Biosens J 2018, Volume 7
DOI: 10.4172/2090-4967-C1-003

Advances in non-aqueous oxygen electrochemistry, in connection to developing rechargeable Li and Na –oxygen batteries

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Rechargeable Li-oxygen and Na-oxygen batteries if successful and practical can rival internal combustion engines in terms of very high energy density and enable highly competitive electrochemical propulsion for electric vehicles. These systems however, are very problematic. So far, we do not have electrolyte solutions that are stable enough towards the active metals and also towards the oxygen reduction moieties which are superoxide and peroxide species. These oxide moieties are reactive towards all relevant polar-aprotic solvents, especially in the presence of Li ions, which are highly electrophilic Lewis acids in aprotic solutions. Oxygen reduction in the presence of Li ions usually forms solid Li_2O_2 as a final stable product. We can control its formation and deposition mechanism through the properties of the electrolyte solutions, as mentioned in the attached image. We can promote fast Li-peroxide precipitation as thin films on the cathode (bottom-up mechanism) or as thick deposits (top-down mechanism). There is a dilemma what should be preferred, because fast deposition may mean low retention time for side reactions (higher stability). Oxidation of Li-peroxide upon charging may require too high over-potentials which endanger the anodic stability of the electrolyte solutions and cathode materials. We know today to overcome this problem by the use of catalysis by redox mediators. We developed new solvents that can be better protected against attacks by oxygen reduction species. We explored alternative anodes which should be less reactive than lithium or sodium metals. In order to explore properly and optimize electrolyte solutions and cathode materials we developed a new methodology in which Li or Na –oxygen cells are explored with bi-compartments cells that completely avoid any chemical communication between the anode and the cathode side, except Li or Na ions exchange. We will discuss the true practical horizons of these battery systems.

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