단백질을 포함한 전기투석공정에 있어서 펄스전원을 이용한 오염저감에 관한 연구

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A study on fouling mitigation using pulsed power in electrodialysis of solution containing a protein

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1. Introduction

Electrodialysis (ED) is an ion exchange membrane separation process using an electrical potential difference as a driving force. Applications of ED can be found in the environmental and biotechnological industries as well as in the production of table salt and the desalination of seawater. In spite of the perspectives of ED, fouling of ion exchange membranes is one of the most important limitations in the design and operation of electrodialysis process. Foulants in electrodialysis move toward ion exchange membranes under the electric field and then deposit on the surface of membranes by electrical interaction between the membrane surface and the foulants, increasing the electric resistance of membranes [1]. Many approaches have been examined to minimize fouling during ED, including pretreatment of the feed solution, the turbulence in the compartments, the optimization of process conditions and the modification of the membrane properties. These methods, however, require additional instruments resulting in increase in the installed cost as well as the operating cost.

One of organic foulants, bovine serum albumin (BSA) with negative surface charges and high molecular weight deposits on the anion exchange membrane surface. Movement or deposition of such electrically charged protein may be disturbed by applied alternating electric field through reduction of resistance of the fouling layer and

increase of the membrane performances [2]. It is thought that the electric pulses deform of the gel layer formed on the surface during ED of solution containing charged foulants.

The objective of this study is to reduce the fouling rate of ion exchange membranes using the electric pulses with various frequencies as well as to investigate fouling phenomena in electrodialysis of solution containing BSA.

2. Experimentals

In this study power sources including DC power as a reference power and the square wave pulse powers with various frequencies were used to reduce fouling potentials in electrodialysis of BSA. The pulse powers were supplied during electrodialysis using a function generator 33210A (Agilent, USA) and a dual type power supplier, UP-100D (Unicorn, Korea) connected to an amplifier [3].

A TS-1 (Tokuyama Corp., Japan) two-cell ED stack of CMB and AMX membranes was used for electrodialysis. The electric currents from DC power and the pulse power were kept at 0.6 A. During electrodialysis 800 mL of 3 % Na_2SO_4 was supplied as an electrode rinse solution. A concentrate (1.0 L of 30 g/L of sodium lactate) and a diluate (1.0 L of 80 g/L of sodium lactate containing 1.0 wt% of BSA) were circulated with a flow rate of 0.2-0.3 L/min. The electrodialysis performances between the DC power and the square wave pulse powers were compared in terms of cell resistance and removal rate of lactate.

3. Results and Discussion

It was founded through characterization of BSA that the molecular weight of BSA has negative charges of -25 mV at neutral pH and isoelectric point of pH 4.7 [4]. The adsorption of BSA on the anion exchange membrane surface could not change electric resistance through characterization of the membrane. However, the exchange capacity of the fouled membrane decreased about 42 % due to deposition of BSA on the functional groups in the membrane structure.

In the fouling experiments, little difference in the electrodialysis performance between the DC power and the pulsed powers was observed in

terms of the removal rate of lactate. Considering changes of the cell resistance, however, the pulse powers with 10 Hz, 25 Hz and 50 Hz reduced fouling potentials for the results of the DC power. Meanwhile, the increasing rate of the cell resistances for 100 Hz and 200 Hz were similar with that of the DC power, suggesting that the pulse powers with high frequencies caused close packing of the foulants in the gel layer [2]. In particular, the increasing rate of the cell resistances for the frequencies of 25 Hz and 50 Hz were much lower than that in the DC power. Furthermore, the power consumption for 25 Hz and 50 Hz showed lower than that for the DC power. It is considered that the electric pulses enhanced the mobility of the charged particles in the fouling layer and decreased the electric resistance of the ED cell [1]. Through the electrodialysis performances in Table 1, the square wave pulsed power with various frequencies demonstrated an ability to minimize membrane fouling with optimal frequencies.

Considering the transport of BSA into concentrate during electrodialysis, the frequency of 25 Hz had a similar aspects with the result for the DC power. However, amount of deposited BSA on the anion exchange membrane surface in Fig. 1 was decreased with time in the pulse power of 25 Hz, while amount of deposited BSA was remained as 19.2 mg/cm^2 in the DC power. Observation of the deposited BSA revealed that the electric pulses enhanced the mobility of BSA in the fouling layer by removing the deposited charged foulants on the membrane surface.

4. Conclusion

The fouling experiments of BSA were performed with the square wave pulse powers. It was observed that the fouling potentials were reduced in the pulse powers with various frequencies. It is suggested that the electric pulses enhanced the mobility of the charged particles in the fouling layer and decreased the electric resistance of the electrodialysis cell. Also, the electric pulse powers demonstrated an ability to minimize membrane fouling with optimal frequencies.

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References

1. H.J. Lee, S.H. Moon and S.P. Tsai, *Sep. Purif. Tech.*, In press (2001)
2. P. Zumbush, W. Kulcke and G. Brunner, *J. Membr. Sci.*, **142,** 75-86 (1998).
3. 박진수, 이홍주, 문승현, 한국막학회 춘계학술대회, 수원 (2001).
4. H. Zhu H. and M. Nyström, *Colloids and Surfaces A:Physicochemical and Engineering Aspects,* **138**, 309-321 (1998).

Table 1 Electrodialysis performances with different frequencies

	10 Hz	25 Hz	50 Hz	100 Hz	200 Hz	DC Power
Current eff. (%)	92.5	94.5	93.7	95.2	95.7	84.7
Flux of lactate (mol lactate/m^2hr)	2.39	2.80	2.57	2.32	2.49	1.89
Power consumption (wh/mol lactate)	7.56	5.49	4.67	6.09	5.75	6.89

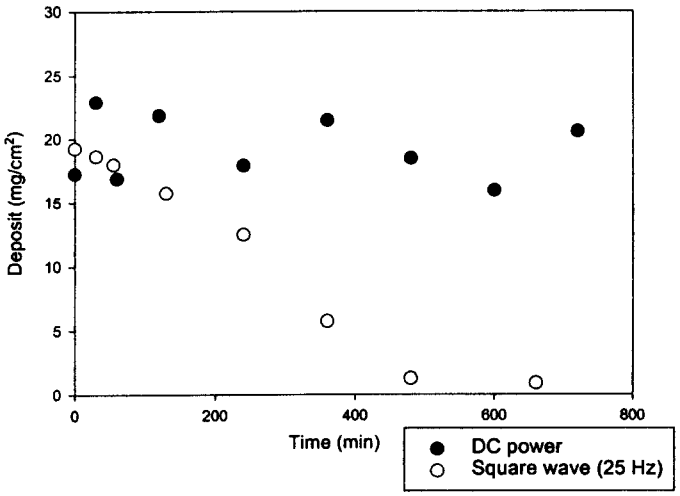

Fig. 1. Influence of the pulse power on the fouling layer in ED.