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Photo Augmented Copper-based Fenton Disinfection under Visible LED Light and Natural Sunlight Irradiation

Dr. Gokulakrishnan Subramanian[1,2], Halan Prakash[1]
1. Department of Chemistry, Birla Institute of Technology and Science, Pilani, K K Birla Goa Campus, NH17B, Zuarinagar, Goa 403726, India
2. Department of Chemistry, Presidency University, Bangalore 560064, India

Abstract

Copper-based Fenton disinfection system (Cu(II)/H_2O_2) is an emerging advanced oxidation process (AOP). Previous works have used reducing agents and organic ligands to improve the disinfection efficiency of Cu(II)/H_2O_2 system. Here, we report visible light/Cu(II)/H_2O_2 system showed enhanced disinfection compared to Cu(II)/H_2O_2 system, without the need of reducing chemical agent or organic ligand. Energy-efficient LED array was used as a visible light source in the visible light/Cu(II)/H_2O_2 system. Under the optimized condition, pseudo-first-order inactivation rate constant (k_{obs}) of *E. coli* by visible light/Cu(II)/H_2O_2 (0.613 ± 0.005 min^{-1}) was about ~8 times greater than Cu(II)/H_2O_2 (0.08 ± 0.011 min^{-1}). Scanning electron microscopy and Baclight Live/Dead assay proved enhanced cell membrane damage by visible light/Cu (II)/H_2O_2 in comparison with Cu (II)/H_2O_2. Based on the bovine serum albumin (BSA) degradation and $OH^{\cdot}$ radical measurement by visible light/Cu (II)/H_2O_2, a ligand to metal charge transfer (LMCT) mechanism by Cu(II)–bacterial complex is proposed for enhanced disinfection. Electrical energy efficiency ($E_{E,1}$) for a log reduction of *E. coli* and the total treatment cost of visible light/Cu(II)/H_2O_2 was determined to be 32.64 KWh/m^3 and 350 ₹/m^3 (3.9 €/m^3 or 4.74 $/$m^3$), respectively, indicating its cost-effectiveness. Disinfection efficiency by sunlight/Cu(II)/H_2O_2 system (solar irradiance; 746 ± 138 W/m^2) was almost comparable to LED-based visible light/Cu(II)/H_2O_2 system, with total treatment cost estimated to be 80 ₹/m^3 (0.9 €/m^3 or 1.1 $/$m^3$).

Keywords:

Disinfection, LED, Fenton, Bacteria, Advanced Oxidation Processes

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