Possibility of the Use of Hollow Fiber Membrane Contactors for Phenol Biodegradation in Saline Solutions

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Abstract

A microporous polypropylene (PP) hollow fiber membrane contactor was used as a reactor to biodegrade phenol in high-salinity solutions by *Pseudomonas putida* CCRC14365 at 30°C. Suspended cells grew only at a NaCl concentration below 2.5 wt%. On the other hand, cells within hollow fibers completely degraded 0.5 g/L of phenol in solution containing NaCl up to 8.6 wt%, likely due to the fact that the membrane-attached biofilm formed on the fiber surfaces enhanced the tolerance of osmotic effect.

Introduction

Toxic organics that enter industrial effluents create problems in the operation of biological treatment plants; for example, many of the “point source” effluents containing priority organics exhibit high salt levels, which prevent microbial growth [1]. Cells immobilized on hollow fiber membrane contactors have been applied for biodegradation [2,3]. Even when phenol level increased to 3.5 g/L, only 250 h was required for complete removal by *P. putida* ATCC17484 in polysulfone hollow fibers [3]. In this work, phenol was selected as model toxic organics and *Pseudomonas putida* CCRC14365 were used [4]. Experiments were made for degradation of phenol in 0-10 wt% NaCl solution in PP microporous hollow fibers. The initial cell density was fixed at 0.025 g/L and the pH was at 6.8. Experiments by suspended cells were also made.

Materials and Methods

The source of *P. putida* and the compositions of nutrient medium and mineral salt medium have been described [3]. *P. putida* was activated at 30°C in nutrient medium, into which 100-mg/L phenol was added for adaptation for 24 h. As cell optical density (OD) at 600 nm reached 2.6-3.1, an aliquot of the culture was centrifuged at 6,000 rpm and 4°C for 10 min. They were inoculated in a 250-mL conical flask, to which 100 mL of phenol solution was poured to give an initial OD of 0.064 (0.025 g/L). The cells were cultivated at 30°C and 100 rpm, and samples were taken at preset time intervals. Samples were subject to filtration through a Millipore filter (0.2 μm) before phenol analysis by HPLC [4]. The properties of hollow fiber used and experimental setup were described earlier [3]. After activated cells were inoculated in culture medium to a level of 0.025 g/L, they were pumped through the shell of the module at 2.0 mL/min. Phenol solution was pumped through the lumen at 2.4 mL/min. Two solutions were totally recycled to each external flask. The temperature was controlled at 30°C.

Results and Discussion

Fig. 1 shows the degradation of 0.1-g/L phenol in the presence of various NaCl levels. To discuss the effect of salt levels, the time required for complete degradation of phenol (t_{100}) is compared. The values of t_{100} are 5 h, 7 h, and 16 h when phenol solution contains 0, 1 and 2

wt% NaCl, respectively. Beyond 4 wt%, biomass cannot growth due to the osmotic effect. The threshold NaCl level is 2.5 wt% estimated by extrapolating specific degradation rate to zero.

Figs. 2~4 show cell growth and phenol degradation in hollow fibers. It is seen that 0.5-g/L phenol is completely degraded when NaCl level is up to 7.5 wt%. The values of t_{100} are 28 h, 50 h, and 60 h when phenol solution contains 0 (not shown), 5, and 7.5 wt% NaCl, respectively. However, at a NaCl level of 10 wt%, ells cannot grow. The threshold NaCl level is estimated to be 8.6 wt%. The tolerance of biomass to salt level in hollow fibers (8.6 wt%) is 3-4 times greater than that in suspended systems (2.5 wt%). Membrane contactors provide a possibility for treatment of phenol in more concentrated salt solutions. Although the ethanol-wetted hydrophobic hollow fibers cannot prevent the movement of toxic organics and ionic species through fiber pores, the membrane-attached biofilm could enhance the toxicity tolerance limit.

References

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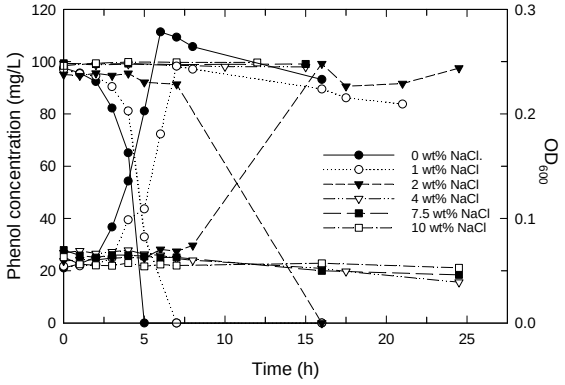

Fig. 1. Effect of added NaCl level on cell growth and degradation of phenol by suspended cells (pH 6.8)

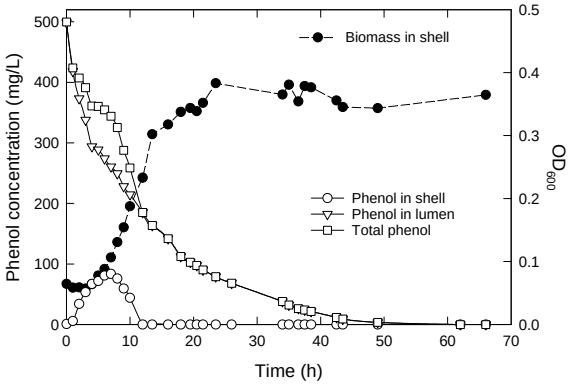

Fig. 2. Cell growth and phenol degradation in hollow fibers in the presence of 5 wt% NaCl in the lumen

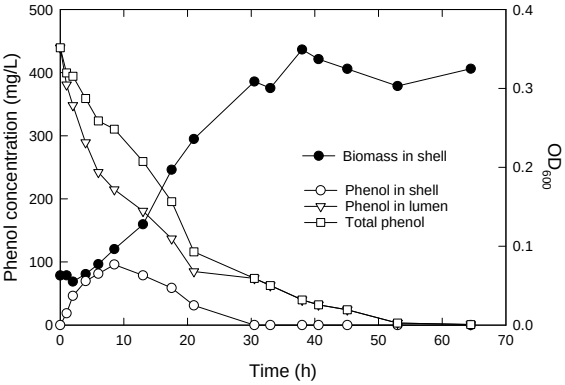

Fig. 3. Cell growth and phenol degradation in hollow fibers in the presence of 7.5 wt% NaCl in the lumen

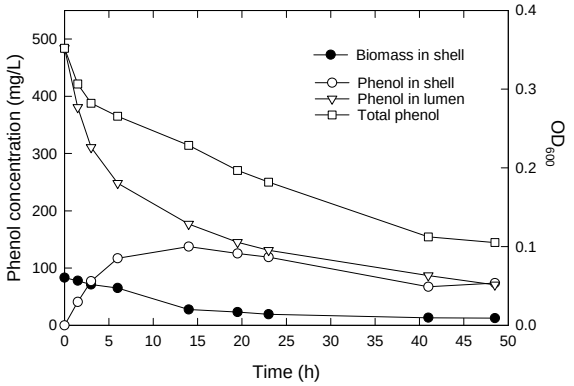

Fig. 4. Cell growth and phenol degradation in hollow fibers in the presence of 10 wt% NaCl in the lumen