

Synthesis & Performance Evaluation of Hybrid Cathode Materials for Energy Storage

Buzaina Moossa^b, Jeffin James Abraham^a, Ramazan Kahraman^b, Siham Al-Qaradawi^c, R. A. Shakoor^{a,*}

^aCenter for Advanced Materials (CAM), Qatar University (CAM), Doha, Qatar

^bDepartment of Chemical Engineering, Qatar University, Doha, Qatar

^cDepartment of Chemistry & Earth Sciences, College of Arts and Science, Qatar University, Doha, Qatar

Corresponding author: Shakoor@qu.edu.qa

Introduction

Abstract

- A hybrid cathode developed by Li⁺ substitution for Na⁺ in Na_(2-x)Li_xFeP₂O₇ (x=0,0.6) structure.
- Achieved improved thermal stability up to 550°C
- Sub micron sized; phase pure, crystalline material developed with irregular morphology.
- Na_{1.4}Li_{0.6}FeP₂O₇ (x=0.6) evaluated with Na and Li half cells exhibit promising cyclability.

Na_{2-x}Li_xFeP₂O₇ (x=0,0.6)

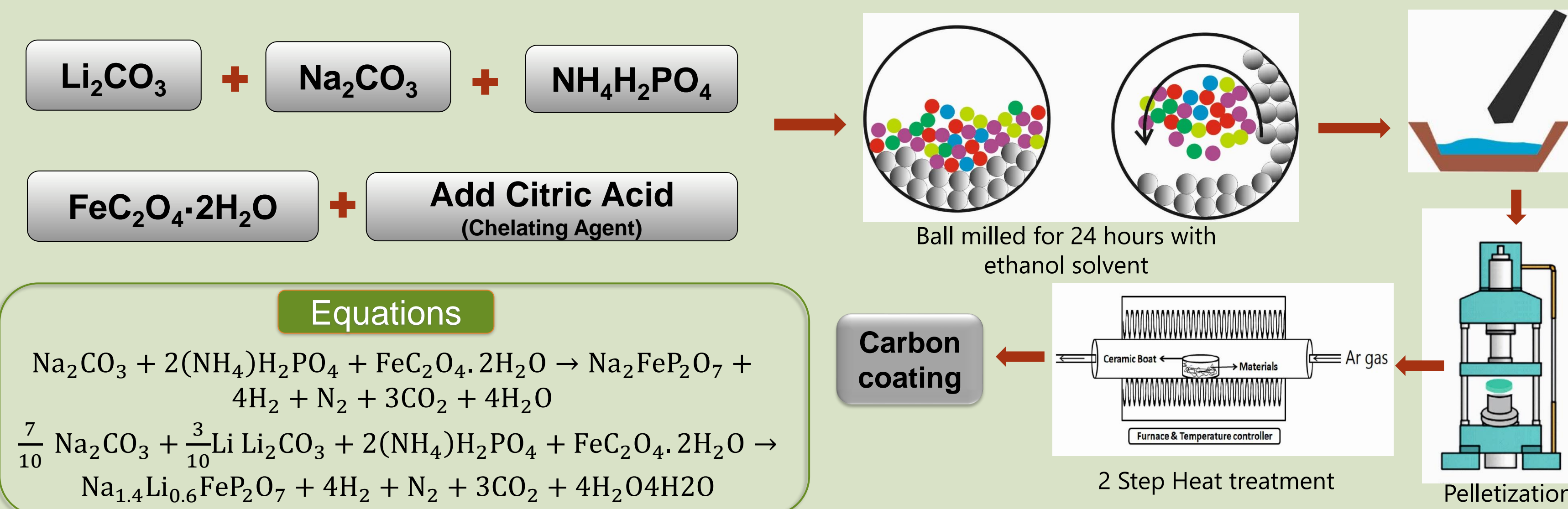
- Both samples Na₂FeP₂O₇(x=0), Na_{1.4}Li_{0.6}FeP₂O₇ (x=0.6), show excellent thermal stability to 550°C.
- Na_{1.4}Li_{0.6}FeP₂O₇ shows better weight retention when compared to Na₂FeP₂O₇.
- Paves way for hybrid cathode materials with improved performance.

