SYNTHESIS OF SODIUM IRON PYROPHOSPHATE CATHOD MATERIAL USING IRON RICH PHOSPATE LEACHATE GENERATED FROM ALPHA TITANIUM PHOSPHATE SYNTHESIS

Reshan W.D.D[1]*, Jayaweera P.M*[2*]
[1] Department of Urban Bioresources, Faculty of Urban and Aquatic Bioresources, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka
[2] Faculty of Urban and Aquatic Bioresources, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka
*Corresponding author: pradeep@sjp.ac.lk

The growing demand for sustainable energy storage systems and resource efficient waste management strategies has increased interest in the recovery of valuable materials from industrial waste streams. This study investigated the synthesis of sodium iron pyrophosphate ($NaFeP_2O_7$) using iron recovered from phosphoric rich leachate that generated as an industrial waste during alpha titanium phosphate (α-TiP**)** synthesis using Sri Lankan ilmenite. The research aimed to transform a waste derived iron source into a value added polyanionic material with potential application as a cathode material for sodium ion batteries. A controlled co-precipitation method was employed to recover iron from the leachate. The acidic solution was neutralized using sodium hydroxide, resulting in the formation of a hydrated iron phosphate precursor at pH 3.5. The precursor was subseq-uently aged, filtered, washed, oven dried at 110°C, and calcined at 650°C to promote pyrophosphate formation and crystallization. The synthesized material was characterized using X-ray diffraction (XRD) and UV-Visible spectroscopy. XRD analysis confirmed the successful formation of monoclinic $NaFeP_2O_7$ belonging to the $P2_1/c$ space group. The refined lattice parameters were determined as a = 9.5677 Å, b = 7.9018 Å, c = 7.3222 Å, β = 111.79°, with a unit cell volume of 514.01 $Å^3$. The diffraction pattern showed good agreement with ICDD Card No. 00-036-1454, confirming phase formation and structural integrity. UV-Visible spectroscopy revealed a prominent absorption band at 281 nm, characteristic of Fe^{3+} ligand to metal charge transfer transitions, confirming the presence of iron-oxygen coordination environments in the precursor system. The results demonstrate that industrial leachate can serve as an effective and low cost iron source for the synthesis of sodium iron pyrophosphate. This approach provides a sustainable pathway for industrial waste valorization while producing a structurally stable material with potential applications in next generation sodium-ion battery technologies.

Keywords: co-precipitation, industrial leachate, iron recovery, sodium-ion battery, UV–Visible spectroscopy, waste valorization, X-ray diffraction