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Bioactive solids obtained from montmorillonite functionalization by biogenic compounds to be used as antimicrobial filler

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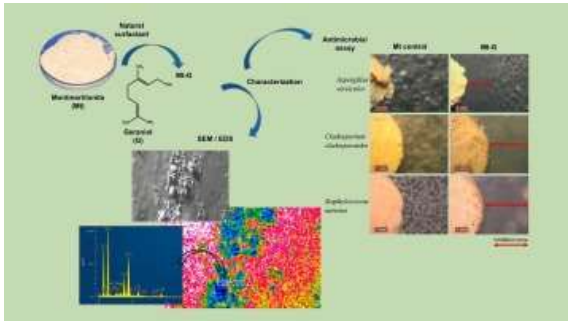
Highlights

- Microbiological spoilage on indoor surfaces is a major problem.
- Bioactive natural minerals can be obtained using biogenic compounds.
- Montmorillonites are low-cost and versatile materials to be used as functional fillers.
- Geraniol is a promising terpenoid due to its bioactivity and is recognized as safe.

Abstract

The growth of fungi and bacteria on material surfaces negatively impacts human health and produces economic losses, and harmful waste for the environment. In the present research, new eco-friendly and low-cost antimicrobial fillers are actively sought by the functionalization of montmorillonite using biogenic compounds. The synthesized hybrids from montmorillonite, natural surfactant, and geraniol were characterized and showed effective antifungal and antibacterial activity.

Graphical abstract



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Introduction

The biodeterioration of material surfaces causes serious problems, especially in indoor environments where people are predominantly exposed for longer periods to the effects of biological contaminants generated from biofilms [1]. Adding to this the waste generated from cleaning and removing the spoilage material or coating has a negative environmental impact besides economic and energy losses [2]. Therefore, efforts are made to obtain eco-friendly materials that exhibit antimicrobial activity to prevent biofilm growth, extend the service life of the materials, and prevent the transmission of infections [3]. Although these new materials show potential, further research is necessary to fully understand their effectiveness and safety over extended periods or in different environmental conditions.

The present research aimed to obtain a bioactive hybrid from montmorillonite (Mt) functionalization by biogenic compounds. For the first time, the essential oil (EO) of geranium (EG) and the terpenoid compound geraniol (GL) were evaluated for the modification of a Mt to obtain a bioactive natural filler. Geraniol acyclic monoterpene alcohol (3,7-dimethyl-2,6-octadien-1-ol) is one of the major geranium EO compounds frequently extracted from *Pelargonium* sp. [4]. This terpenoid is used commercially as an ingredient in perfumes, cosmetics, personal care products, and pharmaceuticals [4]. It is categorized by the Food and Drug Administration (FDA), recognized as safe (GRAS) for specific uses, and has been intensely studied for cancer treatments [5]. On the other hand, clay minerals (e.g. montmorillonites, halloysite, and sepiolite) can be modified to nanoscale to be used as carriers for inorganic and organic compounds [3], [6].

Section snippets

Antimicrobial potentialities of biogenic compounds

The EO and the terpenoid were obtained commercially from the Alfredo Francioni S. A. company (Buenos Aires, Argentina). Plates with malt extract agar (MEA) culture were prepared with different concentrations of EG and GL (0.15, 0.3, 0.6 and 1.2 mg/mL) and 20 µL of the spore suspension (10^5 spores/mL) was inoculated in the center of each plate. Fungal strains used were *Cladosporium cladosporioides* (MG731215), *Chaetomium globosum* (KU936228) and *Aspergillus versicolor* (MG725821). Plates were…

Antimicrobial potentialities of biogenic compounds

The antimicrobial performance of EG and GL was assessed. The MIC determined resulted in 0.3, 0.3, 0.6, 0.3 and > 1.2 mg/mL for the case of EG while that to GL was ≤ 0.15, 0.3, 0.3, ≤ 0.15 and 0.6 mg/mL related to *C. cladosporioides*, *C. globosum*, *A. versicolor*, *S. aureus* and *E. coli*, respectively. GL showed lower MIC against *C.*

cladosporioides, *A. versicolor*, *S. aureus* and *E. coli* than EG. In general, GL presented higher activity against both fungal and bacterial strains. *C. cladosporioides* was…

Conclusions

Bioactive fillers derived from montmorillonite and biogenic compounds can be obtained. Geraniol has demonstrated a broad spectrum of antimicrobial activity, which persists even after its incorporation into the clay matrix for the first time to be used as a bioactive filler. This research highlights the viability of utilizing low-cost natural materials as carriers for environmentally friendly antimicrobial agents, offering promising applications across various fields.…

CRediT authorship contribution statement

Guillermo P. Lopez: Methodology, Investigation. **Leyanet Barberia Roque:** Methodology, Investigation. **Katerine Igal:** Investigation, Writing – review & editing. **Erasmo Gámez Espinosa:** Investigation. **Mariela A. Fernández:** Investigation. **Natalia Bellotti:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Funding acquisition, Formal analysis, Data curation, Conceptualization.…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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