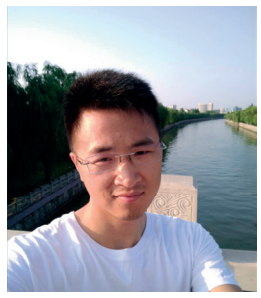
High rate biological production of hydrogen sulfide from elemental sulfur for industrial application



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Motivation

Hydrogen sulfide (H_2S) produced from bioreduction of elemental sulfur (S^0) possesses significant industrial value for applications, including metal recovery from acid mine drainage and serving as a sulfiding agent in hydro-treatment processes for renewable feedstocks. However, the high operational costs, low sulfide production rates, and its liquid phase nature limit the widespread industrial applications of this technology.

Biosulfur, formed through the partial microbiological oxidation of H_2S in bio-desulfurization reactors, is considered waste. Leveraging biosulfur as both the S^0 and carbon source for sulfide production, along with its role as a pH buffer, enables substantial waste valorization. Moreover, biosulfur (Fig.1) is anticipated to exhibit a higher sulfide production rate compared to chemically produced S^0 due to its high bioavailability.

Utilizing hydrogen (H_2) as both the electron donor (Eq.1) and stripping gas facilitates simultaneous H_2S production and stripping in a single bioreactor.

$$S^0 + H_2 \rightarrow H_2S \qquad (1)$$

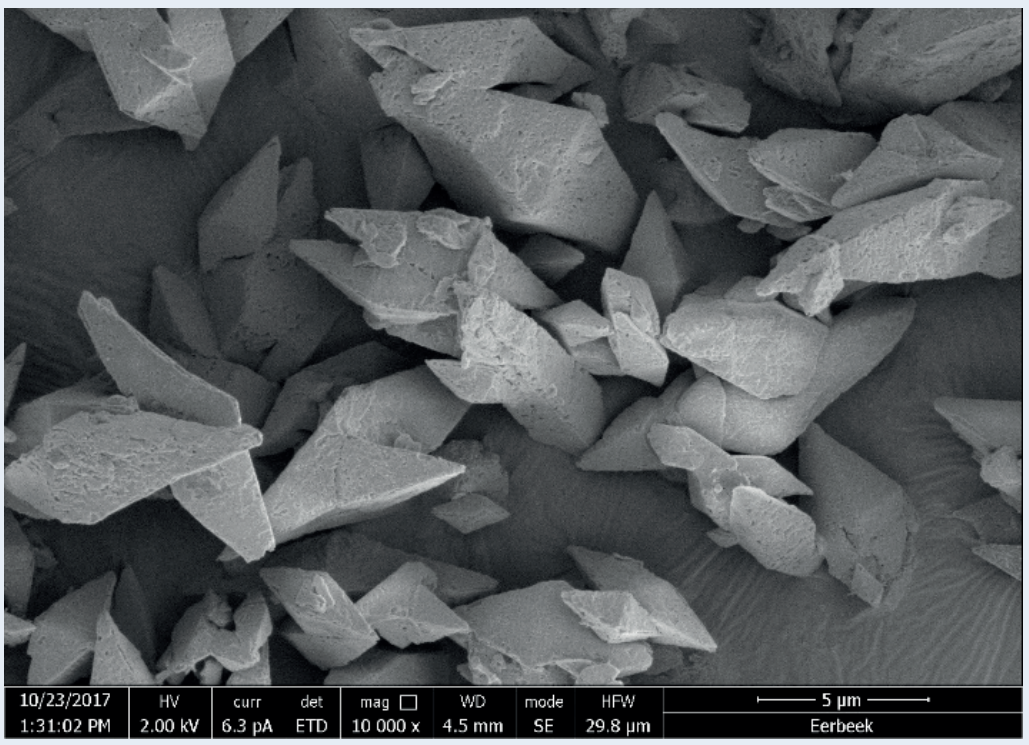

Fig 1. Biosulfur crystals

Technological challenge

CO_2 diminishes the sulfiding effects of H_2S and should therefore be minimized in the off-gas after stripping. In the bioreactor (Fig.2), the carbon source will eventually be stripped as CO_2, along with H_2S. However, insufficient carbon availability can inhibit the growth and metabolism of S^0 reducers, ultimately reducing the rate of H_2S production. The key technological challenge of this research is achieving a high H_2S production and stripping rate while maintaining a low CO_2 concentration.

