Encapsulation of the Retinal using the gamma-Cyclodexrtin based MOFs(COFs)

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Introduction:

An oil-soluble vitamin A is critical for many metabolisms in vivo. Retinal is a one of the vitamin A, which be affected in skin and is a form oxidation of the retinol and could be oxidized to retinoic acid. It easily reacts under the condition as follows oxidation, light, heat, moisture. Many technologies have been studied to decrease the oxidation of retinal which improves the wrinkle as anti-aging material. Gamma-cyclodextrins are widely applied in various fields such as food, pharmaceutics, and cosmetics. They are bio-friendly and could encapsulate the hydrophobic component which is unstable in external environment. Gamma-cyclodextrin based metal-organic frameworks (COFs) are formed by gamma-cyclodextrin as a organic ligand and potassium ion as a inorganic metal center. COFs have the various properties such as highly porosity, large surface areas, and non-toxicity. In this study, the COFs encapsulated the retinal (COF-Retinal) were synthesized to stabilize the retinal in external environment. The characters of COFs encapsulated the retinal were investigated with scanning electron microscope (SEM), X-ray diffraction (XRD), nuclear magnetic resonance (NMR), fourier-transform infrared spectroscopy (FT-IR), and High-performance liquid chromatography (HPLC).

Materials & Methods:

The COFs were prepared by dissolving gamma-cyclodextrin and KOH in water, followed by vapor diffusion of ethanol in to the solution including PEG20000 at room temperature. After 1 day, the synthesized COFs were washing with centrifuge and neutralized with acetic acid and then, drying process conducted. To encapsulate the retinal, The COFs and retinal was put into ethanol and stirred for 24 hours. The morphology of synthesized COFs encapsulated the retinal was analyzed by SEM and the crystallinity was characterized using XRD. The FT-IR spectra were recorded on an FT-IR-Raman spectrometer Thermo-Nicolet and collected in the 4000-650 cm^{-1} range. To investigate the encapsulated retinal, the H1 NMR spectra was recorded under the condition (500 MHz, 298 K). The stability of COF-Retinal was analyzed using HPLC for 3 months at various temperature.

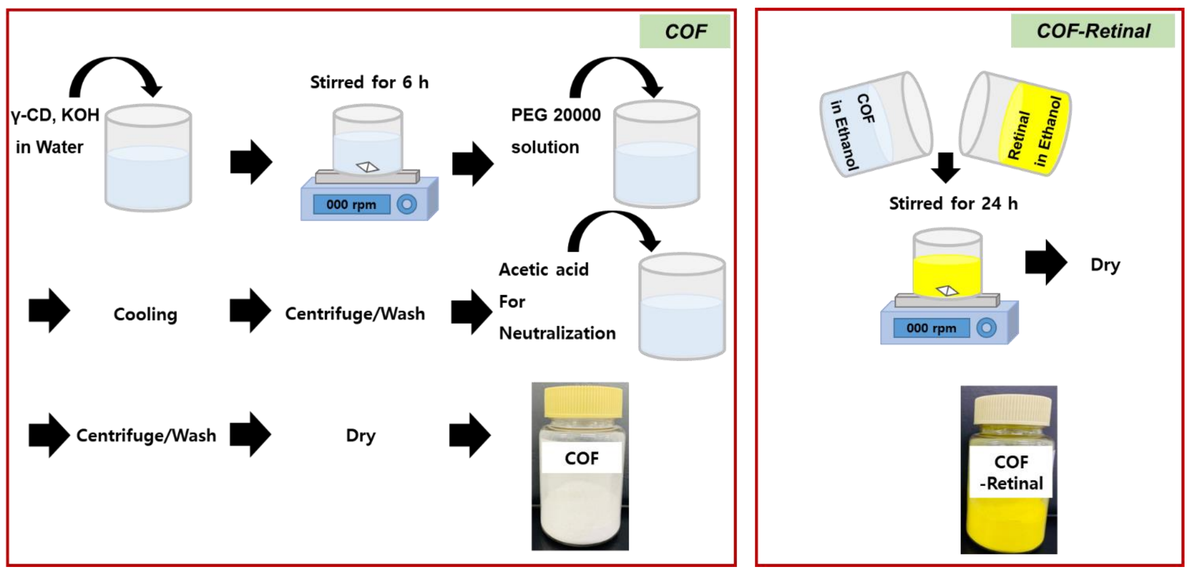

Figure 1. Synthesis of COF

Results & Discussion:

