

The Fundamental Study on Penetration Behavior of Biopolymer Solution for Ground reinforcement

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Introduction

- Biopolymers are in the spotlight as an eco-friendly ground improvement material
- Biopolymer soil treatment(BPST) shows effective improvements in strength, erosion resistance and ground water control
- Applications of biopolymers from a geotechnical point of view are diverse, such as ground improvement, enhanced oil recovery(EOR), and soil remediation
- In this study, experiments on the pore scale were performed to evaluate the injection performance of biopolymer solution

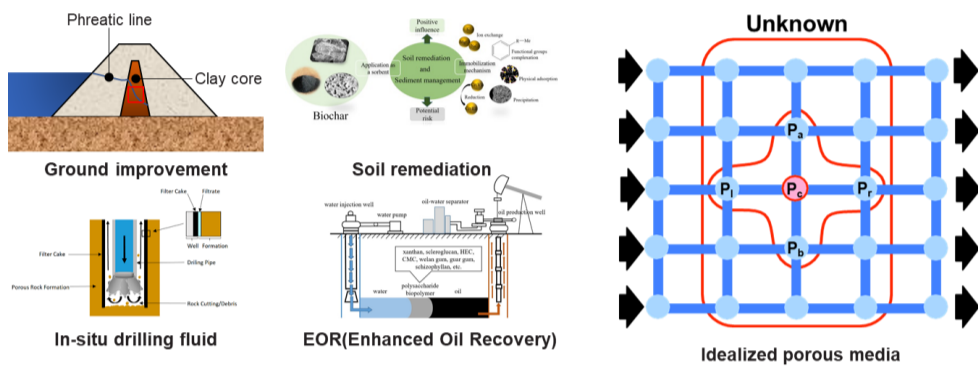


Fig 1. Applications of biopolymer in geotechnical point of view

Materials and method

- Sodium alginate(SA) was used as a biopolymer
- For the SA solution to be used in the experiment, a magnetic stirrer was used by mixing distilled water and SA powder
- Viscosity measurements were performed to define non-Newtonian flow model and to consider the rheological properties of the aqueous biopolymer solution
- The biopolymer solution shows shear-thinning behavior in non-Newtonian fluids and a power-law model was used for analysis

Power-law equation

$$\tau = K\dot{\gamma}^n \quad (\text{Eq.1})$$

K : Consistency index $\dot{\gamma}$: Shear rate n : Flow-behavior index

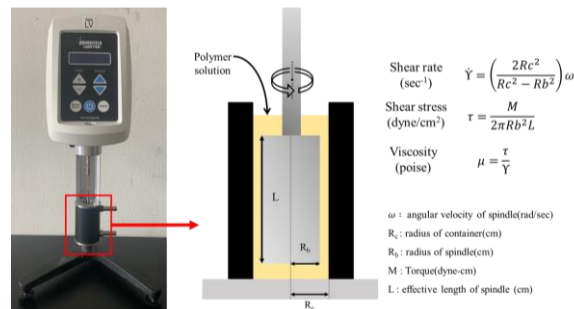
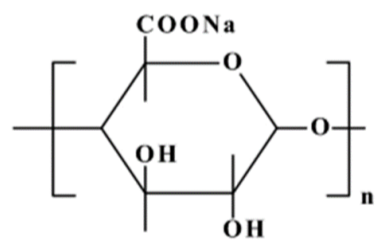


Fig 2. Molecule structure of sodium alginate

Fig 3. Viscosity measurement of SA solution

- A micro-scale test was performed to analyze the injection characteristics of the SA solution
- The micromodel used in this study was created by overlapping the two symmetrical silicon dioxide (SiO₂) glass plates, which can similarly be implemented on the surface characteristics of the soil particles
- The pore saturation changes to the concentration of the SA solution and the volumetric flow rate was analyzed.
- In addition, the relationship between the parameters of the power-law model and the pore saturation according to the biopolymer content was investigated.

