

Carbon Encapsulated Fe-species as Anodes in Alkaline Batteries

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Modern, high energy density electrochemical devices are based around the use of organic electrolytes. Push towards more environmentally friendly, cost effective, renewable/reusable, and overall green approaches has shifted some of the attention towards aqueous battery systems [1]. Material design and tailored synthesis procedures of new nano-architectures have significantly increased capacitance of materials used in aqueous systems [2]. Among them, Fe-species, with their main $\text{Fe}^{2+}/\text{Fe}^{3+}$ pair, have attracted considerable attention due to remarkable redox stability and iron availability/non-toxicity. Herein we propose a new approach to Fe-based materials architecture by electrochemical iron mono-dispersion inside alginate scaffold. Subsequent chemical and/or thermal treatments of the prepared gel allowed us to prepare different nano/micro-sized iron oxide, iron carbide and iron sulfide particles imbedded inside carbon support. Amount of this carbon support can be adjusted by thermal treatment to the optimal amount where it provides sufficient conductivity but does not decrease gravimetric capacitance. Cyclic voltammetry measurements of these materials in 4M KOH show prominent peaks related to $\text{Fe}^{2+}/\text{Fe}^{3+}$ redox pair, possibly Fe^{2+}/Fe reduction and even H_2 evolution at the most negative potentials. Initial cycles of Fe-oxide/C sample are characterized by at least three oxidation peaks, probably due to transformation of various Fe-oxide species (@ -1.05V , -0.97V , -0.78V vs. SCE), which merge into one (@ -0.78V vs. SCE) corresponding to $\text{Fe}(\text{OH})_2$ transformation into Fe_3O_4 and/or FeOOH [2]. Significant peak separation is evidenced for this sample, decreasing its efficiency; however, it possesses remarkable stability with no capacitance loss after 200 cycles. Sample with different Fe-sulfide species and possibly some Fe_3C initially displays two oxidation peaks (@ -0.96 and -0.78V vs. SCE) with the second one diminishing with every cycle and eventually disappearing after 20 cycles. First peak is much more stable with significantly lower peak separation. Characterization is underway to identify phase related to this transition and towards gearing synthesis condition which could produce a material predominant in this crystal structure.

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References:

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