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A Bifunctional Electrochemical Flow Cell Integrating Ammonia Production and Electricity Generation

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Extended Abstract

It has been joint global attention and efforts to reduce the participation of the fossil fuels in the modernized way of energy utilization and power generation [1]. Among the thoughts of improvement, the electricity-fuel-electricity approach realized by a bifunctional electrochemical flow cell has been come up with, which can be used as both fuel-production mode and electricity-generation mode [2]. The fuel-production mode is capable of converting renewable energy that are however intermittent and unreliable into chemical energy stored in fuels to secure an efficient and stable supply of electricity, wherever and whenever the electricity is demanded [3]. The renewable electricity is able to be generated through the electricity-generation mode, which is a promising method to realize the environmentally friendly energy utilization. This reversible system exhibits several distinctive advantages, including non-pollution emission, high specific energy, no self-discharge, and decoupled energy storage capacity with rated power [4].

In this work, a bifunctional electrochemical flow cell integrating both ammonia production and electricity generation modes is developed for renewable energy conversion and storage. Ammonia, a hydrogen carrier having a high hydrogen content of 17.6 wt. %, is relatively easier to convert to liquid phase for large-scale storage. The long-distance ammonia transport can reliably depend on the established infrastructure. This flow cell is able to operate via two modes, i.e., an ammonia-production mode for energy storage in the form of ammonia (via nitrogen reduction reaction) and an electricity-generation mode for energy conversion in the form of electricity (via ammonia oxidation reaction). This flow cell is constituted by a PtAu/C-coated nickel-foam electrode for nitrogen and oxygen reduction reactions, a Pt/C-coated nickel-foam electrode for water and ammonia oxidation reactions, and an alkaline anion exchange membrane for charge-carrier migration. Charging this flow cell with the supply of nitrogen results in a Faradaic efficiency of 2.70% and an ammonia production rate as high as 9.34×10^{-10} mol s^{-1} cm^{-2} at 23 ^{o}C. Moreover, energizing this flow cell with ammonia results in an open-circuit voltage of 0.59 V and a peak power density of 3.31 mW cm^{-2} at 23 ^{o}C.

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