Advanced oxidation process for water purification using deep-ultraviolet light and TiO_2 nano composite electrode

*Akihiro Okazaki[1], Haruo Kuriyama[1], Izumi Serizawa[1] ,Aiga Hara[2] , Yuiri Hirano[2], Yukihiro Nakabayashi[2], Nitish Roy[2], Norihiro Suzuki[2], Chiaki Terashima[2], Kazuya Nakata[2], Ken-ichi Katumata[2], Akira Fujishima[2].

[1] ORC Manufacturing, 4896, Tamagawa, Chino, Nagano, Japan, [2] Tokyo University of Science, 2641, Yamasaki , Noda,Chiba, Japan.

*a-okazaki@orc.co.jp

Keywords: MRM, SDGs, Innovation, water purification,photocatalyst,boron-doped diamond,deep UV(222 nm) light,electrochemical.

Introduction

Ozone has a strong oxidizing power (oxidation reduction potential : 2.07 eV). Therefore, it is effective in sterilization, disinfection and deodorization. Ozone attracts attention as an eco-friendly water processing technology. However, the oxidizing power of ozone is insufficient for the decomposition of persistent organic substances. Therefore, in this study, we focused on the advanced oxidation process to produce a hydroxy radical (oxidation-reduction potential : 2.85 eV), which has a stronger oxidation power, by decomposing ozone and hydrogen peroxide (oxidation-reduction potential 1.77 eV) effectively. We used boron-doped diamond (BDD) as an electrode to generate ozone. Also, the titanium oxide was added on the BDD electrode and used as a photocatalyst. We aim at achieving the high-speed, low-cost and eco-friendly water purification by using the fast oxidation of ozone formed from the BDD electrode and the strong oxidation derived from photocatalyst simultaneously.

Experiment

We fabricated a mesoporous TiO_2 thin film on a boron-doped diamond (BDD) layer by a surfactant-assisted sol-gel method[1)], in which self-assembled amphiphilic surfactant micelles were used as an organic template. Scanning electron microscopy revealed uniform mesopores, approximately 20 nm in diameter, that were hexagonally packed in the TiO_2 thin film. Wide-angle X-ray diffraction and Raman spectroscopy clarified that the framework was crystallized in the anatase phase. In addition, Current–voltage (I–V) measurements showed rectification features at the TiO_2/BDD hetero junction, confirming that a p–n hetero-interface was formed. Water purification ability, was evaluated from the decomposition of a residual pharmaceutical products (sulfamethoxazole (SMX)), which adversely affects a real aquatic environment. 1.2 mW/cm^2 of 222 nm UV light was irradiated on the photocatalyst (TiO_2/BDD), while applying constant current to BDD electrode. We examined the SMX concentration over time by high performance liquid chromatography (HPLC) measurement.

Results and Discussions

Figure 1. shows the SMX decomposition by photocatalytic effect and electrochemical effect (red line). As references, result of photocatalytic effect (purple line), electrochemical effect (blue line) and photolysis (pink line) are also included. When electrochemical effect and photocatalytic effect were used in combination, the decomposition of SMX was enhanced. Also, the decomposition of the by-product generated by the decomposition of SMX was also improved these results clarified the combination of electrolytic effect, photocatalyst, and ultraviolet light promotes the decomposition of not only SMX but also by-products.

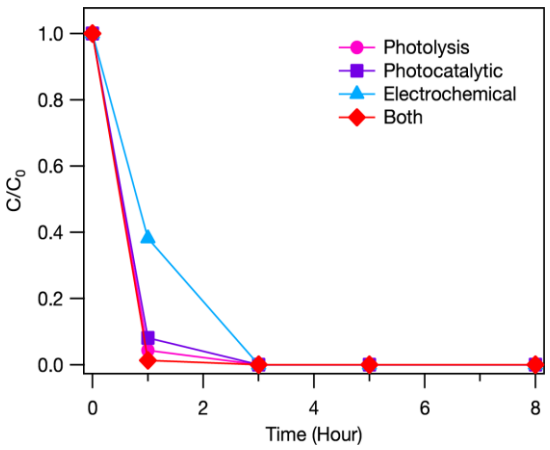

Fig. 1. SMX decomposition by photocatalytic effect (purple line), electrochemical effect (blue line), photolysis (pink line) and both (red line).

References

1) X. Jiang, X. Suzuki *et al.*, *Eur. J. Inorg. Chem.*, 2013, 3286 (2013); (b) N. Suzuki *et al.*, *Chem. Lett.*, 44, 656 (2015)