Why Li Substitution?

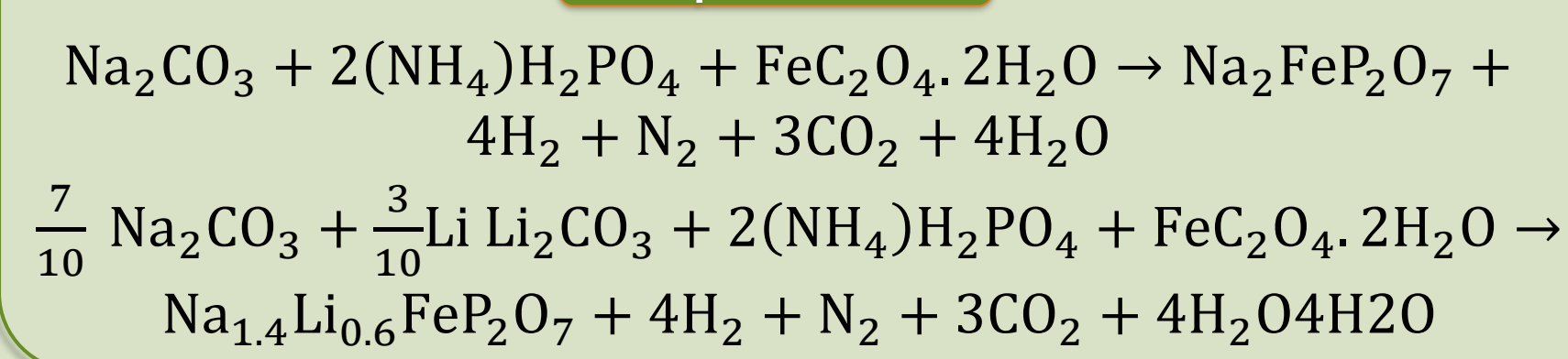
- Inadequate performance of Sodium Ion Batteries like slow ion transport, low energy density.
- Improve thermal stability
- Li substitution previously carried out in was Na_{1.0}Li_{0.2}Ni_{0.25}Mn_{0.75}O₂.
- This material displayed specific capacity of 95mAhg⁻¹, good cyclic performance and excellent rate capability.

Experimental Procedure

Synthesis of Na_{2-x}Li_xFeP₂O₇(x=0,0.6)



