Separation of Ethanol from Culture Broth by Pervaporation with Hydrophobic Porous Membrane *

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Separation of ethanol-water mixture from alcoholic fermentation broth in which yeast is suspending is carried out by pervaporation, using hydrophobic microporous hollow fiber membrane of polypropylene. Results show that this membrane has a selective permeation ability of ethanol and has a potential to be applied as a new fermentation system.

Key words: Pervaporation, Alcohol fermentation, Hydrophobic membrane

In a conventional alcoholic fermentation process a major constraint is inhibition by ethanol produced and end-product. In order to maintain an ethanol productivity at the optimal level, these inhibitions should be removed continuously from culture broth. Medium containing ethanol is separated by centrifuge\(^1\), sedimentation\(^2\) or membrane\(^3\). These methods, however, require a distillation process after separation. From this point of view a vacuum fermentation system is more effective\(^4\). Recently Kimura et al. have reported a pervaporation of alcohol-water mixture with silicone rubber membrane\(^5\). This method will be more practical from the point of energy-saving.

In this paper a combined system of alcohol fermentor and hydrophobic microporous membrane separator which permeate alcohol preferentially is reported. Membrane used is microporous hollow fiber of polypropylene, supplied by Mitsubishi Rayon Co. Ltd. The inner diameter of fiber is 200\(\mu\)m, and the wall thickness is 22\(\mu\)m. The bubble point is 12.5\(\text{kg/cm}^2\). The effective membrane area is 0.3m\(^2\).

The schematic diagram of fermentation system is shown in Fig.1. Alcoholic fermentation is carried out by use of commercial packed yeast (Oriental Yeast Co., Ltd.). The medium proposed by Wada et al.\(^6\) is used. Batch or continuous culture with pH-stat (1) at 5.5 is carried out in a 5l fermentor (2) (working volume = 2l) at 30\(^\circ\)C.

![Fig.1 Schematic diagram of fermentation system.](image)

\(1.\) pH controller, \(2.\) Fermentor, \(3.\) Fresh medium reservoir, \(4.\) Peristaltic pump, \(5.\) Liquid level controller, \(6.\) Membrane module, \(7.\) Vacuum pump, \(8.\) Trap 1, \(9.\) Trap 2, \(10.\) Cooler, \(11.\) IN-KOH solution, \(12.\) Manometer.
with gentle agitation. At the continuous culture a fresh medium (3) is supplied by a peristaltic pump (4) controlled by a liquid level controller (5). The culture broth is fed to a membrane module (6) at feed rate of 200ml/min and flows outside fibers. The temperature of broth at the module is 30°C. The downstream pressure is kept at 4mmHg by a vacuum pump (7). Permeate is trapped at trap 1 (8) (at room temp.) and trap 2 (9) (at -20°C). The concentration of ethanol and glucose in culture broth or trapped permeate are analyzed by a high performance liquid chromatography (column: SCR-101N, Shimadzu Corp.).

The results obtained at continuous culture are shown in Fig. 2. Sampling of permeate as well as continuous cultivation is started after batch cultivation of 13hrs. The amount of permeate trapped at trap 1 is very small compared with that at trap 2. The liquid chromatograms of culture broth and permeates at trap 1 and 2 are shown in Fig. 3. Fig. 2 and 3 give the following results: (1) The ethanol concentration of permeate at trap 2 is more than three times higher as that of feed broth, (2) The permeation rate is almost constant during the time of this experiment, (3) The composition of permeate at trap 1 is similar to that of culture broth and (4) The permeate at trap 2 contains only ethanol and water.

The ethanol concentration of permeate at trap 2 is plotted in Fig. 4 against that of culture broth of various alcohol concentration, together with a vapor-liquid equilibrium curve of ethanol-water mixture at 760mmHg. Although a selectivity of this membrane is a little bit smaller than that of distillation, no degradation of permeability is observed even in direct treatment of culture broth. This result indicates that the microporous hydrophobic membrane has a potential to be applied as a new fermentation system.

References