

Sustainable Design of a Solar-photovoltaic Electrocoagulation Wastewater Treatment System for Kuwait Oil Industry

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Abstract

This study presents the development and implementation of an innovative solar photovoltaic electrocoagulation (SPEC) system for treating industrial wastewater effluents generated by the Kuwait Oil Company (KOC). By integrating advanced wastewater treatment technology with sustainable energy solutions, the system not only addresses critical environmental challenges but also produces green hydrogen as a valuable byproduct. Leveraging Kuwait's abundant solar resources, this research aligns with the nation's Vision 2035 environmental goals and sustainable development objectives. The prototype system consists of a four-part reactor with adjustable aluminum electrode plates, solar panels, and novel features, including dual-threaded bar electrode spacing control and an efficient hydrogen collection mechanism. Experimental investigations were conducted with varying power inputs (43W to 173W) to treat 34 liters of industrial wastewater using 16 aluminum electrode plates with a total surface area of 16,704 cm². Consistent electrode arrangements and wastewater characteristics ensured reliable comparisons across trials. Performance analysis revealed a linear relationship between power input and treatment efficiency. At the maximum power setting (173W), near-complete turbidity removal was achieved within 8 minutes, whereas lower power inputs (43W–103W) extended the treatment duration to 20–28 minutes. The solar photovoltaic system demonstrated exceptional stability and performance, particularly at higher power levels, ensuring efficient and reliable operation throughout the process. The findings underscore the potential of the SPEC system as a scalable and cost-effective solution for industrial wastewater treatment tailored to Kuwait's environmental and industrial needs. The system's ability to operate sustainably using renewable energy while generating green hydrogen further positions it as a pioneering approach in wastewater management and renewable energy innovation.

Keywords

Sustainable wastewater treatment, Solar photovoltaic, Electrocoagulation, Industrial wastewater, Kuwait oil industry, Water recycling, Environmental sustainability