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## Crystal structure and magnetic properties of fluorophosphates $\text{Na}_2\text{Fe}_{0.9}\text{Mn}_{0.1}\text{PO}_4\text{F}$ cathode material

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The sodium iron fluorophosphates  $\text{Na}_2\text{Fe}_{0.9}\text{Mn}_{0.1}\text{PO}_4\text{F}$  was synthesized by solid-reaction state route. A mixture of  $\text{Na}(\text{CH}_3\text{COO})$ ,  $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ ,  $\text{MnCO}_3$ ,  $\text{NH}_4\text{H}_2\text{PO}_4$ , and  $\text{NaF}$  was ground. The mixture was first calcined at 350 °C for 3 h under Ar atmosphere and was pressed into a pellet. Theses mixture was sintered at 625 °C for 6 h under Ar atmosphere. The crystal structure and magnetic properties of the as prepared materials were studied by X-ray diffraction (XRD), vibrating sample magnetometer (VSM), and Mössbauer spectroscopy. Structure refinement of  $\text{Na}_2\text{Fe}_{1-x}\text{Mn}_x\text{PO}_4\text{F}$  was analyzed using Fullprof program. From the XRD patterns, consistent with  $\text{Na}_2\text{FePO}_4\text{F}$ , the crystal structure of  $\text{Na}_2\text{Fe}_{0.9}\text{Mn}_{0.1}\text{PO}_4\text{F}$  sample was found to be orthorhombic with space group of Pbcn. Lattice parameters of  $\text{Na}_2\text{Fe}_{0.9}\text{Mn}_{0.1}\text{PO}_4\text{F}$  are as follows:  $a_0 = 5.2399 \text{ \AA}$ ,  $b_0 = 13.8828 \text{ \AA}$ ,  $c_0 = 11.8028 \text{ \AA}$ , and  $V = 858.0840 \text{ \AA}^3$ .  $\text{Na}_2\text{FePO}_4\text{F}$  cathode material has reported two-dimensional (2D) layer structure of  $\text{PO}_4$  tetrahedra and  $\text{Fe}_2\text{O}_6\text{F}_3$  biotahedra, which consists of a pair of  $\text{FeO}_4\text{F}_2$  octahedra through fluorine ion sharing [1]. The temperature dependence of zero-field-cooled (ZFC) and field-cooled (FC) curves was measured at temperatures from 4.2 to 295 K under applied field of 100 Oe. Mössbauer spectra have been taken at various temperatures ranging from 4.2 to 295 K. We have confirmed that no evidence for long range magnetic ordering by using Mössbauer spectroscopy at 4.2 K.