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Short communication

Enrichment and cultivation of a sulfide-oxidizing bacteria consortium for its deploying in full-scale biogas desulfurization

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ABSTRACT

Operational experiences and strategies to get suitable chemolithoautotrophic sulfide-oxidizing biomass from activated sludge wastewater treatment plant for its deploying in a full-scale biogas desulfurization plant are described. An economic nutrient source was applied to foster microbial selection and rapid growth. Respirometry was implemented on full-scale installations to monitor the ability of the specialized bacteria consortium to oxidize reduced sulfur i.e. H_2S. During the deployment in the full-scale desulfurization reactor, intermittent sulfide feed from biogas scrubbing was performed to accelerate the startup the desulfurization process.

1. Introduction

Gaseous fuels, including those generated from non-fossil sources such as biogas, commonly contain significant concentrations of hydrogen sulfide (H_2S). Besides the corrosion effects caused on the pipes and in the combustion equipment, significant environmental damage is caused by the acid rain produced by the emitted SO_2.Thus, reliable economic desulfurization processes with minimum impact to the environment are needed. Physicochemical methods complemented with biological treatments have shown to satisfy these requirements, especially for biogas desulfurization [1–5].

Abbreviations: OUR, Oxygen uptake rate (g m^{-3} h^{-1}); FSB, Full-scale bioreactor; SOC, Sulfide-oxidizing consortium; ORP, Redox potential (mV); PSB, Pilot scale bioreactor; TVS, Total volatile solids (kg m^{-3}).

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Biotechnological treatments are effective when an adapted sulfide-oxidizing consortium is used, but its diversity and activity can depend on its origin and the surrounded environmental conditions such as pH, temperature and ionic strength. In some sulfide-oxidizing microorganisms, the elemental sulfur can be either excreted out (*Thiobacilli*) or accumulated (*Thiotrix*) as globules inside the cell. Both municipal and industrial wastewater may contain a number of undesirable sulfur compounds (i.e. cysteine, H_2S, mercaptants), which favor the growth of sulfide-oxidizing microorganisms as part of their microbial diversity, especially under oxic environments.

Recent papers [6–10] describe the use of activated sludge from wastewater treatment plant as inoculum source of sulfide-oxidizing microorganisms for its deployment in different size of odor control and desulfurization installations, but no additional details are reported, especially for full-scale installations, where large amounts of sulfide-oxidizing biomass are required with the consequent supply of macronutrients under chemolithoautotrophic conditions.

Respirometry has shown to be an effective technique to assess the activity of microorganism present in wastewater treatment plants by monitoring the dynamic changes of dissolved oxygen concentration also called oxygen uptake rate (*OUR*), which is induced by the pollutant consumption [11].

The aim of the paper is to evaluate the operational strategies to get sufficient and active sulfide-oxidizing biomass able to perform efficient biogas desulfurization at full-scale installations. The respirometric activity of the specialized sulfide-oxidizing consortium (SOC) was followed to assess its sulfide-oxidizing activity during both the enrichment from activated sludge wastewater treatment plant and its subsequent propagation. The startup of the biogas desulfurization full-scale system is also described.

2. Materials and methods

2.1. Experimental systems

Two different experimental systems, depicted in Fig. 1, were used. The pilot scale bioreactor, PSB consisted of a plastic cubical-shaped container with a useful volume of 0.8 m^3, it was equipped with an air-diffuser at the bottom to supply and maintain the dissolved oxygen concentration above 2 g m^{-3}. The full-scale bioreactor, FSB was made on concrete on a rectangular shape with an useful volume of 106 m^3, the setup was instrumented with pH, redox potential (ORP) and online dissolved oxygen sensors; the FSB was interconnected to an absorber column by a recirculation waterway, moved by an industrial centrifugal pump.

2.2. Experimental approach for cell enrichment and cultivation

A volume of 0.2 m^3 of activated sludge with a TVS concentration of 20 kg m^{-3} was used as an inoculum for the PSB. The aliquot was obtained from a wastewater treatment plant of a brewery industrial unit located in Chile. The enrichment of the specialized sulfide-oxidizing consortium was promoted by five successive batch cultures using the mineral nutritive medium described below and sodium thiosulfate ($Na_2S_2O_3$) as energy source with an initial concentration of 20.5 kg m^{-3}. A 90% of suspension volume in PSB was replaced by new mineral medium after thiosulfate conversion reached a sulfate yield of 700 mmol mol^{-1} of the theoretical production of sulfate from the initial thiosulfate. The PSB was sampled daily for pH and sulfate determinations. At the beginning of the procedure, the temperature in the PSB oscillated between −1 and 10 °C due to winter conditions in the site, thus a temperature control system was implemented to keep the temperature around 28 °C with no cell damage. The pH was maintained between 6.0 and 8.5.

The sulfide-oxidizing capacity of the cultured microorganisms was assessed by respirometry. Once the sampled suspension reached oxygen consumption rates as O_2 greater than 40 g m^{-3} h^{-1} (equivalent to 25% of the *OUR* needed in the FSB for complete oxidation of the 1% volume fraction of H_2S flowing at a rate of 550 m^3 h^{-1} from the scrubbing column), the biomass suspension in the PSB was considered suitable for fostering a rapid cultivation on the FSB and consequently 90% of suspension volume was transferred from the PSB to the FSB.

2.3. Nutrient medium

The composition of the mineral medium was based on previous industrial experience [12], and for the present work the macroelements (N, P, K and Mg) and micro-nutrients were supple

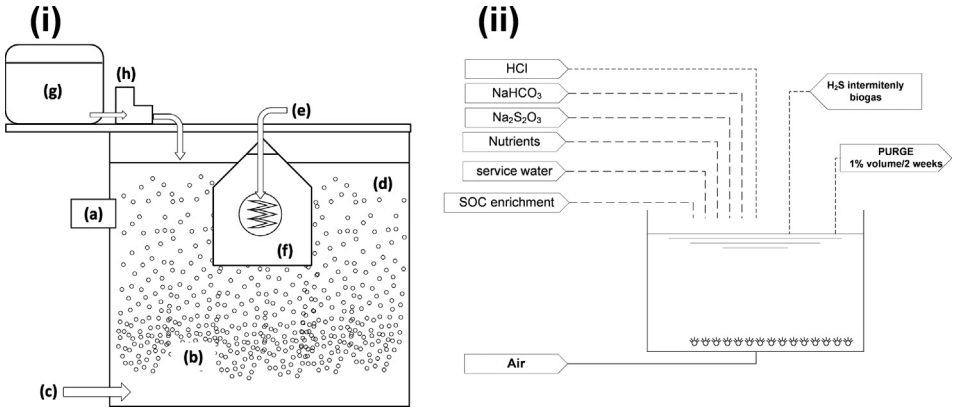

Fig. 1 – i) Pilot scale bioreactor, PSB (0.8 m^3). a) Plastic container, b) air diffusion, c) inlet air, d) biomass suspension, e) electrical resistance, f) temperature diffuser, g) dissolved thiosulfate container, h) dosing pump. ii) Full-scale bioreactor, FSB (106 m^3) coupled to an absorption column.

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