Development of Concept of Innovative Chemical Reaction System using External Stimuli Responsive Capsules

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1. Introduction – Process intensification has attracted much attention in the field of chemical engineering since the 2000s. Stankiewicz and Moulijn defined process intensification as "Any chemical engineering development that leads to a substantially smaller, cleaner and more energy efficient technology," and it can be categorized into two classes: equipment and methods [1]. In a general chemical industry, many reactors, mixture operations, and separation operations are needed to produce chemical product, and the design and maintenance become complex. In this study, the application of the drug carrier to a chemical reaction process was investigated from the view point of process intensification.

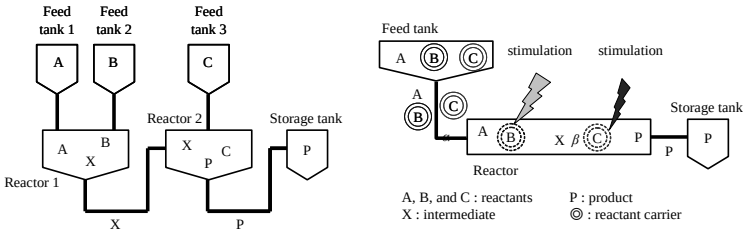
2. Experimental - Pluronic was used as the micelle and NKX-1595, which is a hydrophobic organic dye, was used as the internal substance. A Pluronic micelle solution containing NKX-1595 was prepared by a dialysis method. The Pluronic and NKX-1595 were dissolved in N,N-dimethylacetamide with concentrations of 0.5 wt% and 2.1×10^{-5} wt%, respectively. To form a Pluronic micelle and remove the organic solvent, the solution was dialyzed for 24 h in a cellulose membrane bag against ion-exchanged water. The effects of ultrasonic stimulation on the release of NKX-1595 from the Pluronic micelle were investigated. In addition, the effect of radical scavenger addition on the effluence of dye was also investigated. For comparison, the effect of thermal stimulation on the release of dye was also investigated.

3. Results and Discussion - The internal dye was rapidly released from the micelle at low ultrasonic frequencies, and radical scavenger addition was not influence the effluence of dye. Therefore, ultrasonic physical effect is considered one of the main factors. It also can be observed that degree of dye release increases with the Pluronic micelle size. The release of the dye from the micelle by ultrasound is not only affected by ultrasonic frequency but also by the molecular structure and micelle size. In addition, we investigated the effects of thermal stimulation on effluence of dye at several environmental temperatures. The internal dye was gradually released from the micelle when the environmental temperature was higher than 303 K. Thus, appropriate design of external stimulation enables controlling not only the amount of effluence but also the release rate of the internal dye from the micelle. Figure 1 shows the comparison of the conventional chemical reaction system and the proposed system. Model reactions are described as shown in Eqs. (1) and (2).

$$A + B \rightarrow X \quad (1)$$

$$X + C \rightarrow P \quad (2)$$

In conventional methods, two reactors are often required. However, these conventional reactors can be substituted with one simple flow reactor by using reactant carriers and suitable stimuli.



(a) Conventional method (b) New method

Figure 1. Schematic of conventional and new chemical reaction systems

4. Conclusions - The possibility of innovative chemical reaction system using external stimuli responsive capsule is revealed.

5. References

[1] A. Stankiewicz, J. A. Moulijin, *Chem. Eng. Prog.*, **96**, (2000) p. 22