Engineering Natural Bioflocculants: Production, Application, and Mechanisms

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Motivation

Synthetic flocculants, such as polyacrylamide, are widely used due to their good flocculation capacity[1]. However, these synthetic flocculants derived from petrochemicals cause environmental issues such as a high carbon footprint and potential eco-toxicity[1]. Extracellular polymeric substances (EPS), microbially-secreted polymers, have been studied as a sustainable alternative to petrochemical-derived synthetic flocculants due to their properties like high molecular weight, non-toxicity, and biodegradability[2]. Recent studies have achieved EPS overproduction in nitrogen-limited open cultures and proven the flocculation potential of EPS[3].

Technological challenge

EPS properties (e.g., polysaccharide/protein ratio, molecular weight, charge density) affect its flocculation capacity[3]. Conditions such as nitrogen limitation and short sludge retention time are known to promote the overproduction of polysaccharide-rich EPS with net negative charge[3]. However, the underlying mechanisms of EPS overproduction are still unclear, and as a result, controlling EPS properties remains a challenge.

Flocculation consists of three processes (Figure 1) that are assumed to be similar for anionic synthetic and microbial flocculants, where adsorption and non-equilibrium bridging amongst colloidal particles promote flocs formation. These processes in EPS flocculation are determined by external factors like hydrodynamic conditions as well as colloid and water characteristics which vary in different types of colloidal suspension. To enhance EPS flocculation performance and promote EPS application, these elemental processes require detailed study.

In short, engineering EPS with strong flocculation capacity for distinct colloidal suspensions is essential to outperform synthetic flocculants.

