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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Coconut-protein-carbohydrate (CPC) suspension was prepared with coconut flour and used as a representative feed sample due to the scarcity of coconut in Japan. The feed sample characteristics were evaluated and found to be interchangeable with the actual CSE. The first part of this study successfully evaluated the overall cross-flow UF performance under various operational conditions using 6.5g/ml solid concentration CPC suspension. Changing the membrane MWCO (10 and 30 kDa) caused only minor impacts, and there were no systematic relationships between the membrane MWCO and permeate flux found. Considering the flux under different TMPs, the results explicitly indicated that the fouling layer had the compressible property. The permeate flux of CPC suspension was smaller at both the initial stage and the pseudo-steady stage compare with the process operated under lower TMP even though the pressure is a driving force. 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. The second part highlighted the filtration performance under different electrostatic conditions. According to the results of previous section, 30 kDa membrane was adopted and the operating conditions were; 0.2 MPa, and 25°C. First of all, to confirm just the effect of pH on the coconut protein, quasi-pure coconut protein solution prepared by the precipitation technique was subjected to dead-end UF. The permeate fluxes of dead-end quasi-pure coconut protein filtration logically corresponded to the other studies that investigated the electrostatic interaction on protein filtration. The results showed the sequence of the highest to the lowest flux obtained as pH 9 > pH 2 > pH 6.3 > pH 4 in which pH 4 is an isoelectric point (pI) of the coconut protein or the point that protein net charge becomes neutral. An investigation using the dead-end module was also done for CPC suspension. CPC suspension was diluted to approximately 3.5g/ml due to the limitation of the dead-end module. Interestingly, the filtration performances of CPC suspension were substantially different and complicated. The sequence of the highest to the lowest flux obtained was almost about opposite to the quasi-pure coconut protein; pH 4 > pH 6.3 > pH 9 > pH 2. Coconut meal was reported to have 43–45% carbohydrate, including many polysaccharides. It could play an important role when the suspension pH has been changed. The polysaccharides are responsible for the presence of a carboxylic functional group that can ionize to the negative charge when the solution pH became higher than pKa. Therefore, the interaction between protein and polysaccharide molecules took place in the CPC suspension and resulted in distinct filtration performances. Next, modified pH CPC suspension was subject to cross-flow UF. The order of the best to the worst performance corresponded with the dead-end UF but ultimately showed the difference; pH 4 > pH 6.3 > pH 2 > pH 9. The effect of cross-flow velocity results in the preferential size of the deposition, in which the smaller particles are more liable to develop the foul. The first two parts of this research could be shortly summarized that even though the electrostatic interaction was reported to have a strong influence on the protein UF, the particle size alteration should be carefully considered due to the effect of cross-flow velocity. The third section is focusing on the applicability of existed filtration models. To promote practical use includes process design and describe the fouling mechanism, a mathematical expression is needed to be considered. Four classical fouling models: complete blockage, standard blockage, intermediate blockage, and cake filtration, were adopted for quantitatively explaining the fouling behavior of both dead-end and cross-flow UF at different pH conditions. The cake filtration model could give a good agreement with all pH conditions carried out by dead-end filtration. However, for cross-flow filtration at pH 6.3 and 9, the fouling mechanism was an intermediate blockage. A combined pore blockage and cake filtration model was also investigated. It could fit the dead-end UF well but could not give any satisfaction to the cross-flow filtration. Note that the model was developed based on dead-end filtration. In addition, according to the results mentioned above, an effort to adopt the model for cross-flow UF, which concerned the cake layer compressibility, has been exerted. Nevertheless, the complexity of the feed suspension made a measurement of several empirical constants needed for the cross-flow model impossible. Due to the simplicity and easiness of using the dead-end module, it would be better if the cross-flow flux could be predicted by utilizing the dead-end filtration data. Thus, 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 (R_r) was defined and assigned to be a function of total dead-end fouling resistance, cross-flow velocity, permeate viscosity, feed density, and TMP. It returned that the proportion of removed resistance to the total resistance was a power-law function of the inversion of Reynold number and modified Euler number and three empirical constants were determined to give a good fit with the experimental data. 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. (899 words)