Equations



Results & Discussion

TGA Analysis

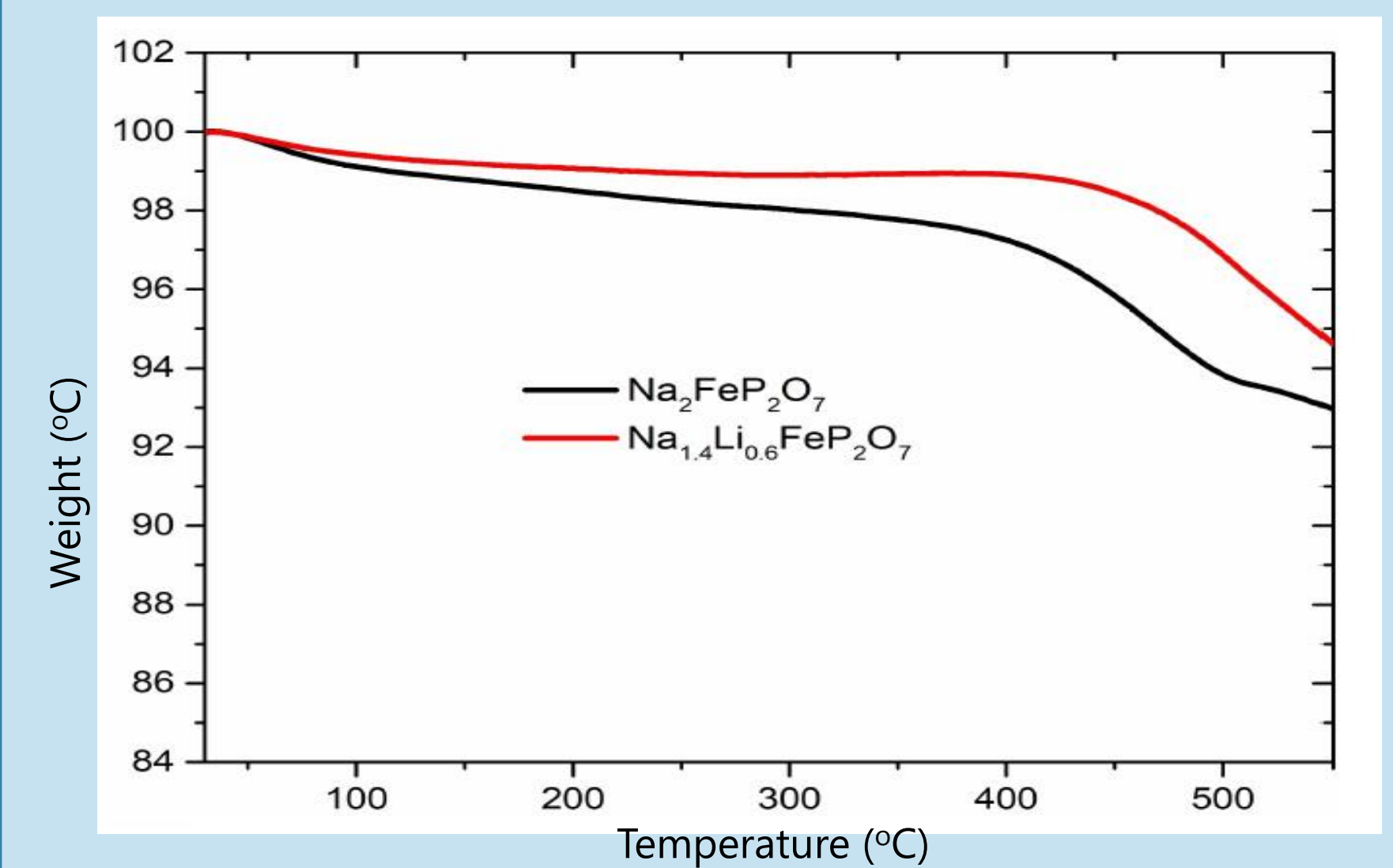


Fig 1. TGA Analysis for Na₂FeP₂O₇ and Na_{1.4}Li_{0.6}FeP₂O₇ under N₂ atm

Cyclic Voltammery curves

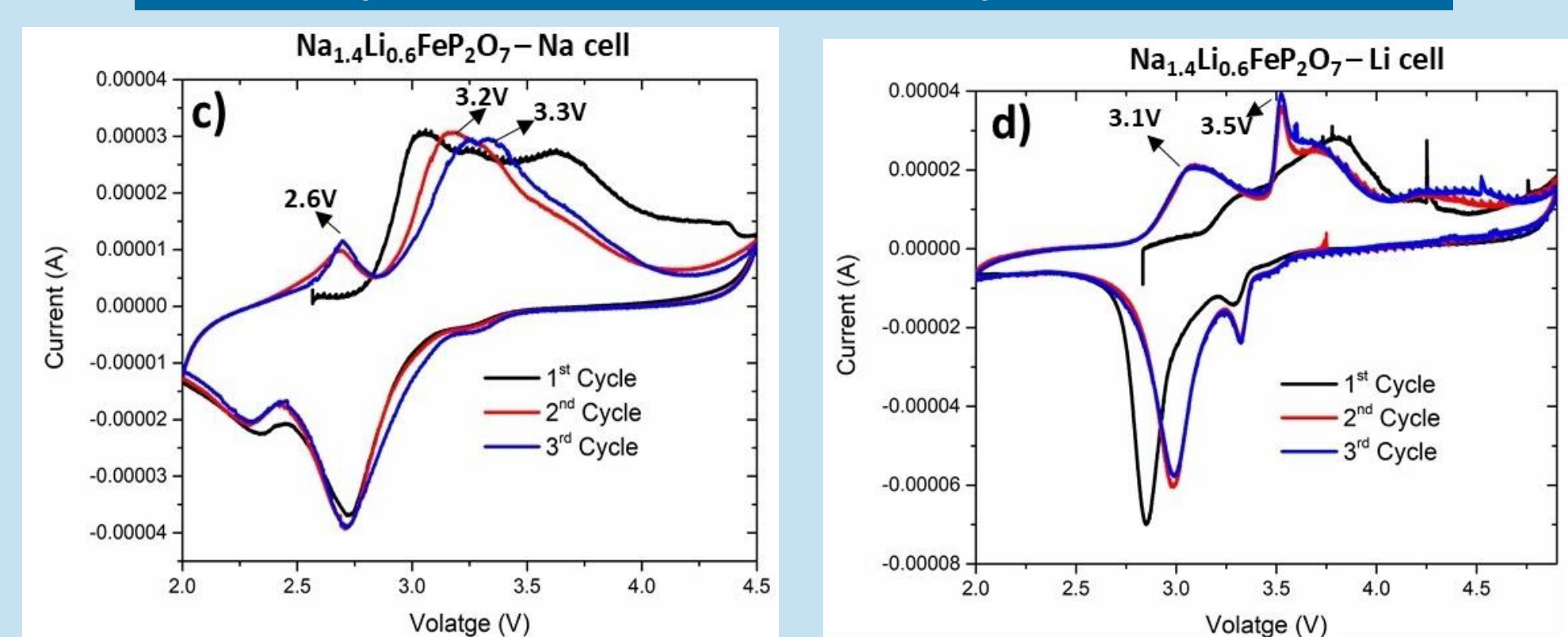