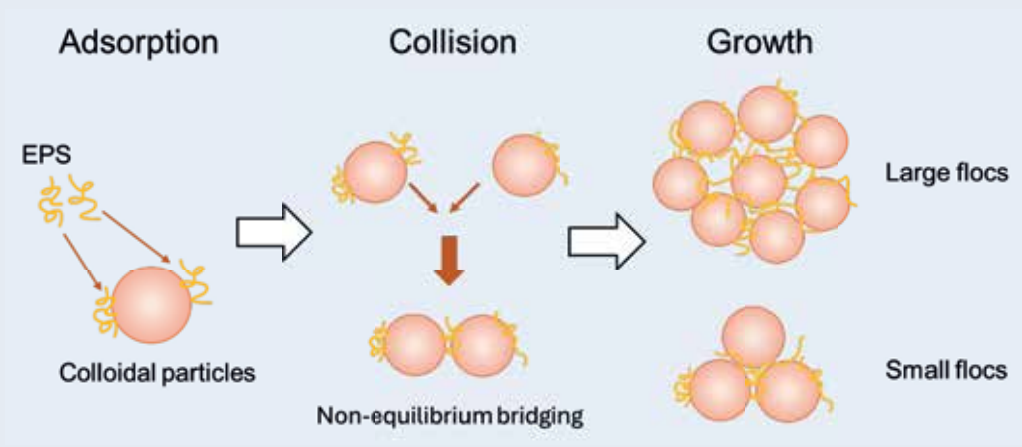

Figure 1. Elemental processes of flocculation with EPS as flocculants

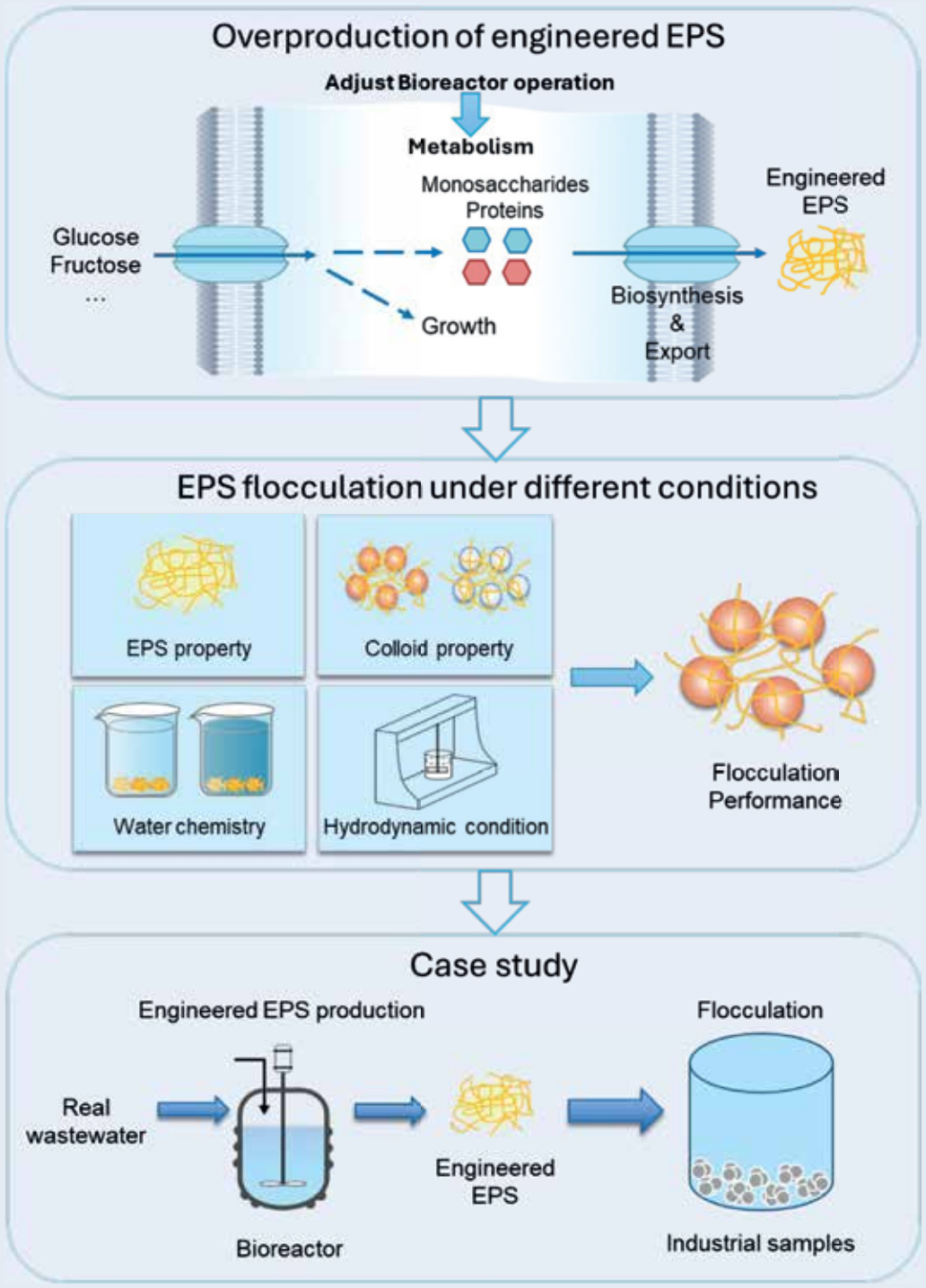

Figure 2. The schematic diagram of the process in this project.

Research goals

A comprehensive approach will be followed as shown in Figure 2. The main research goals of this project are:

- Understand the mechanisms of EPS overproduction and regulate EPS properties by adjusting bioreactor operation conditions.
- Study the processes and kinetics of flocculation in relation to EPS properties, colloid properties, water chemistry and hydrodynamic conditions.
- Develop strategies to enhance EPS flocculation performance in a case study under industrially-relevant conditions.

References

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[2] More, T. T., et al. (2014). Journal of Environmental Management, 144, 1-25.
[3] Ajao, V., et al. (2019). Journal of Hazardous Materials, 375, 273-280.