Enhancing the Properties of a Morning Facial Defense Mask with Lignin Nanoparticles from Corncob

Panadda Tarat, and Jidapha Tinoi*

Division of Biochemistry and Blochemical Innovation, Department of Chemistry, Faculty of Science, Chiang Mai University, Thailand

*Corresponding author : jidapha.t@cmu.ac.th

Abstract

This study aimed to investigate the properties of lignin nanoparticles for potential application in skincare products. Lignin was extracted from corncobs using an alkaline solution under autoclave conditions, resulting in a yield of 9.85%. The extracted lignin was subsequently converted into nanoparticles through ultrasonication. The particle size and stability of lignin nanoparticles were analyzed using Dynamic Light Scattering (DLS) analysis. The results demonstrated the average particles of 173.58 nm with Zeta potential and polydispersity index (PDI) values of -6.90 mV and 0.260, respectively. The antioxidant activity of the lignin nanoparticles was evaluated using DPPH and FRAP assays. The DPPH assay revealed an IC_{50} value of 11.27 µg/mL, while the FRAP assay demonstrated a FRAP value of 1,203.97 ± 24.10 mg $FeSO_4$•H_2O per gram of lignin nanoparticles. The lignin nanoparticles were investigated for their UV absorbability corresponding to UV-B and UV-A. The results showed that a 150 µg/ml concentration significantly absorbs UV to levels acceptable for sunscreen applications. The tyrosinase inhibitory activity assay demonstrated that lignin nanoparticles had IC_{50} value of 20.399 mg/mL, indicating their potential to reduce melanin production. Subsequently, the morning facial defense mask incorporating lignin nanoparticles was evaluated for its physical characteristics, revealing a light brown, transparent gel with a semi-fluid consistency, smooth texture, and good spreadability on the skin. Additionally, it remained stable at 4–8°C and room temperature. Furthermore, the morning facial defense mask containing lignin nanoparticles from corncobs retained strong UV protection and exhibited an antioxidant potential with a FRAP value of 761.76 mg $FeSO_4$•H_2O per gram of the mask.

Introduction

Corn is an important economic crop, but its production mainly focuses on kernels, leaving corncob, which account for 19–33% of the total cob weight, as agricultural waste. Most corncobs are burned, causing air pollution and PM2.5 issues. However, corncob is rich in lignocellulose, a source of lignin with potential applications in the cosmetic industry due to its UV-absorbing, antioxidant, and antimicrobial properties. This study focuses on extracting lignin from corncobs using an alkaline solution and developing lignin nanoparticles (LNPs) through ultrasonication. The biological properties of LNPs were then analyzed for their potential use as an active ingredient in a morning facial defense mask.

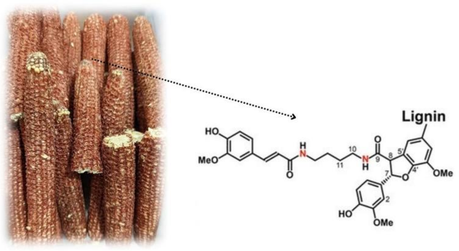


Figure 1 Lignin structure in corncob

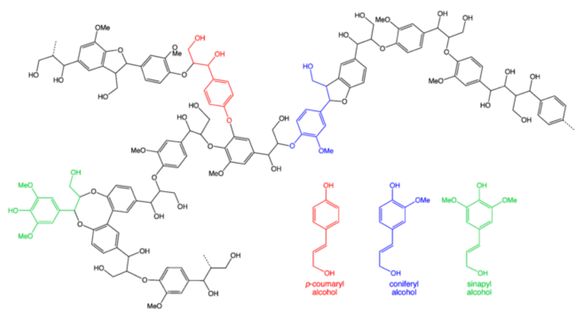
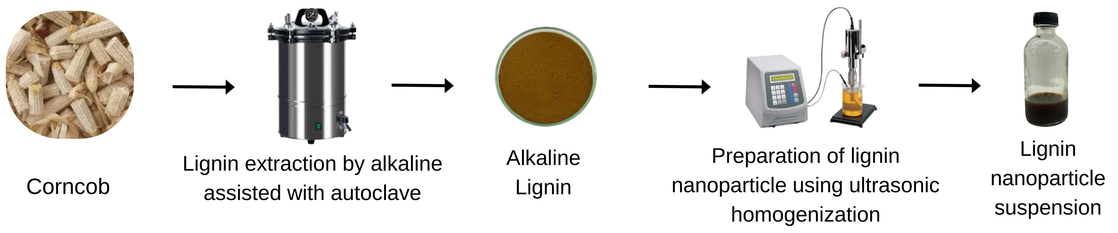


