SYNTHESIS AND INVESTIGATION OF MIXED-POLYANION CATHODE MATERIALS FOR NA-ION BATTERIES

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An increasing consumption of fossil fuels, which are still the world's leading energy source, and the emission source of CO_2, have caused multiple environmental severe problems such as pollution and climate change [1]. In order to meet the Paris climate agreement goals of future energy requirements [2], as well as climate neutrality by 2050 [3], the development of renewable energy sources has become more and more urgent. Although the electricity generated by wind turbines, solar panels or hydropower is clean and safe, the supply is an intermittent and requires large-scale storage devices to obtain a balance. Electrochemical energy storage has many desirable features such as pollution-free operation, high round-trip efficiency, a wide range of power and energy, long cycle life and low maintenance, as well as easy integration into the grid [4,5].

Li-ion batteries are more and more widely used as rechargeable power sources, owning to their high energy and power density. However, the high cost of Li and necessary transition metals as well as safety issues related to the use of highly flammable electrolytes have pushed towards the search for alternatives. Na-ion batteries and especially their aqueous variants are attracting particular attention as potential candidates for large-scale energy storage because of the accessible and unlimited Na resources and elimination of certain rare transition metals. Moreover, the aqueous aspect makes them significantly safer, non-flammable, low cost and environmentally friendly in comparison to the current Li-ion technology [6,7].

Compounds with a mixed polyanion framework have recently gained attention as a new class of compounds for material exploration. The potential tunability of the structure by using various combinations of polyanions can potentially lead to a novel cathode. However, the redox reaction in complex structures often involves complex structural evolutions during the electrochemical reaction, which require careful analysis. In this work we synthesized and investigated several polyanionic compounds with different redox couples: $Na_7V_4(PO_4)(P_2O_7)$, $Na_4Fe_3(PO_4)_2(P_2O_7)$, $Na_4Mn_3(PO_4)_2(P_2O_7)$ as electrode materials Na-ion batteries. Different organic electrolytes (1M $NaPF_6$ in diglyme or EC:DEC) as well as aqueous ones (1M Na_2SO_4, 28m KAc+8m NaAc, 8m NaTFSI etc.) were tested with all these materials.

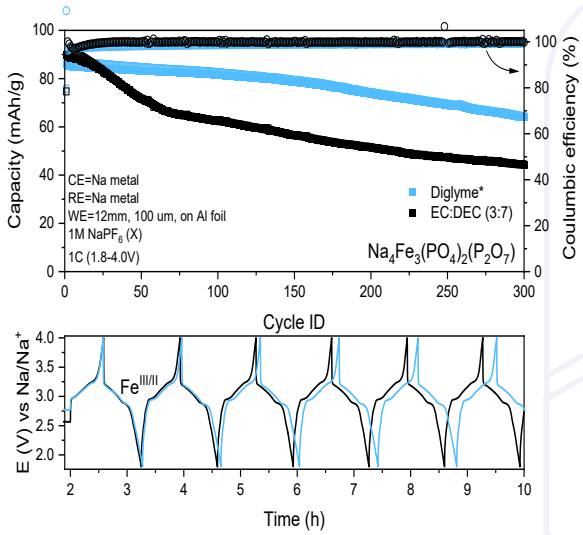

Fig. 1. Galvanostatic cycling of $Na_4Fe_3(PO_4)_2(P_2O_7)$ electrode in different organic electrolytes.

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