An Investigation of the Electrochemical Properties of Molybdenum (IV) Sulfide as Anode Additive for Secondary Iron Air Battery

Aremu Emmanuel Olugbemisola, Kwang-Sun Ryu*
Department of Chemistry, University of Ulsan, Nam-gu, Ulsan 680-749, Korea

E-mail: aremu2003@naver.com

Metal air battery is an attractive technology for future generation energy storage owing to its high theoretical capacity. Compare to several other types of metal air batteries which have been identified, iron as an anode material is a candidate of metal air battery that is yet to be fully exploited. With electrode efficiencies of 96, 35 and 40% for charge, energy and voltage respectively, a current capacity less than $300AhKg^{-1}$ and an OCP of 1.28V, the iron air battery could find its operation in a range of technologies. However, the major drawback to its application in commercial scale is passivation during discharge which mitigates the anodic utilization. In addition to that is hydrogen evolution reaction (HER) on the surface. Past efforts revealed that the comprisal of sulfides salt such as BiO, K_2S, FeS, Bi_2S_3, or K_2S and Na_2S etc. as additives to Fe electrode and electrolyte respectively, performances can be enhanced. Meanwhile these studies failed to shed light on the modification of the electrode surface and the reaction mechanisms involved in the suppression of HER through the inclusion of additives. Based on previous studies described above, we hypothesized that the use of MoS_2 could help achieve a charge efficiency value >95% by mitigating HER on Fe electrode. The ease of employing MoS_2 as additive such as its high corrosion resistance, mechanically suppressibility, efficient catalyst for HER, excellent electrical conductivity etc., has been reported for different alkaline battery. To the best of our knowledge, no work has been conducted using our choice of additives so far. In addition to that, we elucidated on the role of Na_2S as an electrolyte additive in enhancing rate capability and thirdly, we discovered the impact of molybdenum trioxide on the Fe/air electrode. Cyclic voltammetry was conducted in a potential range of -1.3 to -0.1V over a scan rate of $0.5mVs^{-1}$. At a current density of 50 $\mu A cm^{-2}$ to the potential of -1.3 V vs Ag/AgCl, galvanostatic discharge was conducted. Likewise, XRD and SEM images were carried out to confirm the presence of our elemental additives. Our discovery revealed an excellent charging efficiency of 96% at a discharge capability of 2C rate. This was attributed to the use of small sized molybedenum (IV) sulfide and high purity carbonyl as electrode additive. For the first time, we saw how hydrogen evolution reaction was 99% eliminated. Also, the molybdenum trioxide produced at the electrode during oxidation reaction mitigated passivation totally at the electrode surface thereby allowing for a high discharge rate.

References:

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