Figure 2 Lignin structure and its main components

Methodology

The lignin nanoparticles preparation



The characteristic of lignin nanoparticles

Dynamic Light Scattering (DLS)

Lignin nanoparticle suspension (0.01% w/v) was prepared and analyzed using Dynamic Light Scattering (DLS)

↓

The average particle size, polydispersity index (PDI), and zeta potential were measured and recorded

UV absorbability

Lignin nanoparticle solutions (60, 80, 100, 150, and 200 µg/mL)

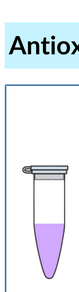
↓

The transmittance of the solutions was measured at wavelengths ranging from 290 to 400 nm using a UV-visible spectrophotometer

Evolution™ 201 UV-Visible Spectrophotometers

Antioxidant activity of lignin nanoparticle

DPPH assay



Mixed lignin nanoparticles with DPPH solution

↓

Incubated in the dark for 30 minutes and Measured absorbance at 515 nm

FRAP assay

Mixed lignin nanoparticles with FRAP reagent

↓

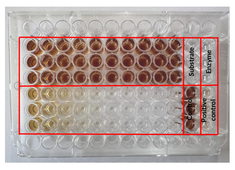
Incubated for 15 minutes and Incubated at room temperature for 15 minutes

Anti-tyrosinase activity

Mixed lignin nanoparticles with tyrosinase enzyme and Incubated in the dark for 5 minutes

↓

Added L-DOPA solution then incubated for another 20 minutes and measured absorbance at 475 nm



Preparation of the morning facial defense mask containing lignin nanoparticles from corncob

The morning facial defense mask was formulated containing lignin nanoparticles in deionized water, along with Carbopol, triethanolamine, Glycerin, propylene glycol, xanthan gum, Coco-caprylate

↓

Tested for biological properties

Figure 3 The morning facial defense mask containing lignin nanoparticles from corncob

Results and Discussions

Lignin and lignin nanoparticles from corncob

Alkaline lignin is a dark brown fine powder. The percentage yield of lignin is 9.85% w/w.

The lignin nanoparticle suspension had a dark brown color and was a colloidal suspension with a concentration of 7 mg/mL

The characteristics of lignin nanoparticles

Table 1 : The particle size and distributionof lignin nanoparticles were analyzed using Dynamic Light Scattering (DLS)

Parameters	Size distribution (nm)	Zeta Potential (mV)	Polydispersity index (PDI)
Lignin nanoparticles	173.8±0.94	-6.90±0.31	0.26±0.01

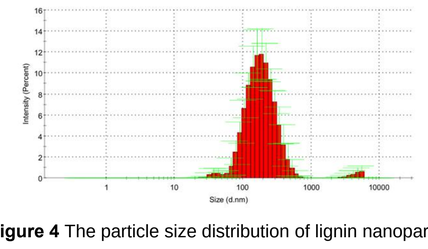


Figure 4 The particle size distribution of lignin nanoparticles

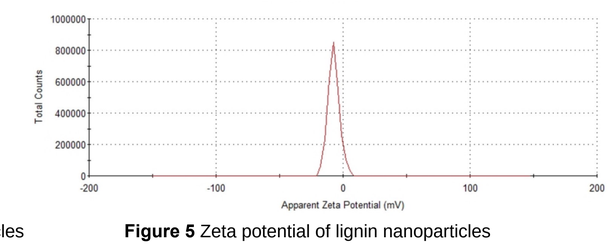


Figure 5 Zeta potential of lignin nanoparticles

The physicochemical properties of lignin nanoparticles from corncobs were analyzed. The average particle size was 173.8 ± 0.94 nm with a polydispersity index (PDI) of 0.260 ± 0.01, indicating good dispersion of particle. However, the zeta potential (-6.90 ± 0.31 mV) suggests poor stability in suspension.

