Use of pretreatment methods to enhance biodesulfurization efficiency

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Abstract

Biodesulfurization (BDS) is of great importance in the field of energy production and environmental sustainability. Traditional methods of desulfurization, such as hydrodesulfurization, often involve chemical processes that generate harmful by-products and consume large amounts of energy. In contrast, BDS employs microorganisms or enzymes to selectively remove sulfur oil, resulting in cleaner and low-sulfur products (Kilbane 2017). This environmentally friendly approach offers several advantages, including reduced emissions of sulfur oxides (SOx), which are major contributors to air pollution and acid rain. Furthermore, BDS allows for the utilization of low-concentration sulfur fuels and plays a crucial role in promoting cleaner energy production and reducing the ecological footprint of the transportation and industrial sectors (Stylianou et al. 2021).

While biodesulfurization (BDS) offers numerous benefits, it also has some drawbacks to consider. One such limitation is the relatively slow kinetics of the bio-catalytic reactions involved, which lead to longer processing times and lower productivity compared to the conventional desulfurization methods. The efficiency of BDS is highly dependent on the presence of specific sulfur compounds in the fuel, and certain compounds may be more resistant to biodegradation, limiting the overall desulfurization effectiveness. Additionally, the scalability of BDS processes is a challenge, as maintaining optimal conditions for microbial growth and activity on industrial scale is complex and costly.

Therefore, pretreatment methods play a crucial role in enhancing the efficiency of BDS process, enabling more effective removal of sulfur compounds from fossil fuels. Among the various pretreatment techniques, ultrasonication, electro-oxidation, and the use of carriers such as zeolites have shown promising results. Ultrasonication involves the application of high-frequency sound waves, which generate cavitation and microstreaming effects. This promotes the dispersion of sulfur compounds in the fuel matrix and improves their accessibility to the biocatalysts, thus enhancing the BDS efficiency (Mei et al. 2003; Yi et al. 2019). Viscosity is also reduced due to these phenomena. Electro-oxidation, on the other hand, employs an electric potential to oxidize sulfur compounds, making them more amenable to microbial degradation during BDS (Dávila et al. 2019). Additionally, the use of carriers, particularly zeolites provides a suitable matrix for the immobilization of BDS enzymes, improving their stability and increasing

their contact time with sulfur compounds. Moreover, zeolites can selectively adsorb and concentrate sulfur compounds, facilitating their subsequent biodegradation.

Towards this, to increase the BDS efficiency, six carriers (zeolite, vermiculite, bentonite, 3 biochars and mutag biochip) were selected and their adsorptive capabilities and suitability as BDS carriers were investigated in the presence of two bacteria species (*Serratia sp.* (SER) and *Burkholderia sp.* (BUR)) that have been previously isolated from real environmental samples. Furthermore, ultrasonication was applied at 28kHz for the treatment of heating oil and dibenzothiophene (DBT) samples. DBT is used as a representative compound for sulfur-containing heterocyclic organic compounds in BDS processes. Boron Doped Diamond (BDD) electrodes (as anode) were used for the electro-oxidation process and graphite electrodes (as cathode) at a constant current (1,6 mA) for 60 min process (agitation 180 rpm, and T=25^{o}C).

The experimental results revealed a promising increase in DBT reduction and the formation of specific other compounds (e.g. 2-HBP, DBTO, and $DBTO_2$) which may be used as indicators for enhancing the desulfurization process.

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