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Chemically reduced graphene oxide paper as positive electrode for advanced Zn/Ce redox flow battery

Zhipeng Xie[a,b,*], Baolu Liu[a], Chenfan Xie[c], Bin Yang[a], Yunfen Jiao[a], Dingjian Cai[a], Liang Yang[a], Qi Shu[a], Anhong Shi[a]

[a] Engineering Research Institute, Jiangxi University of Science and Technology, Ganzhou, 341000, China
[b] State Key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun, 130022, China
[c] School of Petroleum and Chemical Engineering, Dalian University of Technology, Panjin, 124221, China

HIGHLIGHTS

- The RGOC paper possesses good flexibility with a porous structure.
- The C/O ratio of RGOC is different from that of RGOT.
- The activity of RGOC towards Ce^{3+}/Ce^{4+} is better than that of RGOT.

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ABSTRACT

Zn/Ce redox flow battery (ZRFB) is emerging as a promising technology to store large amount of energy economically and efficiently, wherein a highly efficient positive electrode with a continuous and fast electronic and ionic transportation path is urgently desired. The unique nanostructure of reduced graphene oxide (RGO) paper electrode is prepared by a simply chemical reduction method, which facilitates transference of the electron and Ce^{3+}/Ce^{4+} at the electrolyte/electrode interface. Thus ZRFB exhibits superior extent of charge (81.0%) and energy efficiency (71.3%). The results show RGO paper is a good candidate for positive electrode of ZRFB.

1. Introduction

Energy is of importance to all of us. It is necessary to develop new energy resources [1–3] for reducing environmental pollutants [4] and improving human life level. However, the more widespread use of them is dependent upon the development of an affordable and reliable energy storage system. Redox flow batteries (RFBs) have received increasing attention for their storing enormous amount of electrical energy friendly and efficiently [5,6]. For a typical RFB, its electroactive species are dissolved in two electrolytes stored in separate tanks instead of in electrodes, which is different from traditional batteries. The cell reactions occur when electrolyte flows through electrode with the help of pump. The electrode only offers a place where electrode reaction occurs without undergoing any deformation, which is helpful to prolong the service life of the battery. The capacity of RFB is determined by the amount of electroactive species in electrolyte, while the power output by the size of the electrode. For example, the greater the amount of Ce^{3+}/Ce^{4+} in positive electrolyte, the greater the capacity of ZRFB. The architecture characteristic of separation of power output from capacity gives RFB considerable design flexibility.

It is of fundamental importance to select suitable electrode material for optimization and upgrading of battery performance. The factors to be considered in selection of electrode materials for RFB application include conductivity, mechanical strength, chemical stability and electrochemical activity. Generally, selection of electrode material for RFB application is the process of finding a balance point in the above mentioned factors based on the specific use. The kinetic characteristics of Ce^{3+}/Ce^{4+} electrode reaction on glassy carbon, platinum, platinized titanium, carbon felt, graphite, porous carbon, and graphene oxide/graphite composite electrodes were investigated by different researchers [7–18]. Although some achievements have been made in the research of electrode, it is still necessary to search for alternative materials with better performance toward effective positive electrode for advanced ZRFB application.

Graphene-based materials have attracted significant attention for their excellent mechanical and electrical properties [19–24], which can

* Corresponding author. No.86, Hongqi Ave., Ganzhou, Jiangxi, China.
E-mail address: zhpxie_06@126.com (Z. Xie).

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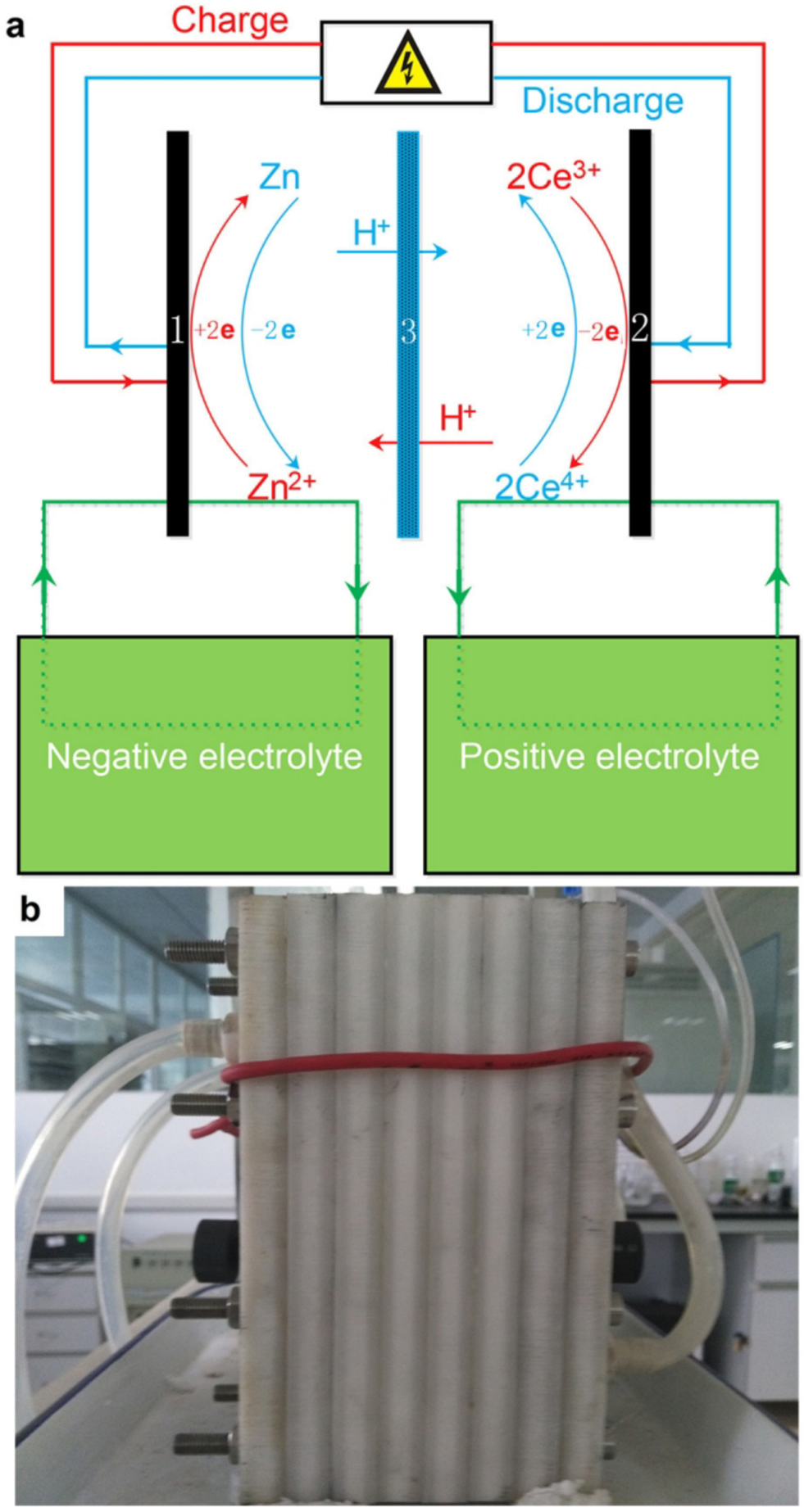

Fig. 1. a)Working principle of Zn/Ce redox flow battery. b)Assembled ZRFB. 1. negative electrode, 2. positive electrode, 3. Nafion 115 membrane.