Meetings International

23rd International Conference on

NANOTECHNOLOGY

June 27-28,2024 | London, UK

Antifungal activity and differential responses of $CaZn_2(OH)_6{\cdot}2H_2O$ and ZnO nanoparticles

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Statement of the Problem: Sick Building Syndrome (SBS) manifest when building occupants experience health issues like allergies and respiratory problems, which are linked to time spent indoors (Nag, 2019). These symptoms, often related with microorganisms, significantly affect well-being and productivity. Mitigating SBS is crucial for promote healthy indoor environments. Nanoparticles (NP) used as additives in construction materials, improve mechanical properties and durability due to their high surface area and reactivity (Vandenberg et al., 2021). However, proper NP dispersion is essential, since poor dispersion can weaken mechanical properties and create structural vulnerabilities (Askari-Dolatabad et al., 2020).

Methodology: We assessed the antifungal activity of NP of ZnO and CaZn2(OH)6·2H2O (CZ) against fungal isolated from modern buildings with microbial growth. The strains were identified as Scolecobasidium sp., Curvularia sp., Phoma sp., Fusarium sp., and two strains of Stachybotrys sp. ZnO NP were synthesized using Sol-gel (SG) and Hydrothermal (HT) methods, while CZ NP were synthesized using SG, HT, and microwave (MW) methods. X-ray diffraction was applied to identify phase composition. Minimum inhibitory concentrations (MIC) and minimum fungicidal concentrations (MFC) were determined. Based on the MIC, cement mortar specimens with dimensions of 5 cm per side will be prepared to assess their antifungal protection against the fungal strains. The effectiveness of NP in the mortars will be assessed at both the beginning and end of the assays using techniques as ultrasonic pulse velocity, 3D mapping, colorimetric analysis, and vacuum water saturation.

Results: ZnO synthesis via SG and HT methods resulted in pure compounds with crystallite sizes of 12 and 29 nm, respectively. CZ synthesis showed over 90% purity for all methods, with minor traces of zincite, portlandite, and calcite, and crystallite sizes ranging from 56 to 70 nm. MIC assays revealed that CZ were more effective against all fungi, requiring lower concentrations for inhibition for CZ-MW, except for Fusarium sp., where ZnO show higher effectiveness. Interestingly, CZ-SG demonstrated fungicidal activity against most fungi. The two strains of Stachybotrys sp. showed different response to NP. Fusarium sp. was the most resistant requiring higher concentrations, nevertheless all samples show a fungistatic effect. The fungal application on mortars specimens, did not show significant changes in color between the initial and final assessments. Generally, open porosity increased by the end of the treatment, except for CZ-MS. An inverse relationship was detected between open porosity and ultrasonic pulse velocity; higher porosity corresponds to lower ultrasonic propagation velocity, a trend consistent across both control samples and treated mortar samples.

Conclusions: The different tested nanoparticles were effective in inhibiting fungal growth, particularly against Phoma sp. and Scolecobasidium sp., where CZ displaying fungicidal properties. Despite this, CZ was ineffective against Fusarium sp. Both ZnO and commercial antifungals achieved fungicidal results after 24 h, highlighting the primarily fungistatic effect of these NP. The nature and type of NP exert distinct effects on fungi and their modes of action. CZ and ZnO emerge as potential alternatives for controlling fungi, also the compatibility of CZ with built surfaces represents an advantage for applications on the construction sector.

Biography

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