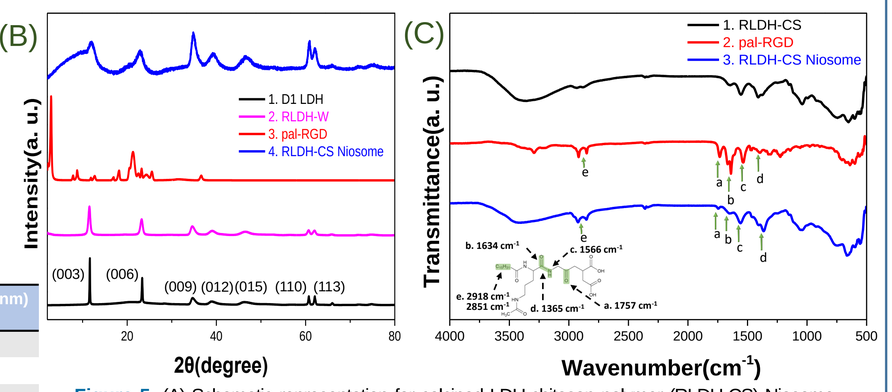


Figure 5. (A) Schematic representation for calcined LDH-chitosan polymer (RLDH-CS) Niosome composite manufacturing process. Niosome is carrying pal-RGD. (B) XRD pattern of LDH, RLDH-W, pal-RGD and RLDH-CS Niosome nanocomposite. (003) peak of RLDH-CS Niosome nanocomposite and broadened as compared with LDH and RLDH-W. (C) FT-IR spectrum clearly showed the characteristic peaks for pal-RGD at 1365, 1566, 1634, 1757, 2851, 2918 cm^{-1}

Ⅲ. Uptake & Release

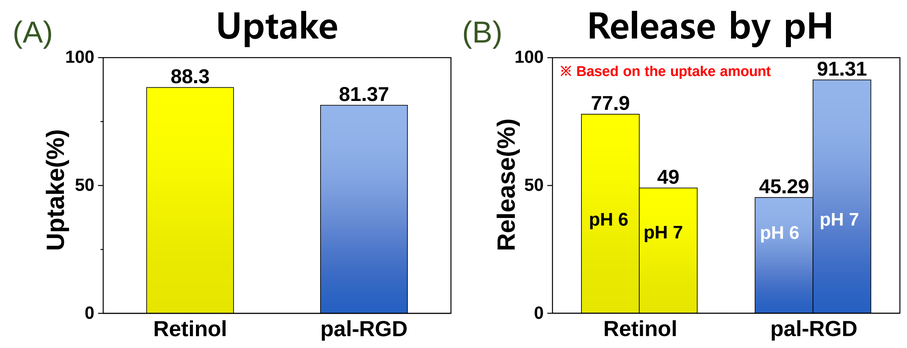


Figure 6. (A) Niosome uptake by RLDH-CS (B) Niosome release from the RLDH-CS, at two solution pH value: 6 and 7

Conclusions:

We have used a commercial LDH to obtain the LDH nanosheet by the calcination-reconstruction method in the 3% acetic acid solution of chitosan polymer. In FT-IR spectra, a broad road but dominant band for OH vibration around 3400 cm^{-1} compared to pure chitosan and the partial shift of Mg(Al)-O band toward lower frequencies would support the chemical interaction between the LDH and chitosan. Considering the hydrolysis and deprotonation of calcined LDH, it would expect a grafting of chitosan polymer on the active LDH surface during the reconstruction. Additionally, the nanocomposite is very stable both in low pH solutions and in the recycling conditions, mainly due to the chemical bonding of LDH surface and chitosan polymer. The nanocompisite exhibited the excellent uptake and release behavior for retinol and pal-RGD incorporated niosome.Therefore, the result explains that the nanocomposite's capacity potential is mainly ascribed to the positive surface charge of LDH nanosheets and polymer network in the nanocomposite.

Acknowledgments:

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