	INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI **SHORT ABSTRACT OF THESIS**

Name of the Student	:	AANISHA AKHTAR
Roll Number	:	156107015
Programme of Study	:	Ph.D.
Thesis Title: Prediction and Prevention of Downhole Complications in Real-time Oil Well Drilling		
Name of Thesis Supervisor(s)	:	Prof. Senthilmurugan Subbiah Prof. Prof. Kaustubha Mohanty
Thesis Submitted to the Department/ Center	:	Yes
Date of completion of Thesis Viva-Voce Exam	:	25.04 -2021
Key words for description of Thesis Work	:	Ultra filtration, Forward Osmosis, Ceramic membrane, Sugarcane juice, Clarification, concentration

SHORT ABSTRACT

Membrane technology is an ever-growing field as it has several advantages over other traditional processes. Typically, membrane processes such as Ultra filtration (UF) and Forward Osmosis (FO) have several functional applications including water treatment and food processing (clarification and concentration). Among the various processes in the sugar industry, clarification and concentration of sugarcane juice suffers from several technological limitations and is thus taken up as the area of this research work. During the sugarcane juice processing (clarification, concentration) and storage following technical limitations are observed: gel formation at high concentration, browning (enzymatic) of juice, loss of vitamins and the components responsible for the juice flavour, taste change due to the thermal and chemical pre-treatment. The conventional method of sugarcane juice processing involves the pre-treatment with lime, sulphur dioxide and heat treatment above 100°C. Considering the issues as mentioned above as well as scalability and process simplicity, membrane technology can be considered to be the most viable technology for the clarification and concentration of juice.

In this research, the entire work carried out was divided into four major parts as given below,

- Feasibility study of the clarification of sugarcane juice by $LaPO_4$ coated ceramic UF membrane and its fouling and cleaning analysis.
- Feasibility study of the concentration of sugarcane juice by Aquaporin HFFO membrane and corresponding bottlenecks to be addressed to implement same in the industrial scale.
- Development of a batch FO process mathematical model for concentration of sugarcane juice by Aquaporin HFFO membrane and its validation.
- Process simulation and performance optimization of Aquaporin HFFO membrane to minimize the SEC with maximum yield.

As part of the first objective, the application of the $LaPO_4$ ceramic membrane for the clarification of sugarcane juice was explored to avoid the use of lime and to produce chemical free sugarcane juice. The effect on the polyphenol oxidase (PPO) enzyme removal efficiency, bacteria removal efficiency, permeates flux decline profile, and membrane cleaning efficiency was evaluated. Again, the result of a long terms sugarcane juice storage study revealed that the UF clarified juice could be stored in refrigerated condition for seven weeks without significant change in the quality of the juice. Moreover, the importance of the inline physical cleaning and its operating mechanism is evaluated to understand the fouling and cleaning phenomena of the ceramic membrane.

As part of the second objective, the performance of a commercially available Aquaporin HFFO membrane for the concentration of sugarcane juice by adopting an appropriate UF pre-treatment technique was studied. The effect of various process parameters such as DS flow rate, DS concentration and its direction of flow (co-current, counter-current) on water and reverse solute flux in batch mode was studied. In this study NaCl is used as a draw solute. The experimental results showed that counter-current flow configuration between FS and DS were able to provide 13% high water flux than co-current flow configuration. In the case of counter-current mode batch FO operation, sugarcane juice was concentrated to a maximum of 1.6 times of initial concentration in just 12 min by using an initial DS concentration (NaCl) of 100 gL^{-1} (with negligible RSF). The effect of UF clarified and raw sugarcane juice on FO membrane fouling was studied. The cleaning study concluded that the fouled membrane could be regenerated easily by DI water wash for 30 min for UF clarified juice. However, regeneration of membrane for the case of raw juice was not possible with DI water wash alone, and it required 0.1 M NaOH wash.

Under the third objective, modeling, validation of the batch FO process was carried out. A mathematical model of the batch FO process was developed by integrating the FO membrane module, FS and DS storage tank. The model for the FO membrane module was developed by integrating mass, momentum and membrane mass transfer equations. The unknown model parameters of FO module were estimated by minimizing the error between FO batch experimental data and model output. The estimated parameters were used to predict the performance of the model using the remaining experimental data. The developed model was able to predict experimental output within an error of 5% for permeate flux and reverse solute flux. The estimated value of model parameters such as pure water permeability (A), solute permeability (B), structural parameter (S), α_f and α_d were found to match the reported values in the literature.

As part of the fourth objective, in process simulation of the batch FO process, three case studies were carried out viz. case I: FS and DS both are recycled, case II: FS recycle and DS in continuous mode and case III: both FS and DS were in continuous mode. From these three cases of the simulation study, it was observed that case III was more effective in terms of concentration, reverse solute flux and specific power consumption. The SEC was 78.85 W L^{-1} for Case III (both feed and DS in continuous mode),which was the lowest among all three cases. Again, a simulation study was carried out for the two FO modules in a series system and compared with other DS flow rates to find the optimal DS flow rate. A 60:40 DS flow-rate ratio showed the best results in low SEC, low RSF, and high concentration. Overall, the obtained results will serve as a useful solution for future use of membrane technology in sugar industries.