Development of Photochemical Organic Synthesis Using Carbonate in Sea Water

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Summary

Carbon dioxide fixation is a potential technology for the realization of photocatalytic CO_2 reduction. Many studies on CO_2 fixation have investigated photocatalysis on semiconductors such as titanium dioxide, silicone carbide and strontium titanate. However, these systems used ultraviolet irradiation, whereas a CO_2 fixation system using visible light is more desirable. In contrast, biological CO_2 fixation systems have also received much attention. For example, CO_2 or HCO_3^- can be reduced to formic acid with formate dehydrogenase (FDH) and NADH. Therefore, a CO_2 fixation system that combines the photoreduction of NAD^+ with photosensitizer and ferredoxin-$NADP^+$ reductase, and HCO_3^- reduction with FDH can be established.

In this work, photochemical synthesis of malic acid was investigated from pyruvic acid and HCO_3^- (in sea water) with malic enzyme (ME) and $NADP^+$ photoreduction by the visible light photosensitization of zinc chlorin-e_6 (Zn Chl-e_6) in the presence of NADH as an electron-donating reagent. Irradiation of a solution containing NADH, Zn Chl-e_6, methylviologen (MV^{2+}), pyruvic acid, $NaHCO_3$, $NADP^+$, ferredoxine-NADP-reductase (FNR) and ME with visible light resulted in malic acid synthesis. The produced malic acid was 0.65 mmol dm^{-3} after 3 h irradiation. Moreover, produced the malic acid was up to 2.10 mmol dm^{-3} after 3 h irradiation under 0.01 m mmol dm^{-3} $NADP^+$ condition, and the conversion ratio of pyruvic acid to malic acid was about 20.0 %.