

Article

Portable Solar-Integrated Open-Source Chemistry Lab for Water Treatment with Electrolysis

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Abstract: Harnessing solar energy offers a sustainable alternative for powering electrolysis for green hydrogen production as well as wastewater treatment. The high costs and logistical challenges of electrolysis have resulted in limited widespread investigation and implementation of electrochemical technologies on an industrial scale. To overcome these challenges, this study designs and tests a new approach to chemical experiments and wastewater treatment research using a portable standalone open-source solar photovoltaic (PV)-powered station that can be located onsite at a wastewater treatment plant with unreliable electrical power. The experimental system is equipped with an energy monitoring data acquisition system. In addition, sensors enable real-time monitoring of gases—CO, CO₂, CH₄, H₂, H₂S, and NH₃—along with temperature, humidity, and volatile organic compounds, enhancing safety during electrochemical experiments on wastewater, which may release hazardous gases. SAMAs software was used to evaluate energy-sharing scenarios under different grid-connected conditions, and the system can operate off the power grid for 98% of the year in Ontario, Canada. The complete system was tested utilizing a laboratory-scale electrolyzer (electrodes of SS316L, Duplex 2205, titanium grade II and graphite) with electrolyte solutions of potassium hydroxide, sulfuric acid, and secondary wastewater effluent. The electrolytic cell specifically developed for testing electrode materials and wastewater showed a Faraday efficiency up to 95% and an energy efficiency of 55% at STP, demonstrating the potential for use of this technology in future work.

Keywords: solar photovoltaic; electrolysis; electrochemistry; environmental sensor; water treatment; portable station; electrode material



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1. Introduction

The application of electrolysis and electrochemistry in wastewater treatment presents a novel and promising opportunity [1]. Electrochemistry, particularly in wastewater, is being explored as a treatment targeting recalcitrant pollutants [2,3]. Electrolysis, on the other hand, is attracting attention as a green and sustainable method to produce hydrogen, and if applied to wastewater, could simultaneously provide treatment of conventional pollutants, representing a great opportunity [4,5]. This approach aligns with global efforts to develop environmentally friendly technologies that address both energy production and water management challenges [6,7]. By harnessing renewable energy to power electrolysis [6], wastewater electrolysis could offer a more economical and sustainable alternative for green

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