Kinetic Model of Disinfection Using Novel Chitosan-N-Doped TiO_2 Photocatalyst Derived from Fishery Waste

Li-Ting Yen[1,4], Chih-Huang Weng[2], Ying-Chen Chen[1], Jing-Hua Tzeng[1,3], Yao-Tung Lin[1,*]

[1]Department of Soil and Environmental Sciences, National Chung Hsing University, Taichung, Taiwan

[2] Department of Civil and Ecological Engineering, I-Shou University, Kaohsiung, Taiwan

[3]Department of Civil and Environmental Engineering, University of Delaware, DE, U.S.A.

[4]Department of Plants, Soils and Climate, Utah State University, UT, U.S.A

Disinfection applications of titanium dioxide (TiO_2) have been widely explored. However, most TiO_2 materials are restricted to the presence of UV-light only. Nitrogen-doped TiO_2 (N-TiO_2) synthesized by our research group show high disinfection performance under visible light. According to our previous results, N-TiO_2 damages the external cell wall/membrane, degrades the cellular membrane and releases the essential intracellular component, leading to the death of bacteria. Chitosan (CTS) is a natural polymer found in insect exoskeletons, crustacean shells, and fungal cell walls, which is the second most abundant polysaccharide after cellulose. CTS has a wide range of applications and beneficial properties, including antifungal and antibacterial. Most of the literature measured the removal rate of pollutants via CTS or CS-TiO_2 or adopted the simple agar- well diffusion technique to determine the disinfection performance. The aforementioned studies rarely discuss the impacts on the microorganism reacting with CTS-TiO_2 under visible light and with the absence of the light source. Furthermore, there is little literature investigating the kinetic model of disinfection performance using CTS and CTS-N-TiO_2. In this study, we assume that incorporating shrimp-shells-CTS onto the surface of N-TiO_2 will enhance photo-disinfection capacity and show the disinfection effect in the dark. The CTS-N-TiO_2 photocatalyst has been synthesized and the photo-disinfection kinetic model experiments carry out under various key parameters, i.e., bacteria species (Gram-positive bacteria, *S. aureus* and Gram-negative bacteria, *E. coli*), visible light intensity, dosage, and initial bacteria concentration. The photo-disinfection mechanism of bacteria was investigated via SEM for the morphology of bacterial cells in the photo-disinfection process. Disinfection experimental results show that CTS exhibited 99.9% of *E. coli* and *S. aureus* within 2 h. The novel CTS-N-TiO_2 photocatalyst is equipped with excellent disinfection activity against both *S. aureus* and *E. coli* under visible light and also in the dark. The two kinetic models (one for CTS and the other one for CTS-N-TiO_2), containing k_1, k_2 and k_3 constants, can describe the different disinfection stages. The model was adopted to fit the disinfection results using both CTS and CTS-N-TiO_2. CTS-N-TiO_2 is advantageous for abating the problem of abundance fishery waste and the kinetic model results of CTS and CTS-N-TiO_2 are benefiting for the further application.