UV absorbability

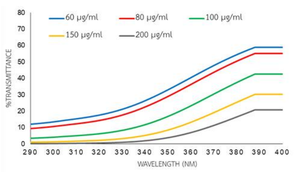


Figure 6 Transmittance of lignin nanoparticles from corncob

At 150 and 200 µg/mL, lignin nanoparticles concentrations effectively absorbed both UV-A and UV-B, demonstrating their potential suitability for sunscreen formulations.

Anti-tyrosinase activity

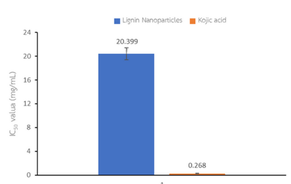


Figure 7 IC_{50} of lignin nanoparticles and Kojic Acid

Lignin nanoparticles from corncobs exhibited anti-tyrosinase activity with an IC_{50} of 20.399 mg/mL, comparable to kojic acid (IC_{50} = 0.268 mg/mL)

Antioxidant activity of lignin nanoparticle

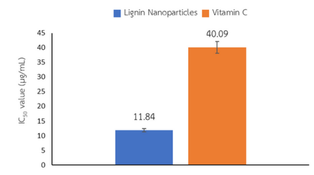


Figure 8 IC_{50} values determined by DPPH assay

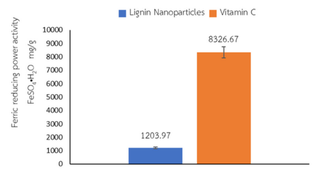
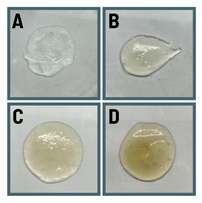


Figure 9 IC_{50} values investigated by FRAP assay

DPPH assay showed an IC_{50} of 11.27 µg/mL, indicating strong antioxidant activity. FRAP assay showed a FRAP value of 1,203.97 mg $FeSO_4$•H_2O per gram, compared to vitamin C

Evaluation of the properties of the morning facial defense mask



The mask is a clear gel with a light brown color, which darkens with increasing lignin nanoparticle concentration. It remains stable without phase separation.

Figure 10 The morning facial defense mask ₥ormulations with Lignin Nanoparticles (A) Gel base, (B) 150 µg/mL, (C) 300 µg/mL, (D) 500 µg/mL

The UV protection of the mask was lower than commercial products, indicating limited effectiveness in UV absorption. The FRAP assay showed strong antioxidant potential (761.76 mg $FeSO_4$•H_2O/g), though slightly lower than lignin nanoparticles.

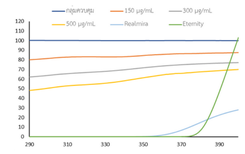


Figure 11 UV protection of the morning facial defense mask

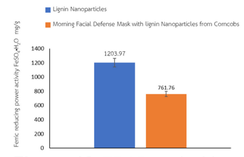


Figure 12 FRAP antioxidant activity of the morning mask

Conclusions

Lignin was extracted from corncob and converted into lignin nanoparticles, which exhibited moderate stability. Due to their small in nano-sized. The nanoparticles demonstrated good dispersion and showed UV absorption, antioxidant activity, and slightly tyrosinase inhibition. After formulating the morning facial defense mask and observing its performance, the UV protection was found to be insufficient. However, the mask demonstrated strong antioxidant activity. Further optimization is needed to enhance UV protection and improve product stability.

References

1. Liang, T., Ma, Y., Jiang, Z., Remón, J., Zhou, Y., & Shi, B. (2024). New insights into greener skin healthcare protection: Lignin nanoparticles as additives to develop natural-based sunscreens with high UV protection. Carbon Resources Conversion, 7, 100227.

Acknowledgements

- Biorefinery Research Laboratory members
- Department of Chemistry, Faculty of Sclence, Chiang Mai University