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ADVANCEMENT OF SUSTAINABLE IN-SITU ENERGY SYSTEMS FOR MARTIAN AUTONOMY: OPTIMIZING CO2 UTILIZATION AND ENERGY EFFICIENCY

Abstract

To establish a sustainable human presence on Mars, an efficient, self-sustaining energy system is essential due to the planet's remote location and the high cost of Earth-based resupply missions. This paper presents a novel approach that utilizes Mars' abundant CO resources, drastically reducing dependence on Earth-supplied energy and cutting mission costs. The proposed system harnesses solar energy to excite a semiconductor, creating electron-hole pairs that react with CO, producing formic acid and carbon monoxide. Through advanced separation techniques, these by-products are processed, with formic acid then used in Direct Formic Acid Fuel Cells (DFAFCs) to generate electricity in a closed-loop cycle that recycles CO and recovers water. The model's modular design allows it to adapt to changing mission requirements and technological advancements. However, challenges such as Mars' low pressure, extreme cold, dust storms, material corrosion, and high energy demands for CO processing present barriers to implementation. Optimizing catalysts, conducting simulated Martian tests, employing AI-driven monitoring, using corrosion-resistant materials, and recovering waste heat are critical steps to enhance the system's resilience and longevity. This innovative approach not only meets Mars' energy needs but also lays a foundation for future space missions by integrating cutting-edge technologies and strategic planning.