809 **Conversion of raw cassava starch to ethanol in a novel circulating aerobic-anaerobic loop bioreactor with cells immobilized in loofa (*Luffa cylindrica*) sponge**

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**[Introduction]** Commercial production of ethanol from abundant biomass materials requires development of cheap and efficient production systems. In this study, development of a bioreactor with cells immobilized in loofa (*Luffa cylindrica*) sponge for conversion of raw cassava starch to ethanol was investigated.

**[Methodology and Results]** A circulating loop bioreactor (CLB) with cells immobilized in loofa sponge was constructed for simultaneous saccharification and fermentation of raw cassava starch. The CLB has a total working volume of 9L and consists of an aerated riser and a non-aerated downcommer columns, which are connected at the top and bottom by cylindrical pipes. By aerating the riser column, the liquid broth circulates between the two columns through the connecting pipes. The immobilized *Aspergillus sp.* and *Saccharomyces cerevisiae* IR2 were placed in the aerated riser and the non-aerated downcommer columns, respectively. The effects of aeration rate on enzyme and ethanol productivities were investigated. Amylase enzyme production rate increased as the aeration rate was increased, but the ethanol yield and productivity decreased. The highest ethanol productivity was obtained at an aeration rate of 0.5vvm. The CLB was operated for more than 360 hours and the average ethanol productivity and yield from raw cassava starch were 0.56 g-ethanol/h and 0.45g-ethanol/g-starch, respectively. The ethanol productivity can be increased by increasing the DO concentration in the riser and decreasing the DO in the downcommer. To achieve this, it is necessary to uncouple aeration rate with liquid circulation rate. Thus, the upper connecting pipe was equipped with a valve, which can be programmed to open and close at desired time intervals. Optimization of enzyme and ethanol productivities in this modified CLB is now under investigation.

**Keywords:** ethanol, raw cassava starch,circulating loop bioreactor, loofa sponge, immobilization

810 **Outdoor cultivation of *Chlorella sorokiniana* in a novel tubular photobioreactor with internal static mixers**

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**【Introduction】** Productivities in tubular photobioreactors have been limited by poor mass transfer characteristics. In order to solve this problem, a tubular photobioreactor with internal static mixers was developed for increased mass transfer efficiency [1]. In this study, outdoor cultivation of *Chlorella sorokiniana* was investigated in the novel tubular photobioreactor. Scale up of the photobioreactor was also studied.

**【Methodology and Results】** The effects of standing biomass concentration on outdoor biomass productivity by *Chlorella sorokiniana* was investigated. The cultures were diluted every morning with fresh medium in order to maintain the desired standing biomass concentration. The biomass productivities in the novel photobioreactor with static mixers varied from 0.55 g/L.d to 1.47 g/L.d depending on the solar light intensity and the standing biomass concentration. Under all the conditions investigated, biomass productivities were higher in the novel tubular photobioreactors when compared to the values obtained in the tubular phtobioreactors without static mixers. The average increase in the productivity due to installation of the static mixers varied from 27% to 46% depending on the standing biomass concentration.

The possibility of scaling up the photobioreactor was investigated by either increasing the length or diameter of the tube. The scale up done by increasing the tube diameter from 3.8 cm (6 L) to 7.5 cm (19 L) resulted in better mass transfer characteristics when compared to the one done by increasing the length of the tube from 4 m (6 L) to 20 m (24 L). Thus, an outdoor cultivation was done in the 7.5-cm diameter photobioreactor. There was no significant difference in the volumetric productivities between the photobioreactor with 3.8 cm and 7.5 cm diameter tubes but the area productivity was about 60% higher in the photobioreactor with large diameter tubes.

1) C. U. Ugwu et al: Abstract for Ann. Conf. Soc. Biosc. Bioeng. Japan, Hokkaido pp. 286 (2000)

**【KEY WORDS】** tubular photobioreactor, flashing light effect, mass transfer, static mixers,