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Reduction of Specific Energy Consumption in Microfiltration of Bacillus velezensis Broth by Air Sparging and Turbulence Promoter

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Abstract : To obtain purified biomass to be used in the plant pathogen biocontrol or as soil biofertilizer, it is necessary to eliminate residual broth components at the end of the fermentation process. The main drawback of membrane separation techniques is permeate flux decline due to the membrane fouling. Fouling mitigation measures increase the pressure drop along membrane channel due to the increased resistance to flow of the feed suspension, thus increasing the hydraulic power drop. At the same time, these measures lead to an increase in the permeate flux due to the reduced resistance of the filtration cake on the membrane surface. Because of these opposing effects, the energy efficiency of fouling mitigation measures is limited, and the justification of its application is provided by information on a reducing specific energy consumption compared to a case without any measures employed. In this study, the influence of static mixer (Kenics) and air-sparging (two-phase flow) on reduction of specific energy consumption (ER) was investigated. Cultivation Bacillus velezensis was carried out in the 3-L bioreactor (Biostat® Aplus) containing 2 L working volume with two parallel Rushton turbines and without internal baffles. Cultivation was carried out at 28 °C on at 150 rpm with an aeration rate of 0.75 vvm during 96 h. The experiments were carried out in a conventional cross-flow microfiltration unit. During experiments, permeate and retentate were recycled back to the broth vessel to simulate continuous process. The single channel ceramic membrane (TAMI Deutschland) used had a nominal pore size 200 nm with the length of 250 mm and an inner/external diameter of 6/10 mm. The useful membrane channel surface was 4.33×10^{-3} m². Air sparging was brought by the pressurized air connected by a three-way valve to the feed tube by a simple T-connector without diffusor. The different approaches to flux improvement are compared in terms of energy consumption. Reduction of specific energy consumption compared to microfiltration without fouling mitigation is around 49% and 63%, for use of two-phase flow and a static mixer, respectively. In the case of a combination of these two fouling mitigation methods, ER is 60%, i.e., slightly lower compared to the use of turbulence promoter alone. The reason for this result can be found in the fact that flux increase is more affected by the presence of a Kenics static mixer while sparging results in an increase of energy used during microfiltration. By comparing combined method with turbulence promoter flux enhancement method ER is negative (-7%) which can be explained by increased power consumption for air flow with moderate contribution to the flux increase. Another confirmation for this fact can be found by comparing energy consumption values for combined method with energy consumption in the case of two-phase flow. In this instance energy reduction (ER) is 22% that demonstrates that turbulence promoter is more efficient compared to two phase flow. Antimicrobial activity of Bacillus velezensis biomass against phytopathogenic isolates Xanthomonas campestris was preserved under different fouling reduction methods.

Keywords : Bacillus velezensis, microfiltration, static mixer, two-phase flow
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