Design in-situ and ex-situ formed coatings to increase the stability of FeF_3 Na-Ion cathodes

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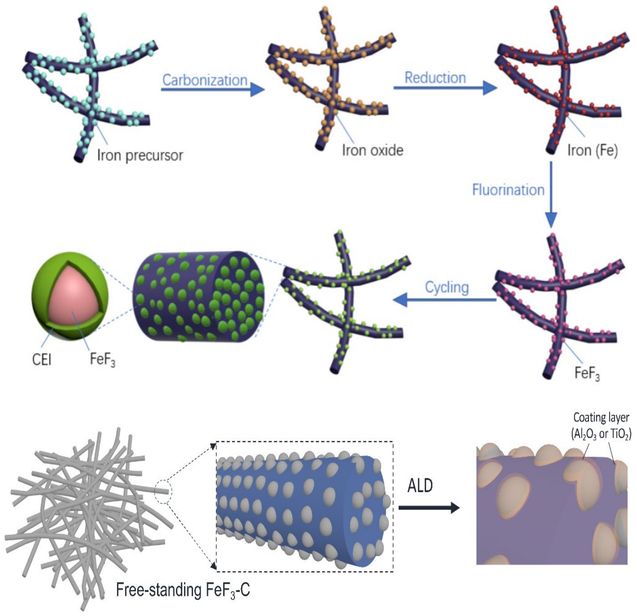
Motivation

- Sodium-ion batteries(NIBs) as a potential alternative to lithium-ion batteries have attracted great attention due to their low cost and high abundance.
- Iron trifluoride (FeF_3) has been explored enthusiastically due to its low cost, great abundance and high theoretical capacity (712mAh/g).
- However, FeF_3 tends to dissolve during charging and discharging. Further input needs to improve the stability of FeF_3-based cathode materials.
- Herein, we designed in-situ formed protective layers by electrode and electrolyte interaction and ex-situ formed protective layers by atomic layer deposition (ALD) technique.

Electrode Fabrication

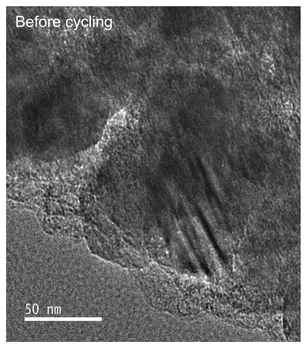
- Electrospinning is used to synthesize FeF_3-Carbon nanofibers (CNFs).

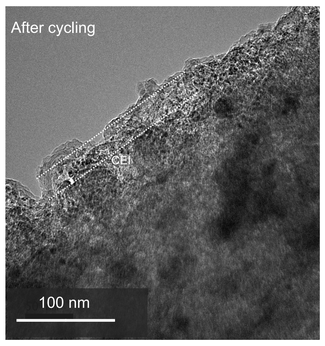


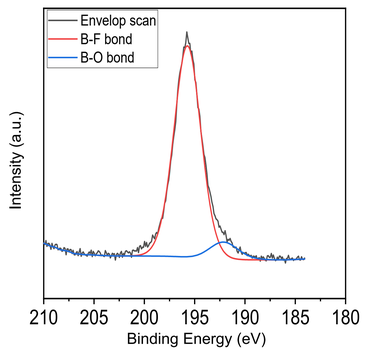
- This approach increases the electrical conductivity and ionic conductivity.
- Conformal alumina (Al_2O_3) ALD coatings are deposited at the surface of cathodes.

Characterization of Designed Coatings

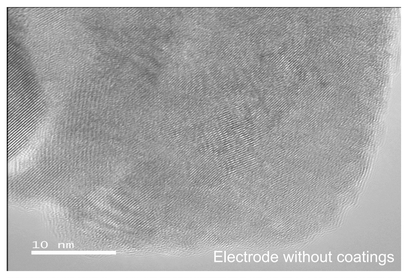
- A in-situ formed protective coating called cathode electrolyte interphase (CEI) was successfully fabricated by the electrochemical reaction.
- XPS of B_{1s} spectra shows the existence of B-F and B-O bonds inside of CEI.

