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Optimal Soil Cementation By Agricultural Urease For Use In Aqueous & Non-Aqueous Environments

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Civil and geotechnical engineers must fortify sandy soil in order to build durable structures on loose terrain. Effective soil cementation can be achieved by microbial induced carbonate precipitation (MICP), a process using microbes to generate urease enzymes that catalyze calcium carbonate precipitation. However, MICP is limited by the large size of the microbes (that are unable to penetrate the pore space of fine-grain sand and silt), microbial-mitigating environmental conditions, bio-plugging, and cost, stifling MICP's widespread commercial use. Additionally, the presence of ammonium reverses the reactions that form calcium carbonate. So MICP cemented sand remains weakened by ammonium salts that are a byproduct of urease-induced carbonate precipitation. Currently, the only method of removing ammonium salts is by repeatedly flushing the treated soil with water. But this process has proven to be energy intensive, time consuming, and subject to strict compliance with environmental protection standards.

Researchers at ASU have developed a method of fine-grain soil cementation using agriculturally-derived urease with several options for optimizing cementation strength depending on construction conditions. ASU researchers address the limitations of MICP by extracting urease enzymes from agricultural sources such as jack beans. Urease enzymes are 25-40 times smaller than microbes that produce them, so their direct application redresses the size and clogging issues with MICP. Results show that agricultural urease can induce carbonate precipitation even under aqueous conditions, and is further facilitated by the addition of bentonite slurry. Adding a strong base, such as NaOH, reduces the ammonium concentration in favor of ammonia and temporarily increases the pH, decreasing the potential of a reverse reaction. Furthermore, pre-treating the soil helps dissolve any foreign substances that may be encrusted on the soil particles, enabling a cleaner, stronger bond to form between particles and precipitate.

Potential Applications

- Civil Infrastructure Engineering
- Foundation Grouting
- Marine & Subaqueous Construction
- Erosion & Groundwater Control
- Underpinning & Foundation Rehabilitation

Benefits and Advantages

- Durability – Stronger bonds between soil particles and carbonate precipitates means longer lasting cementation of superior structural integrity.
- Eco-friendly – Basic neutralization of toxic ammonium salts reduces chances

for contaminate runoff.
- Innovative – Handles finer grain soils than possible with MICP.
- Lower Cost – Deriving agricultural urease is considerably less expensive than the bioprocess that produces microbial urease, and removing ammonium by base treatment is much more economic than water flushing.
- Versatility – Uses including foundation support, slope stabilization, road subgrade improvement, tunneling, erosion control, groundwater control, and earthquake hazard mitigation. A non-disruptive alternative to chemical grouting, micro-fine cement grouting, compaction grouting, and deep soil mixing.

For more information about the inventor(s) and their research, please see Dr. Edward Kavazanjian's directory webpage