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Biomineralisation of Calcium Carbonate via Ureolytically Active Fungi

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Over the last 15 years there has been increasing interest in the use of microbially-induced biomineralisation processes for a range of civil, structural and environmental engineering applications including for rock fracture grouting, soil stabilisation, well sealing, stone and concrete protection/repair and bioremediation. Most studies have focused on investigating calcium carbonate precipitation via ureolysis using bacteria, with very few studies investigating other microbes. However, fungi are also known to induce biomineralisation extensively in the natural environment. One potential advantage of using filamentous fungi over bacterial-based systems is the ability for fungi to grow in situ within porous media. Filamentous fungi grow as hyphae that extend, branch out and fuse back together as the organism searches for nutrients within a porous media, forming a 3D network called the mycelium, which can subsequently be used as a scaffold for mineral precipitation. The overall aims of this research are to (i) identify ureolytically active fungal species which can contribute to calcium carbonate precipitation and (ii) develop treatment strategies for stabilising sands using fungal-induced biomineralisation.

An experimental screening programme was carried out using five basidiomycota fungal species native to the UK: *Lyophyllum decastes*, *Lepista nuda*, *Pleurotus cornucopiae*, *Pleurotus ostreatus*, and *Pleurotus pulmonarius*. Screening was focused on assessing: (i) growth rate via time lapse photography and (ii) urease activity using a phenol red assay and monitoring of NH4+ production and Ca2+ depletion in batch experiments. *Pleurotus cornucopiae* was identified as being the fastest growing and most ureolytically active of the fungal species screened.

Pleurotus cornucopiae was taken forward to the second stage of the research and the conditions required for growth within sand columns was investigated. Factors considered included time for growth of fungal inoculant within broth, growth time within sand column, media grain size, carbon source, and grain size of carbon source. The treatment methodology has also been investigated with the goal of achieving mechanical strength improvement. Variables investigated include concentration of cementation solution, cycle duration, number of cycles and injection strategies. The influence of these variables on mass of calcium carbonate was determined and optical and scanning electron microscopy conducted to investigate crystal morphology and mineral distribution within the porous media. These results demonstrate that improvement in the mechanical behaviour is governed by not only the distribution of calcium carbonate within a treated medium but also the nature of the crystals formed via fungal biomineralisation.

Participation

In-Person

References

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