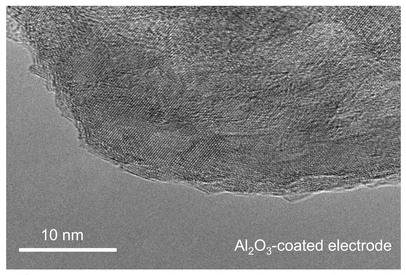


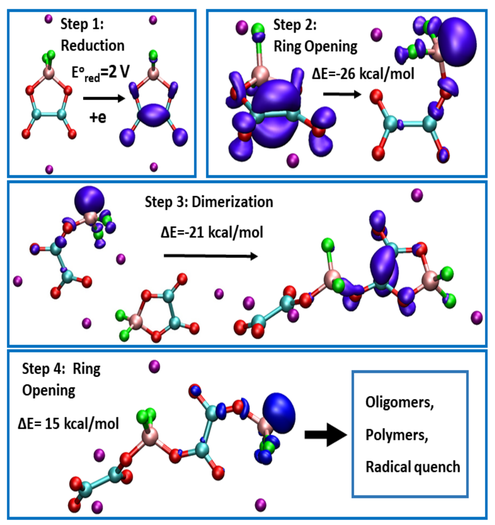




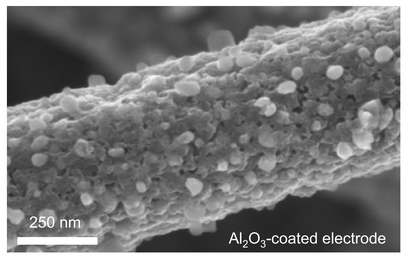
- Quantum mechanics reveal the CEI was initiated by the Na^+-mediated dimerization of electrolyte salt (NaDFOB). Further oligomerization would proceed through analogous steps.

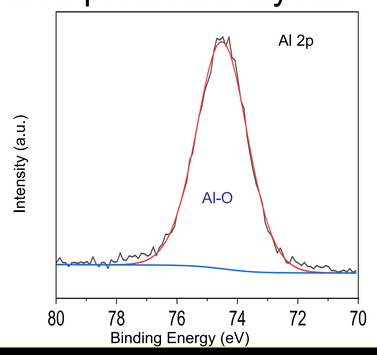




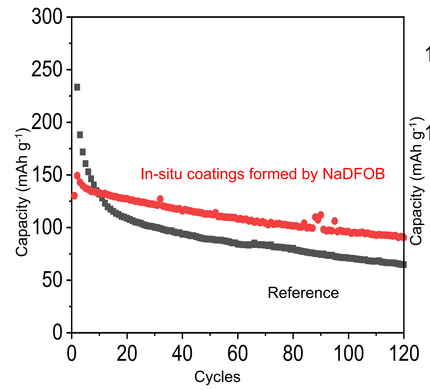


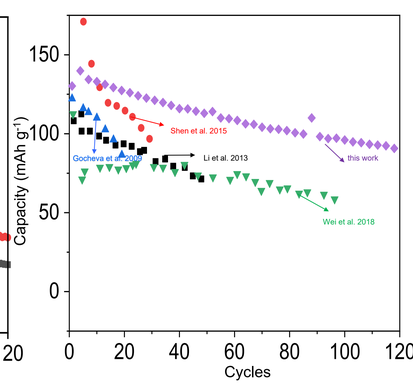
- Al_2O_3 was selected as the ALD coating layers and deposited on the cathode surface for ex-situ formed protective layers.



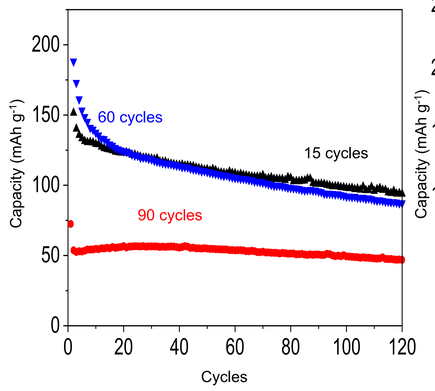


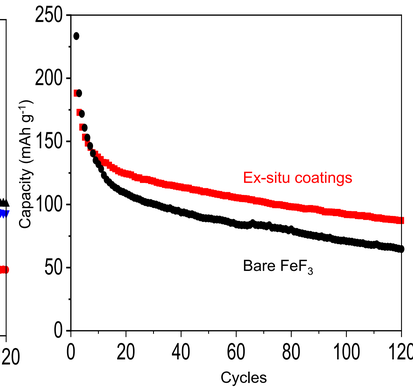
Electrochemical Performance





- In-situ formed coatings improved the cycling stability of FeF_3 in the first 120 cycles.





- Ex-situ formed coatings improved the cycling stability of FeF_3 in the first 120 cycles and 15 ALD Al_2O_3 coatings performed the best when comparing coatings with other ALD cycles.

Conclusion

- In-situ formed protective coatings were successfully designed and showed good performance to improve the cycling performance.
- In-situ coatings were formed by polymerization of DFOB anion during cycling.
- Ex-situ coatings were successfully fabricated by ALD technique.
- 15 ALD cycles for Al_2O_3 coatings exhibited the best cycling performance among coatings with other ALD cycles.

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Disclosure: A nanowire patent has been licensed to Sila Nanotechnologies, Inc.; G. Yushin is a co-founder, BOD member and stock holder of Sila.

Reference

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