Self-hardening alginate gels for strengthening of soils

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The purpose of this research
Contents

- **Introduction**
  - bacterial technology (about MICP)

- **Material & method**
  - how to make gels
  - test for gels application to soil

- **Result**
  - gel observation
  - application to soils

- **Conclusion & discussion**
Introduction

What is MICP?

- MICP (microbially induced calcium carbonate precipitation)

Figure 1. Schematic diagram showing the effective bridge formation (modified after Cheng et al. 2013).

Figure 3. Sand metamorphosis: (a) natural sand; and (b) biocemented sand (biosandstone)

Donovan, M et al. (2013).
Introduction

Advantages and disadvantages of MICP

- Circle: Material cost
- Triangle: Energy cost
- Triangle: Treatment cost

DeJong, J. T. et al. (2013).
Introduction

The purpose of this research

(a) establishment of a gel method

(b) measuring the soil strength after the application of this technology
Material & method

- How to make gels

nutrients

Urea
Yeast Extract
Ammonium Sulfate
Tris-Buffer

bacteria

*Sporosarcina pasteurii*
30°C/1 week/1x nutrients

CaCl2
Material & method

- What’s going on in the gel?

\[ CO\left(NH_2\right)_2 + 2H_2O \rightarrow 2NH_4^+ + CO_3^{2-} \]
\[ CO_3^{2-} + Ca^{2+} \rightarrow CaCO_3(s) \]
Figure 2.3 Chemical reactions involved in combined microbial induced urea hydrolysis and calcium carbonate precipitation (Van Paassen, 2009)

Wu and Zeng_2017_Biomimetic Regulation of Microbially Induced Calcium Carbonate
Material & method

(a) • Optical microscope
• XRD: X-ray powder diffraction
• XPS: X-ray photoelectron spectroscopy

(b) • Compression test

observing gel CaCO3 status

measuring hardness of Soil
Result

Optical microscope

- Crystals were confirmed as the date passed
- The more nutrients, the more crystals

[Images showing optical microscope images]

Day0~Day6 high nutrients

[Images showing nutrient concentration from Day0 to Day6]
**Result**

XRD

- Different form of crystals of CaCO3 were observed

Calcite and Vertilite
Nutrients may be a more important factor for calcium precipitation than calcium amount.
Result

Compression test

- As time progressed, the mixture became harder
Conclusion

• Alginate gel accumulated calcite

• The amount of CaCo3 depends on nutrients

• The soil became hard when the gels are added.
Discussion

• We can control the amount and form of CaCo3

• Using natural bacteria in the future
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