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Ag-Cu Modified TiO2 Nanotubes: Semitransparent Electrodes for Efficient Oxygen Evolution

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The pursuit of sustainable energy and environmental solutions has intensified interest in light-driven materials capable of harnessing solar energy for chemical transformations. One particularly relevant application is water splitting, where oxygen evolution plays a critical role in clean fuel production and maintaining oxygen balance in closed artificial environments. Titanium dioxide remains one of the most studied materials in this domain due to its chemical stability, abundance, and strong photocatalytic properties. When structured at the nanoscale - especially as vertically aligned nanotubes - TiO2 exhibits enhanced surface area, light absorption, and charge transport properties, making it especially promising for surface-driven photochemical processes.
In this study, semitransparent TiO2 nanotubes (TNTs) substrates were fabricated and functionalized with bimetallic Ag-Cu nanoparticles. The substrates were prepared by sputtering a titanium layer onto ITO-coated glass, followed by anodization - a cost-effective, scalable method for producing highly ordered TiO2 nanotube arrays. Subsequently, thin layers of copper and silver were sputtered onto the TNTs, and the entire material was thermally treated using rapid thermal annealing in a hydrogen atmosphere to promote nanoparticle formation and surface activation. The samples were thoroughly characterized using scanning electron microscopy to investigate morphology, UV-VIS spectroscopy to assess optical properties, Raman spectroscopy to confirm structural features, and photoelectrochemical measurements to evaluate their photoactivity.
These electrodes demonstrate oxygen generation capabilities, supported by the engineered combination of nanotubular TiO2 and Ag-Cu nanoparticle coatings. Ag-Cu decorated samples exhibited notable electrochemical responses, with current densities reaching up to 3.52 mA/cm2 at an applied potential of +1 V versus Ag|AgCl in 0.1 M KCl, using 0.1 M NaOH as the electrolyte. This current was accompanied by visible bubble formation on the sample surface, indicating active oxygen evolution. In contrast, pure TiO2 nanotubes calcined in hydrogen under the same conditions showed a significantly lower current density of 0.35 mA/cm2.
Overall, the obtained results show that these materials may serve as functional elements in future light-driven technologies, particularly in remote sensing platforms.

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