The morphologies of COFs were shown in Figure 2. The gamma-cyclodextrin and retinal were uneven shapes, while COF and COF-Retinal were uniform shape. The COF and COF-Retinal were successfully synthesized as shown in Figure 2 and 3. The crystallinity of COFs was maintained after encapsulating the retinal. It could be co-relation with SEM images. The 1H NMR spectra gamma-CD, COF, and COF-Retinal were recorded and used to confirm the retinal encapsulation. The peaks only the originated retinal were shown at COF-Retinal in 1H NMR spectra (Figure 4). It could be concluded that the COFs were successfully encapsuled the retinal. The FT-IR spectra were shown that the gamma-CD and COF are similar with typical features: peak (3000−3700 cm^{-1}) accounting for −OH stretching vibration corresponding to a hydrate water vibration (1652 cm^{-1}). The new peak (1569 cm^{-1}) was shown in COF and COF-Retinal unlike gamma-CD [9]. The COF-Retinal was analyzed to check the content of retinal at various temperature (room temperature, 45℃, 4℃). The initial content of retinal was 2% and the content was maintained the more than 75% at various temperature for 90 days.

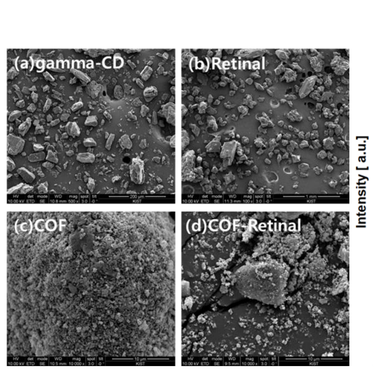

Figure 2. SEM images of COFs; (a)gamma-cyclodextrin, (b)retinal, (c)COF, (d)COF-Retianl.

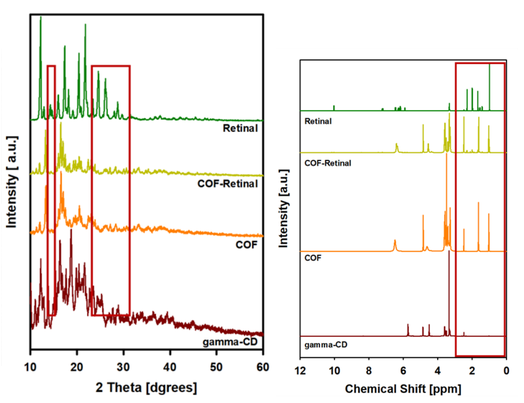

Figure 3. XRD data of COFs.

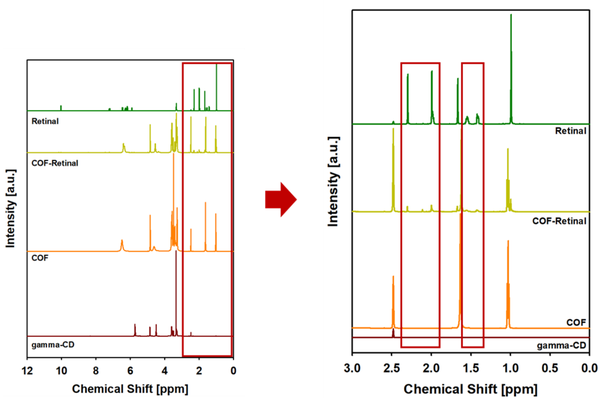

Figure 4. ^{1}H NMR data of COFs.