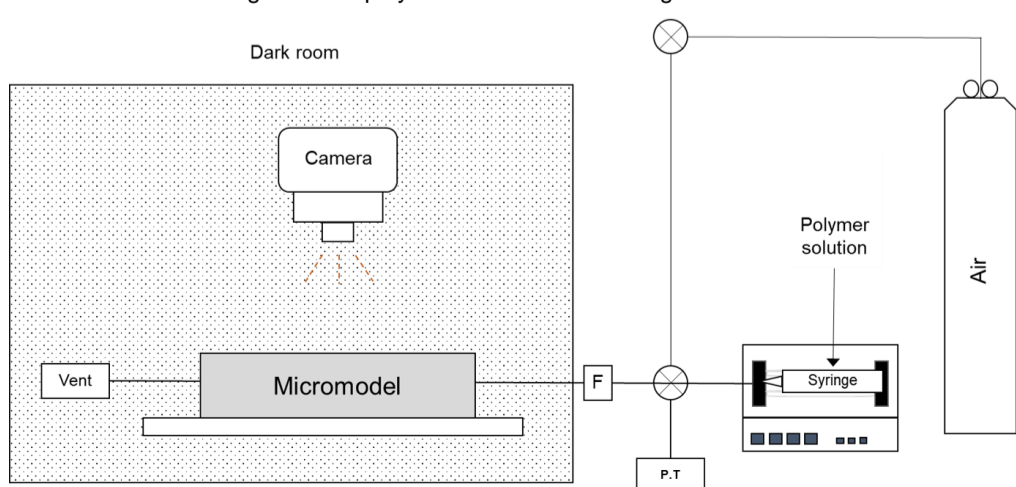


Fig 4. Schematic diagram of micro-scale injection test

Results

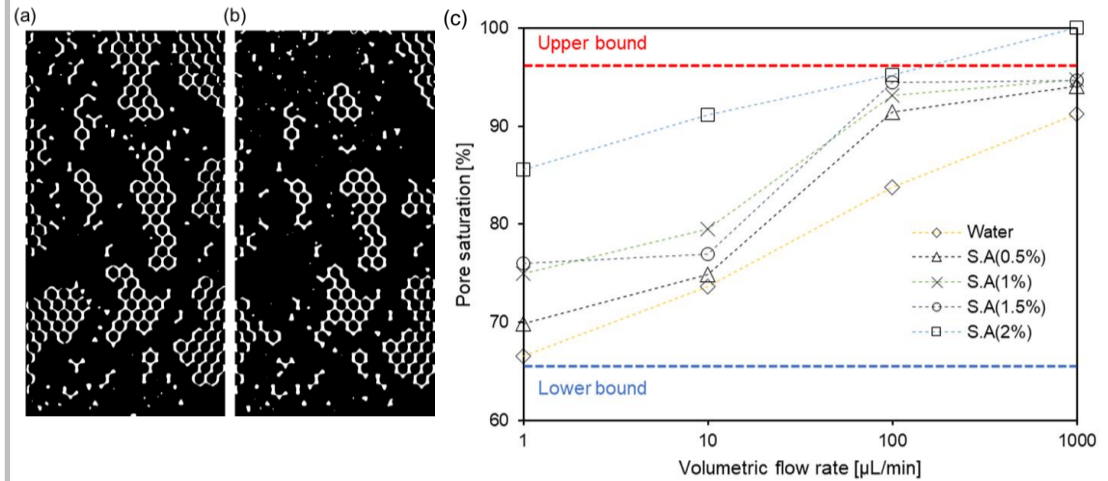


Fig 5. Results of micromodel test (a): SA 0.5% thresholding image (b): SA 1% thresholding image (c): Pore saturation changes with volumetric flow rate

- As the volumetric flow rate increases, the pore saturation increases proportionally.
- For the same injection flow rate, as the content of SA increases, the pore saturation tends to increase.
- SA solution tends to converge when it exceeds a certain volumetric flow rate.

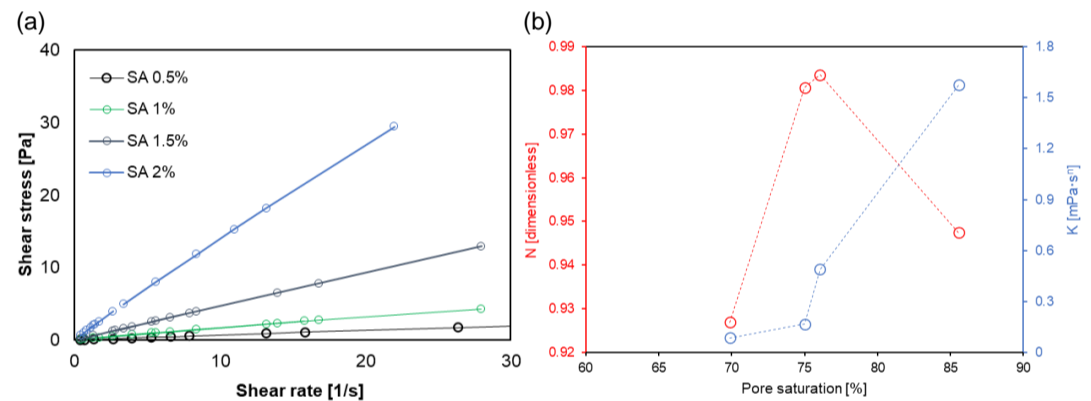


Fig 6. Relationship between rheological properties and pore saturation (a): rheological curve of SA solutions (b): Power-law parameter changes with pore saturation

- All SA solutions changes the shear stress as the shear rate increases, which can be considered as a shear-thinning fluid, one of the non-Newtonian fluid flows.
- As the content of SA increased, the consistency index showed a tendency to increase, but the flow behavior index showed no trend.
- The increase in pore saturation as the SA content because the rate of increase of the consistency index value was higher than the flow-behavior index.

Conclusions

- The viscosity properties of polymer solutions play a major role in analyzing the injection pattern and injection pressure. An increase in the SA content represents an increase in viscosity.
- As the SA content increased, the pore saturation increased, which is judged to be a sharp increase in consistency index of power-law parameter.
- As the SA content increased, the viscosity increased and thus the pore saturation increased, but the increase in the viscosity caused an increase in the injection pressure. Therefore, it is necessary to study the mixing ratio of the SA solution suitable for on-site injection conditions.

Acknowledgement

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References

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