

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

Aldosari, Jana (School: Alanoud Bint Abdulaziz Secondary School)

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_x) 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 Ω), 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 & Design (EGSD)