Abstract
A new concept in photobioreactor design with reactor scale-up as a primary design criterion is proposed for the development of large-scale stirred tank photobioreactors. A photobioreactor is considered as consisting of units, with each unit being composed of a light source (or light distributing object) and its surroundings. The light supply coefficient of each unit depends on its size and the light intensity of the light source. At a given light intensity, the optimum unit size which gives the desired light supply coefficient for the target process is experimentally determined. A large photobioreactor with a desired light supply coefficient is obtained by increasing the number of units. A prototype photobioreactor, consisting of 4 units, was constructed for the cultivation of Chlorella pyrenoidosa. Each unit was equipped with a centrally fixed glass tube into which the light source was inserted. The illuminating system consisted of either 4-W fluorescent or halogen lamps with controllable light intensity. By changing the light intensity, it is possible to use the photobioreactor for the cultivation of various cells with different optima light supply coefficients. Mixing was achieved by means of an impeller, designed in such a way that while rotating it does not touch the glass tubes, which also serve as baffle plates. Although the hydrodynamic stress generated by the impeller was low, a high degree of mixing was achieved even at low rotation speeds. Since the light distributing objects were not mechanically fixed to the reactor, and were separated from the broth by the glass tubes, the reactor could be sterilized by autoclaving and the light distributing objects inserted to the glass tubes after cooling. The photobioreactor was equipped with a ring sparger for aeration. When C. pyrenoidosa was cultivated in the new photobioreactor at low and moderately high light supply coefficients, both the linear growth rates and the final cell concentrations increased linearly with the light supply coefficient of the reactor. A comparison of the results obtained in this new photobioreactor with those of the commercially available photobioreactors with either external or internal illumination showed that the cell yield from the supplied light energy was highest in the new photobioreactor.