Membrane treatment of fermentation liquids to recover ammonia and to concentrate Volatile Fatty Acids

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Abstract:

Anaerobic bioprocesses based on mixed microbial cultures (MMC) can handle a wide variety of organic wastes to transform them into value-added bioproducts within the biorefinery concept (Strazzera et al., 2018). Volatile fatty acids (VFAs) can be obtained by MMC acidogenic fermentation of biodegradable organic wastes, such as waste activated sludge and biowaste. The resulting VFA yield and distribution depend on the composition of the substrate treated and the operating conditions applied, which should prevent methanogens proliferation. Moreover, the maximum VFA concentration that can be reached in acidogenic fermentation could be restricted by product inhibition. Furthermore, VFA-rich fermentation effluents usually contain a considerable amount of Total Ammonium Nitrogen (TAN) that could limit some downstream applications. This study is focused on the treatment of acidogenic fermentation liquids (i) to recover its TAN content using a Gas Permeable Membrane (GPM) and (ii) to concentrate the produced VFAs using a Forward Osmosis (FO) membrane.

Biowaste was collected from a mechanical-biological treatment plant of the Barcelona Metropolitan Area and sieved at 5 mm mesh size before its use. This substrate was subsequently treated in a semi-continuous lab-scale acidogenic fermenter (1.75 L effective volume) working at 35ºC and a Hydraulic Retention Time (HRT) of 4 days. The liquid fraction of the fermentation effluent was subsequently treated in a GPM contactor to recover TAN using diluted H_2SO_4 as the trapping solution (Serra-Toro et al., 2022). The VFA concentration in the fermentation liquid with low TAN content was then concentrated using a biomimetic hollow fibre FO module (Aquaporin Inside®, HFFO®2 module) where a 1.25 M $MgCl_2$ solution was used as draw solution to reach a concentration factor of 2.0-2.5 (batch assays).

The acidogenic fermenter treating biowaste produced a stable VFA production (32-44 g COD_{VFA}/L), mainly dominated by acetic, propionic and butyric acids. This VFA content represented the 52-82% of the soluble COD and the fermentation effluent was also characterised by circumneutral pH values (6.0-8.0) and a high TAN content (3.3-5.7g N/L). Its nitrogen content was successfully recovered as ammonium sulphate using a commercial GPM. This process yielded TAN recoveries higher than 94% at long-term condition and produced a concentrated $(NH_4)_2SO_4$ solution (above 30 g N/L) with high purity. Finally, several tests were conducted using a FO membrane to concentrate the VFAs of the effluent of the GPM treatment, obtaining a fermentation effluent with a VFA concentration up to 76-79 g COD_{VFA}/L with a VFA rejection above 98%.

To sum up, acidogenic fermentation liquids were treated using a gas-permeable membrane that efficiently recovered more than 94% of its TAN content, while producing a highly concentrated $(NH_4)_2SO_4$ solution. The VFAs of the fermentation liquid were subsequently concentrated in a FO unit, reaching a VFA concentration of more than 70 g COD_{VFA}/L.

References:

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