Multicomponent transition-metal alloys and oxides with photocatalytic and antibacterial properties

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Multicomponent transition-metal materials, including alloys and their derived oxides, represent a promising platform for the development of multifunctional systems with tunable photocatalytic and antibacterial properties. These materials address two pressing global challenges: the persistence of organic pollutants in aquatic environments and the increasing prevalence of antimicrobial resistance.

In this work, we investigated Fe- and Ti- based multicomponent transition-metal systems synthesized in both thin film and powder forms using complementary approaches, including magnetron sputtering, electrochemical anodization, and wet-chemical methods. Nanostructured oxide thin films were prepared via anodization of alloy thin film on FTO substrate, enabling controlled morphology, high surface area, and enhanced charge transport properties. Structural and morphological characterization was performed using X-ray diffraction (XRD), and Scanning electron microscopy (SEM) coupled with Energy dispersive X-ray spectroscopy (EDS).

Photocatalytic performance was evaluated through the degradation of Imidacloprid (neonicotinoid insecticide) under UV–visible irradiation, demonstrating that different surface morphology influences reaction kinetics and photocatalytic efficiency. In parallel, antibacterial activity of multicomponent oxides in powder and thin film form was investigated using representative gram-positive (Bacillus subtilis) and gram-negative (Escherichia coli) bacteria. The results indicate that tailored composition and surface chemistry enhance bacterial inhibition through combined effects of reactive oxygen species generation, ion release, and surface interactions.

By correlating synthesis parameters, structure, and functional properties, this study aims to establish design principles for multicomponent transition-metal materials with optimized photocatalytic and antibacterial properties.