Fig 2- Cyclic voltammery curves measured at 0.05mV/s

Charge/Discharge curves

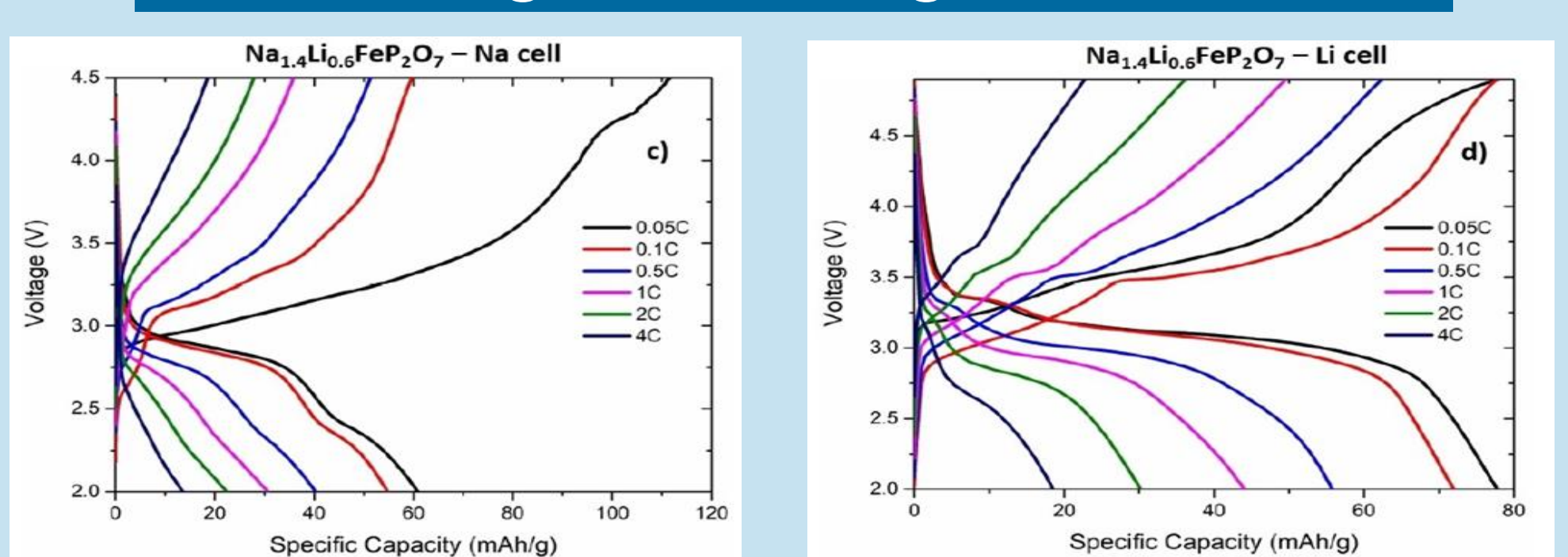


Fig 3- Charge/Discharge curves of Na_{1.4}Li_{0.6}FeP₂O₇ with Na and Li cells

GITT Curves

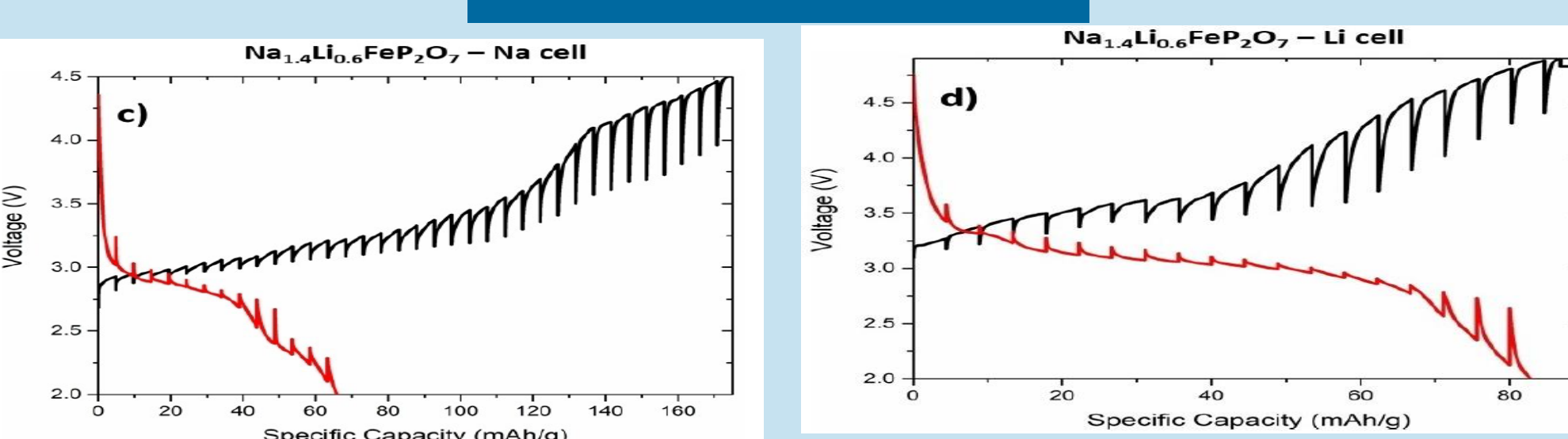


