Abstract
This work aimed at developing an efficient stirred tank photobioreactor for the large scale cultivation of photosynthetic cells. A quantitative method of evaluating light conditions inside photobioreactors was first investigated and a light supply coefficient, which is a product of a light distribution coefficient and light energy supplied per unit volume, was proposed as an engineering parameter for design and scale-up of photobioreactors. Using this parameter, a method of designing and scaling-up internally illuminated photobioreactors was proposed. A photobioreactor was considered as consisting of units, and an optimum and an optimum unit size was defined as a reactor volume that is optimally illuminated by a centrally located single light source. A large scale photobioreactor with the optimally light coefficient can thus be constructed by determining the optimum unit size for the target process and then increasing the number of units in three dimensions. Based on this concept, an optimum unit was constructed and then scaled up to 20.0 L while maintaining a constant light supply coefficient. With a 20 W fluorescent lamp, the unit size (diameter) that gave the optimum light-supply coefficient for the cultivation of Chlorella was 0.075 m Carbon dioxide fixation by Chlorella pyrenoidosa and α-tocophrrol production by Euglena gracilis cells in the 20.0-L photobioreactor were the same as those of the single unit.