Multilayered WO3/GQDs/MXene Thin-Film Photoanode for Enhanced Photoelectrochemical Water Splitting for Sustainable Hydrogen Production

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Hydrogen, the first element in the periodic table, is now becoming the first choice for clean and efficient energy production, serving as a promising energy carrier. However, 95% of hydrogen is still produced using fossil-based methods that generate high carbon emissions. Photoelectrochemical (PEC) water splitting using WO3-based photoanode offers a sustainable alternative; however, it suffers from limited light absorption, rapid electron-hole recombination, and poor stability, reducing hydrogen generation efficiency. In this study, WO3 thin film was deposited on FTO substrate using a low-cost, custom-built aerosol-assisted chemical vapor deposition (AACVD) to obtain a uniform, crystalline film, followed by drop-casting of graphene quantum dots (GQDs) and MXene (Ti3C2T?) to form a heterostructured photoanode. Four samples of pure WO3, WO3/GQDs, WO3/MXene, and WO3/GQDs/MXene were fabricated and systematically compared. SEM and EDX confirmed uniform coverage and successful incorporation of GQDs and MXene. UV-Vis showed enhanced visible-light absorption for WO3/GQDs/MXene, while PL indicated suppressed electron-hole recombination. PEC measurements were performed in 1 M KOH under AM 1.5G illumination. LSV revealed that WO3/GQDs/MXene exhibited a maximum photocurrent density of 1.24 mA cm?² at 1.23 V vs. RHE, an 118% increase over pure WO3, with a 130 mV lower onset potential (0.52 V vs. RHE), indicating reduced energy requirements. EIS showed that WO3/GQDs/MXene had the lowest charge-transfer resistance (780 O), a 56.6% reduction compared to pure WO3, indicating improved charge transport. These results demonstrate enhanced photoelectrochemical efficiency, highlighting WO3/GQDs/MXene thin film as a promising photoanode for efficient photo-assisted hydrogen generation.

Awards Won:

Aramco: Second Place Prize Energy: Sustainable Materials &amp Design (EGSD)