Fig 4- GITT curves for Na_{1.4}Li_{0.6}FeP₂O₇ with Na and Li cells

XRD, SEM & Crystal Structure

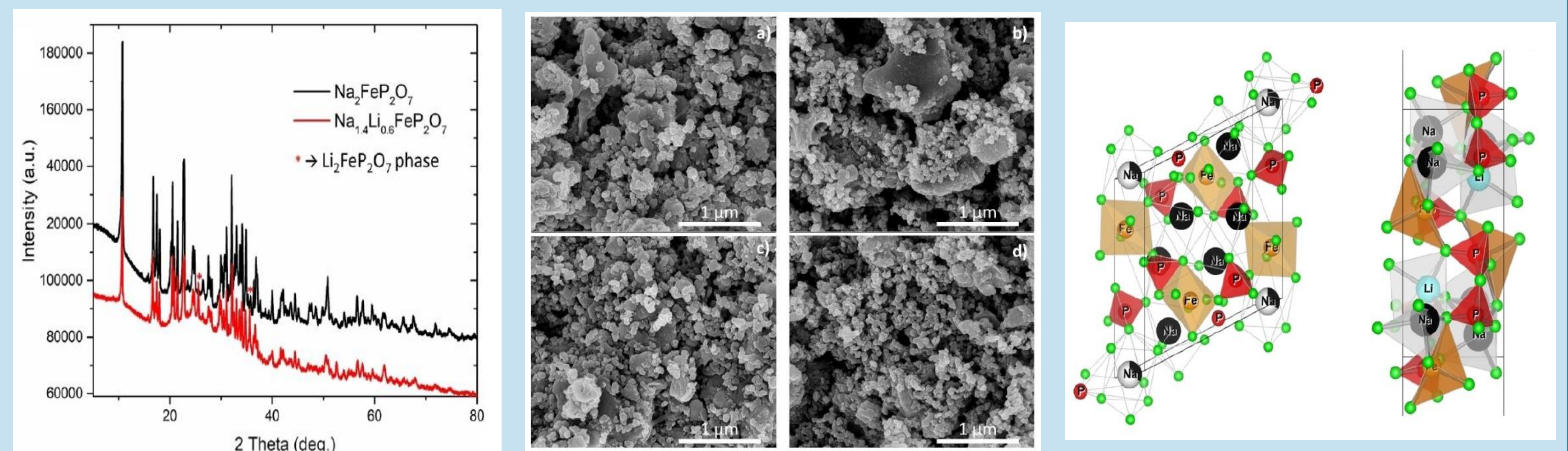


Fig 5- XRD patterns for Na₂FeP₂O₇ and Na_{1.4}Li_{0.6}FeP₂O₇.

Fig 6 FE- SEM images; (a)-pristine Na₂FeP₂O₇, (b) Pristine Na_{1.4}Li_{0.6}FeP₂O₇ and (c) carbon coated Na₂FeP₂O₇, (d) carbon coated Na_{1.4}Li_{0.6}FeP₂O₇.

Fig 7 a- Crystal structure of Na₂FeP₂O₇; b- Proposed crystal structure of Na_{1.4}Li_{0.6}FeP₂O₇

