Hydrogen production in photobioreactor using spent medium of dark fermentation process

Abstract

There is a need of alternate energy sources mainly due to rapid depletion of fossil energy sources. Hydrogen is widely recognized as a clean and efficient energy resource of the future. The biological hydrogen production processes are usually operated at ambient temperature and atmospheric pressure. The maximum theoretical hydrogen yield is 4 mol H_2/mol glucose when glucose is completely metabolized to acetate in the anaerobic dark fermentative process. The acetic acid produced from the dark fermentative process can be utilized by the photosynthetic bacteria for hydrogen production. So, the two stage hybrid process: dark fermentation followed by photofermentation can increase the hydrogen yield up to 12 moles per mole of glucose. The present dissertation was an endeavour towards enhancement of H_2 production from *Rhodobacter sphaeroides* OU001 in an integrated approach over biochemical reaction, fluid dynamics and light utilization. The most suitable physicochemical parameters like pH, temperature, inoculum age, initial substrates concentration were determined by single parameter optimization technique. The most suitable initial concentration of acetate, butyrate and ethanol were found to be 1.25, 1.1 & 0.57 g/L respectively by multiple parameter optimization. The spent medium was utilized for photo fermentation and the overall yield of 6.1 mol H_2/mol glucose was obtained in the combined process. Different types of photo bioreactors, including a flat panel rocking reactor, were developed and studied under similar conditions. The maximum light conversion efficiency of 5.3% was observed in case of batch annular PBR. This reactor was used for continuous photo fermentation of spent medium and synthetic medium. The rate of H_2 production was maximum at a dilution rate of 0.066 h^{-1}. Continuous hydrogen production process with CSTR in series was established and the study suggests that a particular ratio of the reactor volumes can maximize the hydrogen productivity. Pigments produced during photo fermentation may play an important role for H_2 generation.The pigmentation pattern of cells in TLC revealed that the pigments with R_f 0.5, 0.56 and 0.81 were dominant during maximum rate of hydrogen production. The pigments were further characterized by GC/MS and MALDI-ToF. The kinetic parameters determined for hydrogen production can be useful for the scaling up of the process.

Keywords: *Rhodobacter sphaeroides* OU001; biohydrogen production; photobioreactor; spent medium; pigments.