The protection of metals by polysulfides-modified TiO_2-based photoelectrochemical cathodic protection materials in simulated marine environments

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Abstract In recent years, the role of the ocean in national strategic development has become increasingly prominent. However, metal materials that serve in the harsh marine environments are facing extremely serious corrosion problems, which significantly impede the rapid development of marine technology. Unlike traditional cathodic protection technology, the newly photoelectrochemical cathodic protection technology (PECCP)offers a green and environmentally friendly approach to corrosion protection. It harnesses the abundant solar energy present in the ocean to "combat corrosion with light," leveraging the photoelectric conversion effect of semiconductor materials to generate electrons. These electrons are then transferred to marine metals, thereby protecting them from corrosion.Over the past few decades, PECCP has undergone extensive research and development, leading to the creation of various PECCP thin film materials. Here, we summarize some of the recent research progress made by our group in the application of TiO_2-based ordered structured materials for PECCP and offer new perspectives for the corrosion protection of metal materials in the marine atmospheric zone.

This work utilizes a variety of polysulfides ($ZnIn_2S_4$, $AgInSe_2$, In_2Se_3, CdS, etc.) to construct a stepwise channel for photogenerated electron transfer. In conjunction with electron-conducting materials, a series of green and eco-friendly optoelectronic thin film systems have been successfully developed. These include ordered structures like 0D nanoparticles, 1D nanowires, 2D nanosheets, and 3D ultrafine highly branched nanolawns. The resulting photoanode systems exhibit efficient PECCP characteristics for various metal materials (including 316L stainless steel, pure copper, E40, Q345, Q235 carbon steel, etc.) under simulated seawater environments (3.5 wt% NaCl solution and AM1.5 light irradiation).

This work enriches and expands the development of innovative thin film materials for marine corrosion PECCP, pioneering the achievement of photo-electrochemical cathodic protection for a diverse range of marine engineering metals in marine environments.