Rate capability comparison curve

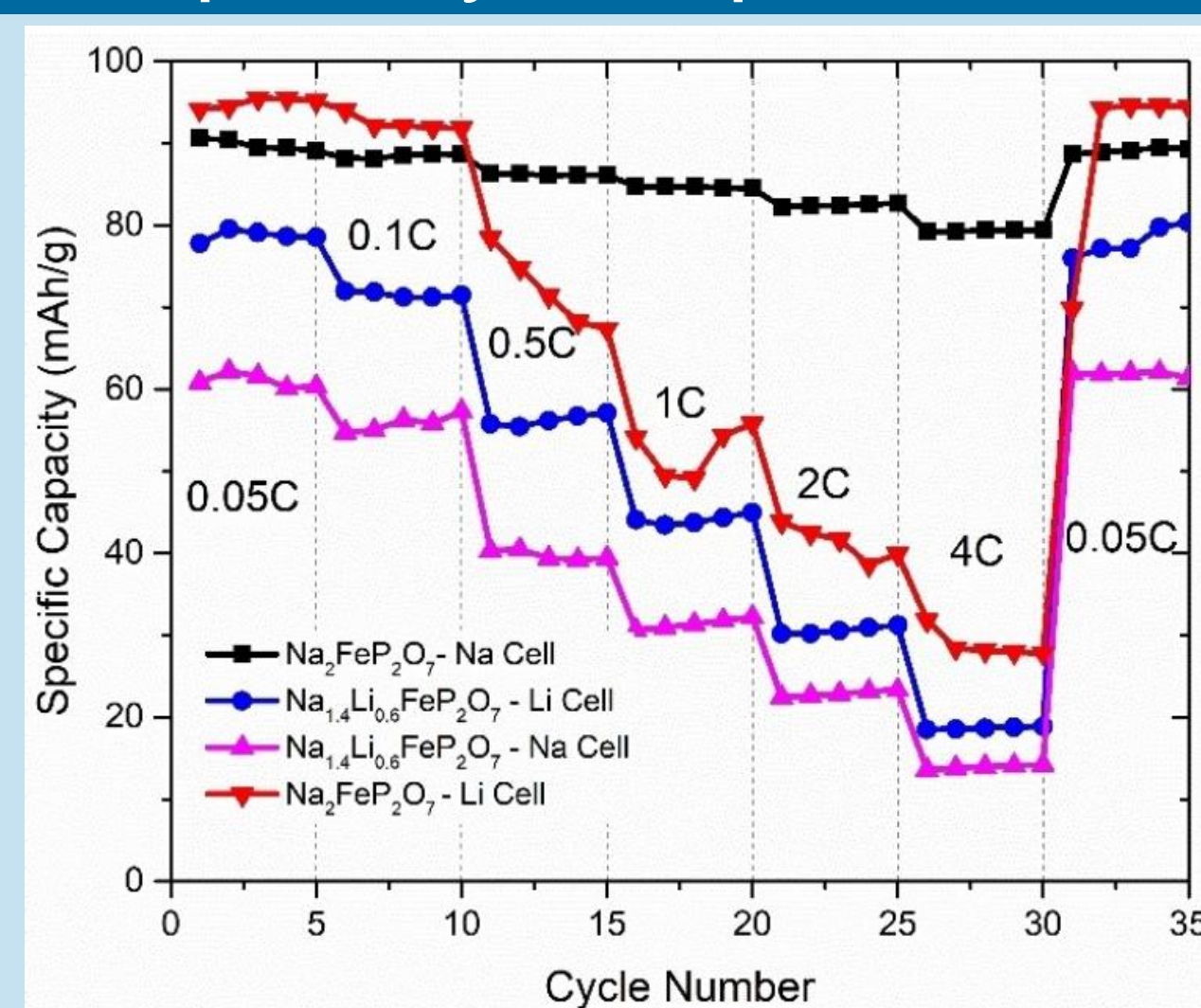


Fig 8 Rate capacity comparison of Na₂FeP₂O₇ and Na_{1.4}Li_{0.6}FeP₂O₇ in Li and Na cells.

Conclusion

- Na_{2-x}Li_xFeP₂O₇ (where x=0, 0.6) was synthesized using a solid-state synthesis technique.
- The XRD spectra validates the formation of phase pure materials and Li substitution does not alter the triclinic parent structure of Na₂FeP₂O₇.
- Carbon coating was introduced to increase electrochemical performance of the material.
- Increased thermal stability is obtained by Li substitution.
- Na_{1.4}Li_{0.6}FeP₂O₇ is electrochemically active and demonstrates cyclability in both the Li and Na cell

Acknowledgment

This work was financially supported by the NPRP Grant #NPRP11S-1225-170128 from Qatar National Research Fund and the QU internal grant- QUCG-CENG-20/21-2.