Abstract
The aim of this study was to construct a novel photobioreactor with improved mixing and light supply efficiencies. A 4-L flat panel airlift photobioreactor with inclined broth circulation guide installed in the downcomer column was constructed. The circulation time (θc) and mixing time (θm) were determined, using the solid flow follower technique and dye method, respectively. The circulation fluid was either tap water or 0.2% potato starch solution. The effects of nature and angles of inclination of the circulation guides and the liquid heights above the circulation guides on the mixing efficiencies of the photobioreactor were studied. A decrease in the angle of inclination and increase in liquid heights resulted in decreased θc and θm in tap water or 0.2% potato starch solution. At 45° angle of inclination and liquid height of 0.02 m, the shortest θc (2.67 s), θm (10.0 s) in tap water, and θc (3.3 s) in 0.2% starch solution were achieved. The photobioreactor was evaluated by cultivation of high lipid-producing Desmodesmus subspicatus LC172266 isolated from Maiduguri, Nigeria. The installation of broth circulation guides (transparent, opaque, or reflective guides) improved the productivity of D. subspicatus, though significant ($P < 0.05$) only in the case of reflective guide. The lipid productivities (g L^{-1} day^{-1}) of D. subspicatus in the photobioreactor equipped with inclined circulation guides were 0.052, 0.0215, 0.020, and 0.016 for reflective, opaque, transparent, and control (none) circulation guides, respectively. Under a mixotrophic condition using a reflective circulation guide and glucose as the carbon source, the lipid productivity was 0.217 g L^{-1} day^{-1} while the value obtained with glycerol was 0.122 g L^{-1} day^{-1}. The lipid productivity by D. subspicatus in the photobioreactor with a reflective broth guide was 94% (0.217 g L^{-1} day^{-1}), higher than the value obtained in batch (flask) cultivation (0.112 g L^{-1} day^{-1}) with glucose concentration of 10.0 g L^{-1} and 46% (0.122 g L^{-1} day^{-1}) higher than the value obtained in batch flask cultivation (0.086 g L^{-1} day^{-1}) with glycerol concentration of 5.0 g L^{-1} under a mixotrophic condition.