CADMIUM BIOSORPTION BY *RHIZOPUS OLIGOSPORUS*

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Keywords: *Rhizopus oligosporus*, biosorption, cadmium, immobilised cell.

Introduction

Pollution of the natural environment by heavy metals has become a serious problem in some industrialised countries and in a number of developing countries of Southeast Asia, including Malaysia. The first case of severe metal poisoning was reported in Japan; the "Itai- Itai" disease was caused by chronic cadmium poisoning (Flick et al. 1971). Cadmium is one of the most dangerous heavy metal both to human health and aquatic ecosystems. Cadmium can be released into the environment from various sources, such as in by-products from zinc refining, smoke from coal combustion, waste from electroplating process and mine wastes. In Industrial wastewater, Cadmium ion concentration can approach 200-250 ppm. This value is very high in relation to water-quality standards as the cadmium concentration of wastewater should be reduced to a value of 0.005-0.01 ppm (Crine, 1993). Methods of removal of metals from industrial wastewater included chemical precipitation, solvent extraction, dialysis or electrodialysis, electrolytic extraction, reverse osmosis, evaporative methods, ion- exchange resin, carbon adsorption and dilution. The increasing of heavy metal contamination as well as increasing value of some metals has stimulated a research for new mechanisms for removal and recovery of these metals. Biological methods using the metal- binding capacity of microorganism such as bacteria, fungus, algae and yeast have been reported to remove metals from aqueous solution. In this study the effectiveness of cadmium removal by using *Rhizopus oligosporus* live biomass and its mechanism of removal was determined.

Materials and Methods

The effects of pH, different initial cadmium concentrations, different biomass concentrations and initial cadmium concentration to biomass concentration ratio were investigated. Synthetic solution of deionised water-containing $CdCl_2.H_2O$ metal salt with molecular weight 228.34 g/mol was used in all biosorption experiments. The biosorption experiments were carried out in batches using 250 mL shake flasks. Known amounts of cells were added to 100 mL cadmium solution. Flasks were agitated in an orbital shaker at 200 rpm, and maintained at 30°C for 24 hours to allow each metal/ biomass system to reach equilibrium. At equilibrium, the cells were separated from solution by centrifugation at 6000 g for 10 min. The concentration of cadmium in cells-free supernatant was determined using atomic absorption spectrophotometer. Biosorption experiments were also carried out using I L stirred tank bioreactor with a working volume of 500 mL cadmium solution, equipped with a six-bladed Rushton turbine. In all experiments, biomass concentration was 1 g/L and cadmium concentration was 100 mg/L. The bioreactor was agitated at 200 rpm and the temperature within the bioreactor was controlled at 30°C. A down flow packed-bed system was also used to perform biosorption experiments in a column operation. The biomass/ biosorbent was packed into a glass column (31 cm x 10.4 mm) with a fixed bed height of 22 cm. Cadmium solution was fed from top of the column. The feeding rate of the column solution was controlled using a peristaltic pump fitted with a Teflon tubing (0.5 mm). Fraction/ effluents were collected periodically by fraction collector at every interval of 1 determined. The influent concentration was monitored at every 10 h interval.

Results and Discussion

The biosorption of Cd^{2+} was determined using several sorption isotherm models such as Langmuir and Scatchard plots. The Langmuir sorption model was found sufficient to describe the biosorption of cadmium by both immobilised and free cells, suggesting that the process was chemical, saturable and equilibrated mechanism similar to ion-exchange mechanism of metals adsorption. A curve of Scatchard transformation plot reflected the covalent nature of Cd^{2+} adsorption by live cells of *Rhizopus oligosporus*. Maximum uptake capacity for immobilised cell was about 2 fold higher (34.25 mg/g) than free cells. The immobilised cells projected a higher cadmium capacity with increasing biomass concentrations compared to free cells, which reached optimum at 0.5 g/L. The initial cadmium concentration to biomass concentration ratio for immobilised cells was lower (33.3 mg/g) compared to free cells (200 mg/g) reflecting that effective removal of Cd^{2+} can be obtained with increasing immobilised biomass concentration. In bioreactor, the cadmium uptake capacity with shake flask experiments for immobilised cells was not affected as observed for free cells. In fixed bed-column, packed-bed with immobilised cells permitted better process control with 2.5 folds higher (0.18 Lh^{-1}) influent-feeding rate achieved compared to packed-bed with free cells. About 99 per cent cadmium removal was achieved for influent containing 5 mg/L and 20 mg/L of cadmium indicating strong affinity of free and immobilised live cells of *Rhizopus oligosporus* towards Cd^{2+}.

Conclusions

As an overall conclusion, the live biomass of *Rhizomes oligosporus* was found to have excellent Cd^{2+} uptake properties. The maximum Cd^{2+} uptake capacity for immobilised live cells was about 2 fold higher than for free live cells. The Cd^{2+} uptake capacity was predominantly ion-exchange mechanism of metals adsorption.

References

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Supported by IRPA Grant 08-02-04-0010