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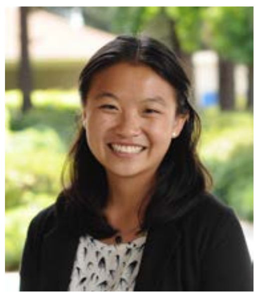
Development of new biological desulfurization processing schemes



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Motivation

Currently, most of the world's sulfur is produced as a by-product of the treatment of gas streams that come from the mining of fossil fuels. These gas streams contain dihydrogen sulfide (H2S), which is recovered and transformed into sulfur using both energy and chemically intensive processes. As the world transitions to using more sustainable forms of energy, sulfur production will decrease and may no longer be available for use in industries such as agriculture. With this decrease comes the need to enhance current sulfur recovery technologies. The biodesulfurization technology utilizes sulfide oxidizing bacteria (SOB) that convert H_2S gas to elemental sulfur under ambient conditions making it more sustainable than physiochemical processes. However, the current process produces thiosulfate and sulfate as by-products, both of which are unwanted due to their consumption of caustic, bleed stream formation, and reduction in the recovery yield of elemental sulfur.

Technological challenge

Recently, it was discovered that the SOB are able to remove sulfide (HS^-) in anaerobic conditions and reduce oxygen in sulfide-free condition [1]. This ability, known as the shuttling capacity, can be further enhanced when the SOB are grown in alternating "anaerobic-sulfide rich" and "aerobic-sulfide-free" conditions [2]. The underlying mechanisms for the shuttling capacity are not understood; therefore, a multi-scale approach is needed to understand this ability (Fig. 1). The technological challenge is to determine if and how the shuttling capacity can be quantified, stimulated, and optimized for the recovery of sulfur.

Research goals

The main goal of this research is to understand and explore the mechanisms behind the shuttling capacity of the SOB. By understanding these mechanisms, new biological desulfurization schemes will be developed to produce more robust microbial communities and limit unwanted by-product formation. The following research questions will be addressed:

1. Understand underlying redox processes the SOB use to produce sulfur
2. Develop methods to quantify the shuttling capacity using a continuous-batch flow reactor
3. Develop methods to stimulate the shuttling capacity
4. Propose and test new process schemes

References
[1] ter Heijne, A., *et. al.*, Environmental science & technology letters, 5(8), (2018). 495-499.
[2] de Rink, R. *et. al.*, Environmental science & technology, 53(8), (2019). 4519-4527.

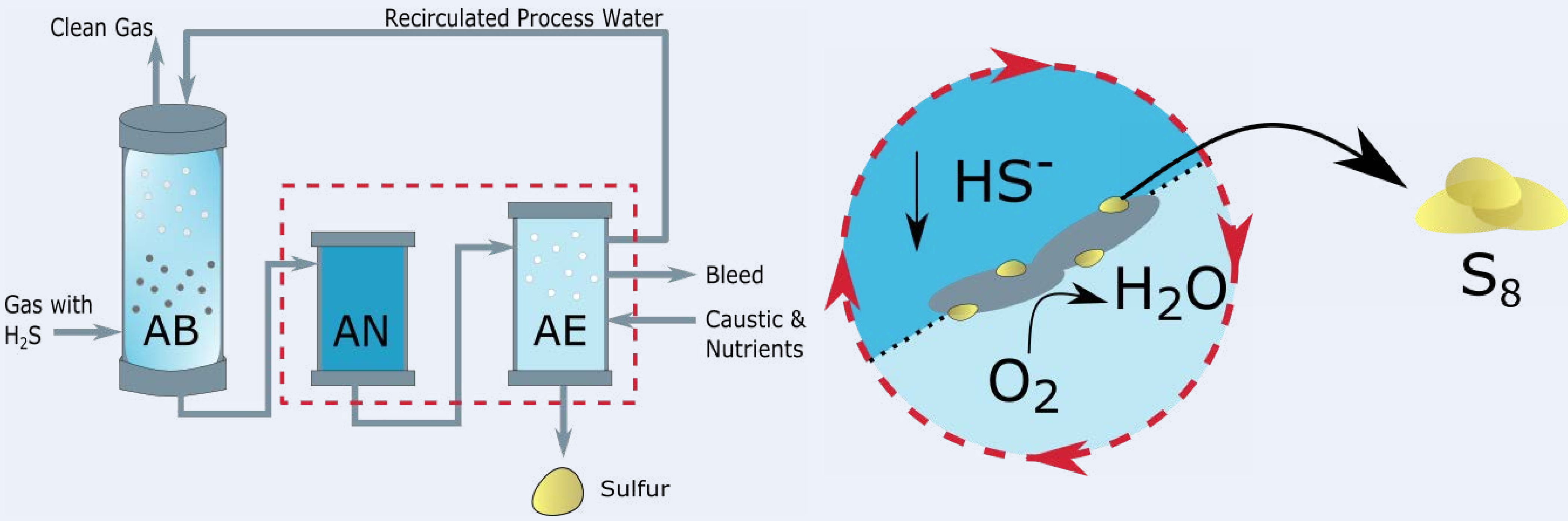

Fig 1. Current process design for the biodesulfurization process with an absorber column (AB), anaerobic reactor (AN), followed by the aerobic reactor (AE). The shuttling capacity occurs between the AN and AE reactors where the bacteria remove the HS-, reduce oxygen, and produce elemental sulfur.

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