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Atomic Force Microscopy Studies on Visible-Light Photocatalytic Disinfection of Water and Its Mechanism

Jing-Hua Tzeng, Gaybullaev Gulomjon
Department of Soil & Environmental Sciences/National Chung Hsing University
250, Kuo Kuang Rd., South District, Taichung city, Taiwan
hua7526@smail.nchu.edu.tw; ggulomjon@gmail.com

Chih-Huang Weng
Department of Civil and Ecological Engineering, I-Shou University
Kaohsiung City 84008, Taiwan
chweng@isu.edu.tw

Yao-Tung Lin
Department of Soil & Environmental Sciences/National Chung Hsing University
250, Kuo Kuang Rd., South District, Taichung city, Taiwan
yaotung@nchu.edu.tw

Extended Abstract

Most of the conventional disinfection methods, such as chlorination, ozonation, and ultraviolet irradiation, have limitations including the production of unintentional toxic by-products, energy and labor intensive, and pathogens recalcitrant. Therefore, great effort has recently been exerted to develop the green disinfection technologies that are inexpensive, safe, and effective. Compared to these widely used disinfectants, applications of photocatalyst-based antimicrobial disinfectant technologies are still in the developmental stage. Titanium dioxide (TiO2) has been shown to eliminate organic compounds and to function as disinfectants and considered as a promising alternative disinfection technology. Upon UV light excitation, the pairs of electrons and holes that diffuse and become trapped on or near the TiO2 surface. These excited electrons and holes have strong reducing and oxidizing activities and react with water and oxygen to yield active oxygen species. Complete oxidation of organic compounds and microorganism cells to carbon dioxide could be achieved. However, most of photocatalytic inactivation is significantly efficient in a presence of UV-light only. Recently, different metals (Ag, Fe, Cu) and nonmetal elements (C, N, S) have been successfully doped onto TiO2, which work by irradiation with visible light, offering the potential applications of TiO2 substrates for use in our living environments.

Most studies mainly focus on disinfection performance under UV/ Visible light irradiation; the inactivation mechanism of the bacteria has seldom been investigated. In the past decades, much progress has been made in understanding the mechanical and more generally the physicochemical properties of microorganisms. However, due to the tiny size of the cells, these properties remain difficult to address at a nanometric level. Conventional electron microscopy (EM) including scanning electron microscopy (SEM) and transmission electron microscopy (TEM) have long been the only tool available for the direct observation of bacterial; however, EM preparation techniques focus on the preservation of the (ultra-) structure of the sample when the sample is exposed to scan in vacuum or for a conductive coating. However, the structure of microorganism will be twisted when it store in the vacuum environment.

Atomic force microscopy (AFM) is a highly versatile microscopy technique that is particularly well suited to the study of microorganisms, because it combines a greatly improved resolution when compared to optical microscopy with little or no sample preparation required. The major advantage of AFM is capable of analyzing samples in their natural, hydrated state. AFM allows measurements of surface

nanostructure in aqueous media of controlled composition, which makes it ideal for analyzing cell wall response during photo-disinfection. AFM provides the opportunity to image single bacterial cells; it can also be used to image several cells where aggregates of microorganisms adhere to each other on a surface. AFM is not only an imaging technology. It is also a highly sensitive force machine, able to measure forces as small as 10 to 20 pN, which give measures and properties of the living material. Nanomechanical properties and nano-adhesive properties of the microorganism can be measured using the AFM as a force machine.

In the present work, nitrogen-doped TiO2 (N-TiO2) have been carried out to determine the major reaction parameters (photocatalyst loadings, light intensity and initial bacteria concentration) and improve our understanding of the disinfection mechanism responsible for the inactivation of the microorganism the influence of photocatalyst loadings, initial bacteria concentration, and light intensity on microbial inactivation has been reported. N-TiO2 at a loading range of 0.2–1.2 g L−1 has carried out to apply under visible light with initial Escherichia coli (E. coli, Gram-negative bacterial) and Staphylococcus aureus (S. aureus, Gram-positive bacterial) concentration range from 104 to 107 CFU/ mL.