Innovative Sensor for Real-Time Monitoring of Solar Panel Infrastructure Durability in Soil

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The durability of solar panels and their infrastructure is significantly impacted by environmental factors, including soil conditions that can accelerate electrochemical corrosion. Soil conductivity emerges as a critical factor in the corrosion process, influenced by water sources such as underground water with high salinity, capillary water with low salinity, and intermittent rainwater, which varies in chemical composition (e.g., pH) over time. Microbial-induced corrosion (MIC) in soil further complicates this scenario, posing challenges for underground and submerged metallic structures, including those associated with photovoltaic systems. MIC is driven by physical, chemical, and biological factors, which interact synergistically to influence soil corrosion kinetics.

To address MIC, innovative monitoring strategies are required. P. Cristiani et al. introduced a galvanic sensor for detecting microbial activity in soil, demonstrating its ability to identify the onset of MIC without auxiliary parameter monitoring. In this study, a novel multiparametric probe was developed and tested in clay-rich soil to assess its capability for real-time monitoring of soil aggressivity and microbial activity. The probe measures various electrochemical parameters, including soil conductivity, redox potential, free corrosion potential, and biofilm formation potential. Probes buried 40 cm deep were tested on several metals and alloys (e.g., stainless steel, brass, carbon steel, ARMCO iron, and pure copper) over three months.

Results reveal that soil conductivity is primarily influenced by water content rather than temperature. Biofilm growth on the sensor was detectable within one week, and microbial activity was characterized via next-generation sequencing. The open circuit potential (OCP) measurements of titanium versus zinc indicated that biofilm formation was independent of free corrosion potential. Notably, corrosion current measurements of the galvanic couple Cu-Zn demonstrated increased activity during water addition events, correlating with higher corrosion rates.

The probe's configuration, employing zinc as both a reference electrode and a biofilm growth monitor, provided robust and reliable data. This setup highlights the critical role of water in activating MIC processes and supports the independent contribution of microbial activity to active corrosion phases. The electrochemical results also indicated passivation trends in carbon steel, suggesting the potential for targeted mitigation strategies. These findings underline the importance of integrating advanced electrochemical monitoring tools to enhance the longevity of metal infrastructure in diverse soil environments.

[1] P. Cristiani, A. Franzetti, G. Bestetti, Monitoring of electro-active bio_lm in soil, Electrochimica Acta, vol. 54 (1), 2008