

Evaluation of *Justicia adhatoda* Linn. extract-loaded layered double hydroxide nanohybrid for sunscreen applications

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Safety concerns regarding synthetic sunscreens have increased the demand for botanical alternatives rich in phytochemicals with natural photo-protectant properties. Layered double hydroxides (LDHs) offer biocompatibility, tunable composition, high anion-exchange capacity, and controlled release. This study focused on developing a plant extract-incorporated LDH nanohybrid and evaluating its photostability and antioxidant activity. Based on the UV blocking ability at UVA and UVB regions, *J. adhatoda* was selected. The sun protection factor (SPF) of ethanolic *J. adhatoda* leaf extract was evaluated using UV spectroscopy and the Mansur equation. Pristine MgAl-NO₃-LDH was synthesized *via* co-precipitation with a Mg: Al ratio of 2:1, adjusting the pH to 10 using 1.0 M NaOH. *J. adhatoda*-LDH (JA-LDH) nanohybrid was prepared *via* ion exchange by adding pristine MgAl-NO₃-LDH (1.500 g) suspension to *J. adhatoda* crude extract (2.000 g) dissolved in DMSO (50 mL). Pristine MgAl-NO₃-LDH and JA-LDH were characterized using FTIR, XRD, and SEM imaging. The antioxidant activity of *J. adhatoda* crude extract and JA-LDH was evaluated by

the DPPH radical scavenging assay. The photostability of *J. adhatoda* crude extract and JA-LDH hybrid was assessed by exposing them to direct sunlight for 3 hours. The SPF value of ethanolic *J. adhatoda* leaf extract was 8.16 at 250 ppm, and with increasing concentration, the SPF value increased. FTIR of JA-LDH showed characteristic bands of pristine MgAl-NO₃-LDH and *J. adhatoda* extract, confirming successful incorporation. XRD revealed a change in basal spacing from 8.508 Å to 7.679 Å upon incorporation, and SEM images showed morphological changes supporting incorporation. The percentage incorporation efficiency of *J. adhatoda* leaf extract in pristine MgAl-NO₃-LDH was 13.0%. The IC₅₀ value of *J. adhatoda* was 15.64 µg/mL, while the IC₅₀ value of JA-LDH was 13.01 µg/mL. JA-LDH showed photostability, indicating LDH stabilizes the incorporated phytochemicals. It is concluded that the JA-LDH is suitable for developing novel sunscreens.

Keywords:

Layered double hydroxide; *Justicia adhatoda* Linn.; Antioxidant; Sun protection factor; Photostability.