論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Modeling of membrane cross-flow filtration process of protein-polysaccharide natural suspension
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第12105号, 授与年月日:2021年9月24日, 学位の種別:課程博士, 審査員:吉川 史郎,関口 秀俊,多湖 輝興,大河内 美奈,松本 秀行,森 伸介
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12105号, Conferred date:2021/9/24, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

Thesis Outline

Modeling of membrane cross-flow filtration process of protein-polysaccharide natural suspension

In this research, Chapter 1 is an **Introduction**, which describes the background of the research, including the current market trend of natural plant-based products which rocketed each year. Hence the alternation of plant-based protein product became a significant issue. Coconut skimmed effluent, which is a waste by-product from coconut oil process, has been selected as a representative suspension in this study. This chapter also provided the necessary information about the coconut skimmed effluent, which started with the coconut oil process. A number of research papers dealing with coconut skimmed effluent utilization, environmental impact, as well as a health benefit, are mentioned. The explanation of the basic mathematical model of membrane separation is also stated. From these backgrounds, the objective of this research was clarified.

Chapter 2 investigated the **Cross-flow ultrafiltration of coconut suspension** in order to provide the information needed for the effective process design. Cross-flow ultrafiltration is renowned for many benefits in the concentration process eg. heat-free process, low energy consumption, continual production, and so forth. Nevertheless, the decrease in performance over time is a big obstacle hold back the utilization of the process. The former studies, coping with the membrane process, neither focused on plant-based materials nor biopolymer. Therefore, this part will head toward that scarcity by employing coconut effluent as a representative prototype of the natural plant-based biopolymer. For this purpose, the effect of membrane molecular weight cut-off (MWCO), transmembrane pressure (TMP), cross-flow velocity, and temperature were investigated to gain data for the process optimization. This chapter successfully evaluated the operational condition mentioned above and found that there were no systematic relationships between the membrane MWCO and permeate flux. The results indicated that fouling layer had the compressible property since the permeate flux of coconut protein-carbohydrate suspension (CPC) was smaller when operated under higher TMP. In the meantime, raising the feed flow rate could help alleviate the fouling mechanism since the shear stress exerted by the feed movement enhances the back transport of the particles on the membrane and retards the development of the cake layer. However, high flow rate adversely induced the arrangement of the particle on the membrane surface which resulted in the increase of the compactness of the cake layer.

Chapter 3 focused on the **Molecular interaction in coconut suspension and filtration performance.** To improve the ultrafiltration performance, it is not limited to the scope of operating condition optimization. Adjusting the feed suspension becomes an interesting alternative factor. This part investigated and discussed the influence of the feed pH on the filtration flux. Four pH points around the isoelectric point (pI) of the coconut protein have been chosen. Intermolecular interactions are reviewed, and the electrostatic effect on the structural rearrangement of protein-polysaccharide is studied. The filtrations were performed using both the nearly pure coconut protein extracted by precipitation, and CPC suspension, the representative liquid for the coconut skimmed effluent. For pure-protein filtration, the results showed that the fouling was severe at the pH close to pI. The results showed the sequence of the highest to the lowest flux obtained as pH 9 > pH 2 > pH 6.3 > pH 4. These results corresponded well to the other researches. However, filtration of CPC suspension showed the best condition at pH equal to pI with the sequence of the best to the worst was pH 4 > pH 6.3 > pH 9 > pH 2. For dead-end mode, and pH 4 > pH 6.3 > pH 2 > pH 9 for cross-flow mode. Based on these outcomes, the concepts describing the selection of pH conditions for filtration of the CPC suspension or the protein-polysaccharide mixture could be made for the optimum process design.

Chapter 4 evaluated the **Models applicability to the coconut suspension ultrafiltration.** Classical fouling models were generally classified into four types: pore blockage, intermediate blockage, pore constriction, and cake filtration. Due to the existence of several mechanisms, the purpose of this part is to examine the applicability of each model to describe the filtration data of dead-end and cross-flow ultrafiltration in various pH conditions. In addition, the combination of pore blockage and cake filtration model was also paid attention to in the case of more than one fouling mechanism that might occur in the CPC suspension ultrafiltration. For this purpose, the deriving of the mathematical model for the four classical mechanisms in both dead-end and cross-flow mode and two combined models were reviewed. The mathematical models were applied to the experimental data then the conclusion was made from this comparison.

Chapter 5 correlated the **Fouling resistance relationship between Dead-end filtration and Cross-flow filtration of coconut suspension.** From the results of model applicability in Chapter 4, the classical model expresses a good agreement with only the dead-end ultrafiltration experimental data. None of the equations could describe the cross-flow ultrafiltration flux decline. Furthermore, the complexity of the feed suspension made a measurement of several empirical constants needed for the cross-flow model impossible. According to this issue, a new mathematical model was proposed to ease the difficulty in experimenting with cross-flow UF. Dimensional analysis technique was employed to find the resistance relationship between dead-end and cross-flow filtration. The removal resistance (Rr) was defined and assigned to be a function of total dead-end fouling resistance, cross-flow velocity, permeate viscosity, feed density, and TMP. This part reviewed the associated theories, including the resistance-in-series model, dimensional analysis, and specific fouling resistance. The model was applied to the observed data, and the applicability was successfully evaluated and the model could satisfy the cross-flow filtration flux competently using only the simple parameter, especially a specific resistance measured from dead-end filtration, which has been reported to be inapplicable for cross-flow filtration flux prediction.

Chapter 6 is the **Conclusions and recommendations.** General conclusions of the study are presented. Then the suggestions for additional work that may be performed to extend the theoretical formulations are mentioned.