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Operation System for Aluminium-Air Cell: A Strategy to Harvest the Energy from Secondary Aluminium

Authors : Binbin Chen, Dennis Y. C. Leung

Abstract : Aluminium (Al) -air cell holds a high volumetric capacity density of 8.05 Ah cm-3, benefit from the trivalence of Al ions. Additional benefits of Al-air cell are low price and environmental friendliness. Furthermore, the Al energy conversion process is characterized of 100% recyclability in theory. Along with a large base of raw material reserve, Al attracts considerable attentions as a promising material to be integrated within the global energy system. However, despite the early successful applications in military services, several problems exist that prevent the Al-air cells from widely civilian use. The most serious issue is the parasitic corrosion of Al when contacts with electrolyte. To overcome this problem, super-pure Al alloyed with various traces of metal elements are used to increase the corrosion resistance. Nevertheless, high-purity Al alloys are costly and require high energy consumption during production process. An alternative approach is to add inexpensive inhibitors directly into the electrolyte. However, such additives would increase the internal ohmic resistance and hamper the cell performance. So far these methods have not provided satisfactory solutions for the problem within Al-air cells. For the operation of alkaline Al-air cell, there are still other minor problems. One of them is the formation of aluminium hydroxide in the electrolyte. This process decreases ionic conductivity of electrolyte. Another one is the carbonation process within the gas diffusion layer of cathode, blocking the porosity of gas diffusion. Both these would hinder the performance of cells. The present work optimizes the above problems by building an Al-air cell operation system, consisting of four components. A top electrolyte tank containing fresh electrolyte is located at a high level, so that it can drive the electrolyte flow by gravity force. A mechanical rechargeable Al-air cell is fabricated with low-cost materials including low grade Al, carbon paper, and PMMA plates. An electrolyte waste tank with elaborate channel is designed to separate the hydrogen generated from the corrosion, which would be collected by gas collection device. In the first section of the research work, we investigated the performance of the mechanical rechargeable Al-air cell with a constant flow rate of electrolyte, to ensure the repeatability experiments. Then the whole system was assembled together and the feasibility of operating was demonstrated. During experiment, pure hydrogen is collected by collection device, which holds potential for various applications. By collecting this by-product, high utilization efficiency of aluminum is achieved. Considering both electricity and hydrogen generated, an overall utilization efficiency of around 90 % or even higher under different working voltages are achieved. Fluidic electrolyte could remove aluminum hydroxide precipitate and solve the electrolyte deterioration problem. This operation system provides a low-cost strategy for harvesting energy from the abundant secondary Al. The system could also be applied into other metal-air cells and is suitable for emergency power supply, power plant and other applications. The low cost feature implies great potential for commercialization. Further optimization, such as scaling up and optimization of fabrication, will help to refine the technology into practical market offerings.

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