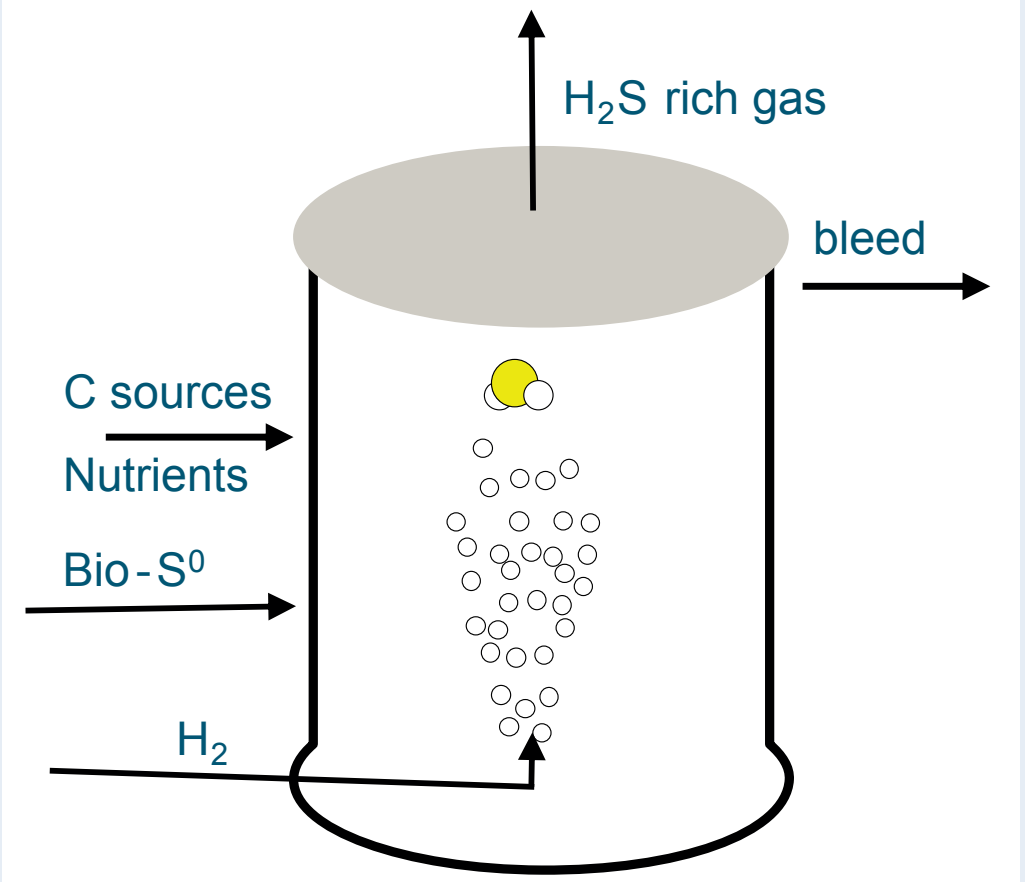

Fig 2. Scheme of S^0 reducing bioreactor

Research goals

This research aims to utilize H_2 and biosulfur in an S^0-reducing bioreactor for the production of gaseous H_2S, achieving high sulfide production/stripping rates. The ultimate goal is to enable cost-effective H_2S generation with minimal CO_2 concentration at an industrial scale. To achieve this, the research focuses on three key objectives:

- identify the rate-limiting steps and develop strategies to overcome them.
- Investigate the Influence of bicarbonate concentration on pH, CO_2 concentration, H_2S production rate and microbial activity.
- Determine optimal conditions for high-rate lithoheterotrophic H_2S production with limited CO_2 concentration.

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