

Realization of good performance of Na-air Battery in real Air Condition

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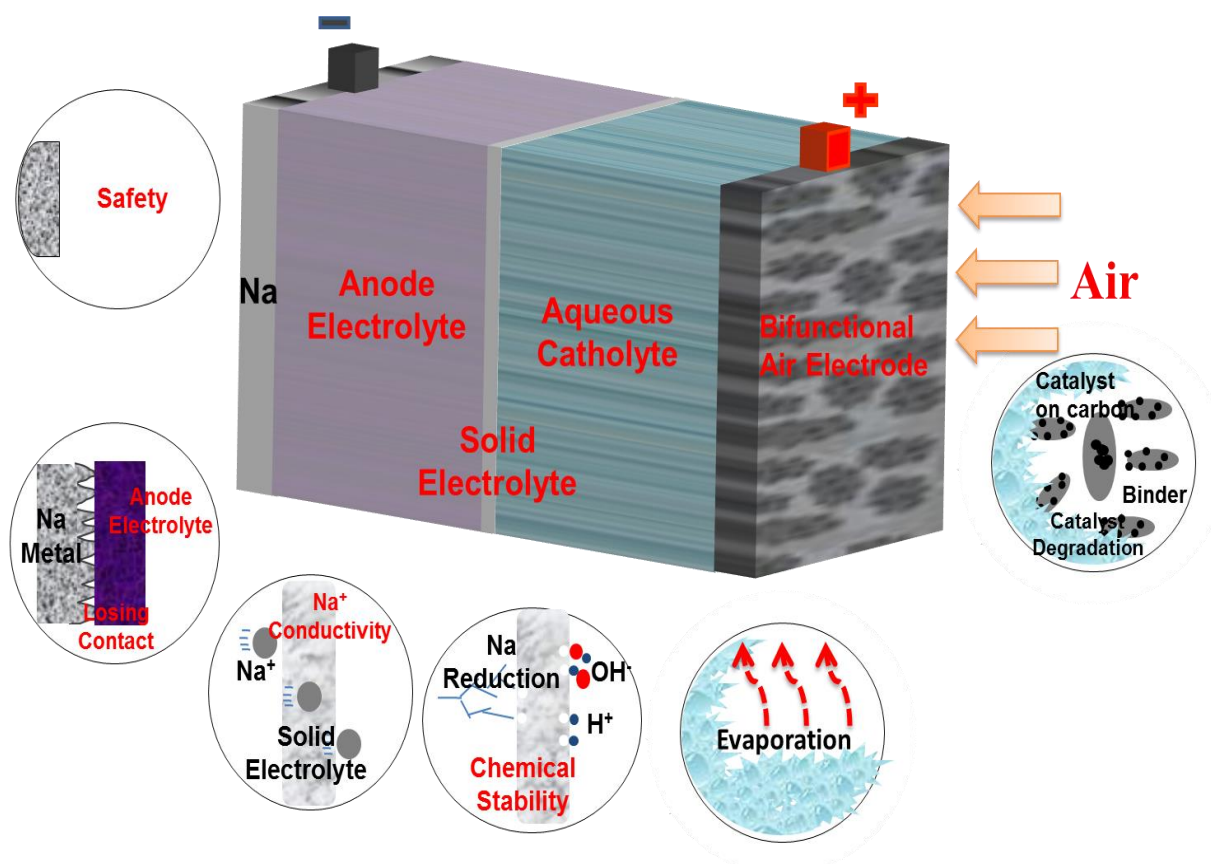
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Graphical Abstract



Challenges of hybrid Na-air battery working in real air.

Abstract

Hybrid sodium-air battery possess higher theoretical open circuit voltage and theoretical specific capacity of $2600 \text{ Wh}\cdot\text{kg}^{-1}$, as well as lower over potential compared to nonaqueous sodium-air batteries [1]. The hybrid sodium-air battery employed in this work, which consists of a sodium metal anode, organic electrolyte, solid conductor with the composition of $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ (ionic conductivity of $1.3\times 10^{-3} \text{ S}\cdot\text{cm}^{-1}$ at 25°C), catholyte, and a porous air electrode [2]. The challenges of hybrid Na-air battery working in real air were introduced: (1) the catalyst preference was poor; (2) the contact between the sodium metal and anode electrolyte was deteriorated after cycling, (3) evaporation of aqueous catholyte. In order to solve these problems, lots of strategies have been selected. Firstly, dual-phase spinel MnCo_2O_4 with nitrogen-doped reduced graphene oxide hybrids (dp- $\text{MnCo}_2\text{O}_4/\text{N-rGO}$) was employed for electrocatalytic oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) in sodium-air batteries, demonstrating comparable ORR and superior OER catalytic performance compared to commercial Pt/C [3]. Secondly, Na[FSA]-[C₂C₁im][FSA] (C₂C₁im⁺: 1-ethyl-3-methylimidazolium and FSA⁻: bis(fluorosulfonyl)amide) ionic liquid was utilized as the aprotic electrolyte in hybrid sodium-air batteries for the first time. The sodium-air batteries were operated at relatively high temperatures up to 70°C to prove their excellent thermal stability and the contact between the sodium metal and anode electrolyte. A large output power density was obtained by increasing the operation temperature because of the high Na⁺ diffusivity and high ionic conductivity of the ionic liquid. The batteries exhibited an extremely large specific capacity of $835 \text{ mAh}\cdot\text{g}^{-1}$ at 50°C ; this capacity corresponds to 99% of the theoretical capacity. In addition, maximum areal output power density of $27.6 \text{ mW}\cdot\text{cm}^{-2}$ was obtained at 50°C . In addition, we present a novel quasi-solid-state Na-air battery by utilizing gel cathode in ambient environment for the first time. The gel is composed of single-walled carbon nanotubes (SWNTs) and room-temperature ionic liquids (ILs) of 1-ethyl-3-methylimidazolium ([C₂C₁im]) bis (trifluoromethylsulfonyl) imide([NTf₂]), which was prepared readily as one “bucky gel of ionic liquid”. A more compatible interface was formed between gel and solid electrolyte, compared with the ionic liquid/solid electrolyte and NaOH solution/solid electrolyte interfaces, realizing good performance of Na-air battery in real air condition.

Keywords: Na-air battery, gel cathode, long cycle, solid electrolyte.

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Biography of Presenting Author



Feng Liang is a full professor of Kunming University of Science and Technology (KUST), also a visiting professor of Kyushu University. He graduated from Tokyo Institute of Technology in 2014, He joined in KUST in 2015. His research topics include Na-air/CO₂ battery, all-solid-state battery, lithium-ion battery, supercapacitors, Plasma prepare and modify nanomaterials and their applications in energy fields, the growth mechanism and preparation of nanomaterials by thermal plasmas. He has published more than 60 papers including *Nature Communications*, *Nano Energy*, *Applied Catalysis B-Environmental*, *Carbon*, and *ACS Applied Materials & Interfaces* et al. He was awarded as High Level Returned Talent Supported by Ministry of Human Resources and Social Security of China (2019), International Association of Advanced Materials (IAAM) Award (2018), High Level Researcher of Yunan Province, China (2016) et al. He is an Advisory Panel of Nanotechnology (IF: 3.57), Editorial Board Members of three international journals.

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