TiO_2 photocatalysis for water treatment

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TiO_2 photocatalysis is becoming an increasingly interesting oxidation process for the air cleaning as well as water treatment. The advantage of photocatalysis in water purification is the complete mineralization of organics caused by the photogeneration of •OH radicals originating from water via the OH groups of the TiO_2 surface. There are several reports on photocatalytic water treatment using TiO_2 photocatalysts (1,2). However, not much attention was paid for the photocatalytic treatment of pollutants referred to as endocrine disruptors (EDs), which are known to be associated with abnormal sexual development and abnormal feminizing responses of animals. We have been interested in photocatalytic degradation of EDs such as bisphenol A (BPA) and 17β-estradiol (E2). These EDCs can cause abnormal growth of wildlife (3,4). According to the Ministry of Construction of Japan, these EDCs are not removed completely by conventional treatment and an average of 24% of the E2 originally contained in the raw sewage remains after treatment and is released to the environment. Photocatalysis appears to be a promising approach to treat such chemicals.

We have recently demonstrated the photocatalytic degradation of EDs under UV irradiated TiO_2 suspensions. For example, an initial BPA concentration of 175 μM in water was totally degraded to carbon dioxide by TiO_2 photocatalyzed reactions under UV irradiation of 10 $mWcm^{-2}$ (5). In case of 17β estradiol (E2), 99% of it could be degraded after 30 min of UV irradiation (Fig. 1) (6).

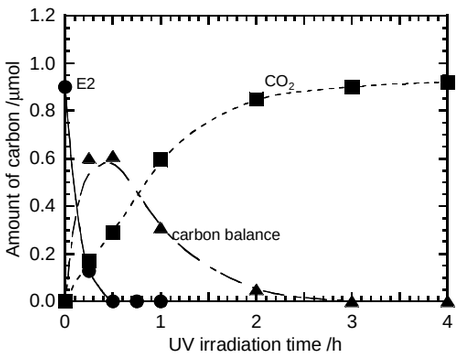

Figure 1. Changes of the mass balance of carbon atom during photocatalytic degradation of E2 in a stirred TiO_2 suspension under UV intensity of 6 mW cm^{-2}.

Although photocatalytic water treatment is promising, a disadvantage with regard to it is the lower quantum efficiencies in comparison to gas-phase photocatalysis. The principle reason for this is the smaller availability of oxygen in liquid water and lower mass transport of target chemicals in comparison to air.

We have developed new immobilized TiO_2 system to improve the effective surface area of TiO_2 as well as the mass transport. We used PTFE mesh sheets as supports for immobilizing the TiO_2, because the PTFE has long-term stability against photocatalytic oxidation. The mesh sheets were attached to a single bar-rotator to facilitate the rotation in the solution. E2 and BPA in aqueous solutions were decomposed quickly under relatively weak UV illumination, while the rate of decomposition being higher with the rotation of the TiO_2-PTFE sheets. The apparent mass transfer rate of the EDCs to the TiO_2 under rotation was 4.5 times higher than that under static conditions. Improvement and optimization of the reactor is now in progress.

References

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