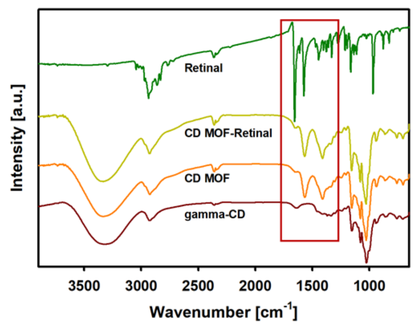

Figure 5. FT-IR of COFs.

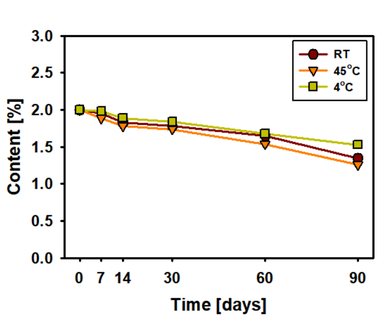

Figure 6. Stabilization of COF-Retinal at various temperature.

Conclusions:

In this study, porosity COFs were used as encapsulated retinal carrier. The COFs were successfully synthesized. The COFs have an uniform shape framework and the crystallinity was maintained after encapsulating the retinal. The COF-Retinal was maintained the content of retinal up to more than 75% at various temperature for 90 days, which the retinal could be protected from external environment. In conclusion, the synthesized COFs could be a promising system and apply for various fields such as drug delivery, food, and cosmetics.

Aknowledgments:

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References:

[1] J. W. Fluhr, M.-P. Vienne, C. Lauze, P. Dupuy, W. Gehring, and M. Gloor (1999) Tolerance Profile of Retinol, Retinaldehyde and Retinoic Acid under Maximized and Long-Term Clinical Conditions, Dermatology 199: 57-60.
[2] O. Sorg, B. Kasraee, D. Salomon, and J.-H. Saurant (2013) The Potential Depigmentating Activity of Retinaldehyde, Dermatology 227: 231-237.
[3] O. Sorg and J.-H. Saurat (2014) Topical retinoids in skin ageing: A focused update with reference to sun-induced epidermal vitamin a deficiency. Dermatology, 228: 314–325.
[4] P. Creidi, M.-P. Vienne, S. Ochonisky, C. Lauze, V. Turlier, J.-M. Lagarde, and P. Dupuy (1998) Profilometric evaluation of photodamage after topical retinaldehyde and retinoic acid treatment, J. Amer. Acad. Dermatol. 39: 960-965.
[5] K. J. Hartlieb, D. P. Ferris, J. M. Holcroft, I. Kandela, C. L. Stern, M. S. Nassar, Y. Y. Botros, and J. F. Stoddart (2017) Encapsulation of Ibuprofen in CD-MOF and Related Bioavailability Studies, Mol. Pharmaceutics 14: 1831-1839.
[6] G. Zhang, F. Meng, Z. Guo, T. Guo, H. Peng, J. Xiao, B. Liu, V. Singh, S. Gui, P. York, W. Qian, L. Wu, and J. Zhang (2018) Enhanced stability of vitamin A palmitate microencapsulated by γ-cyclodextrin metal-organic frameworks, J. Microencapsul. 35(3): 249-258.
[7] T. Rajkumar, D. Kukkar, K. H. Kim, J. R. Sohn, A. Deep (2019) Cyclodextrin-metal–organic framework (CD-MOF): From synthesis to applications, J. Ind. Eng. Chem. 72: 50-66.
[8] Z. Moussa, M. Hmadeh, M. G. Abiad, O. H. Dib, D. Patra (2016) Encapsulation of curcumin in cyclodextrin-metal organic frameworks: Dissociation of loaded CD-MOFs enhances stability of curcumin, Food Chem. (2016) 212: 485-494.
[9] B. Zhang, J. Huang, K. Liu, Z. Zhou, L. Jiang, Y. Shen, and D. Zhao (2019) Biocompatible Cyclodextrin-Based Metal−Organic Frameworks for Long-Term Sustained Release of Fragrances, Ind. Eng. Chem. Res. 58: 19767-19777.