Na-O_2 Batteries Based on $Na_{2-x}O_2$ Evolution

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In this study, we introduce cathodes comprising CNT/Ru nanoparticles composites, describing their synthesis and properties. These cathodes exhibit superior properties, because they have dual catalytic effects. They promote oxygen reduction at lower over-potential (compared to CNT based cathodes) which forms $Na_{2-x}O_2$ (deficient sodium peroxide) as a major product. $Na_{2-x}O_2$ is less reactive than the NaO_2 superoxide moieties which are usually as the ORR products in Na-O_2 cells. We attribute formation of $Na_{2-x}O_2$ on CNT/Ru cathodes to the relatively strong interactions between adsorbed oxygen and the Ru surface, what promotes further reduction of oxygen , beyond the usual reduction of oxygen to sodium superoxide in these systems. We suggest that $Na_{2-x}O_2$ is less reactive in side reactions than NaO_2, thereby the intrinsic stability of the CNT/Ru cathodes is higher than that of CNT or other carbonaceous cathodes in Na-O_2 batteries. All these important aspects, related to the ORR product distribution, including a quantitative analysis, and mapping of all kinds of possible side reactions, should be studied further, since what we present herein is a preliminary analysis. Also, the possible mechanism of oxygen reduction on Ru surfaces, in the presence of Na ions deserves further through studies, with the help of computational work. Here we have shown several interesting directions that justify further rigorous studies. The CNT/Ru cathodes has a clear catalytic effect on all possible oxidation processes in the Na-O_2 cells, including OER and even electrolyte solution oxidation. The Na-O_2 cells which contain the CNT/Ru cathodes are fully discharged at relatively low over-potentials, below 3.6-3.7 V, without endangering the stability of any component in the cell. Thanks to the effectiveness of these cathodes, the cells cycling efficiency before failure (due to the Na anode) is 100% and their energy efficiency is excellent. Thereby, these cells can reach more than 100 fully reversible cycles and thus reach the ultimate limitation of these cells that arises from the Na metal anode side. We hope our study will be helpful for the development of Na-O_2 batteries by providing an understanding of the reaction mechanism and side reaction.

References:

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