Abstract

The development of low-cost ceramic membranes for various separation applications is one of the most discussed topics in recent times due to their outstanding thermal, chemical and mechanical properties. Among the various low-cost precursors used for membrane fabrication, fly ash is getting vast importance as it also addresses the major concern over improper dumping of fly ash, which may otherwise cause severe health consequences. Observing this fact, this work focuses on fabrication of fly ash-based tubular ceramic membrane using different percentages of fly ash, along with few percentages of quartz and calcium carbonate, to find out the optimum raw material composition. Further, the membrane with optimized raw material composition (75% fly ash, 20% quartz, 5% calcium carbonate) was used to evaluate the effect of binder concentration (Sodium salt of carboxy methyl cellulose; Na-CMC) on membrane properties. It was found that 2 wt.% solution of Na-CMC is sufficient for obtaining a membrane with good physical and mechanical properties. The membrane with optimum raw material composition and binder concentration possesses an average pore size of 0.133 μm and porosity of 40.17%, along with outstanding chemical and mechanical strength. This membrane was further used for three different separation processes, namely poultry slaughterhouse wastewater treatment, starch processing wastewater treatment and separation of glycerol from biodiesel. Treated permeate in all the cases was found to satisfy necessary environmental safety norms. Besides, an economic feasibility assessment was also carried out for all three aforementioned separation processes. The process of cost estimation starts with estimating membrane fabrication cost, which comes out to be 250.00 USD/m^2. Process cost estimation was carried out for both lab-scale and pilot-scale setups, filtration areas being 0.00172788 m^2 and 0.07257 m^2, respectively. The total costs involved in aforementioned processes lie between 1.10-5.15 USD/L of permeate produced for lab-scale setup and 0.06-0.47 USD/L for pilot-scale setup.