$FeCo_2O_4$ as an Anode Material for Lithium Ion Batteries

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BACKGROUND

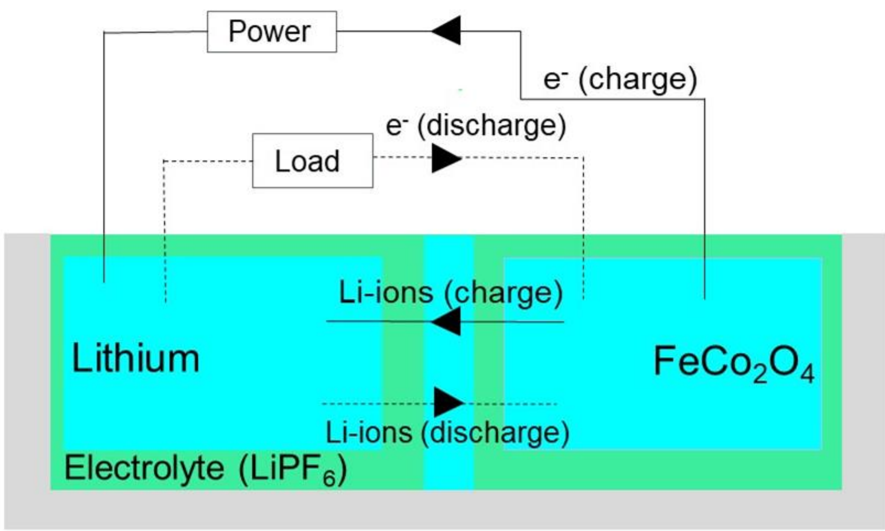

Fig. 1. How a Lithium-ion Battery (LIB) works

Uses of LIBs

- Portable electronic appliances
  - Mobile phones
  - Vehicles

Advantages	Disadvantages
- High energy density - High power - Can go through multiple charge-discharge cycles	- Low capacity retention over time - High production cost - Unsafe

PURPOSE OF RESEARCH

To create an anode with:

Capacity higher than current commercial anode (Graphite)

Using low-cost methods
- Molten Salt Method (MSM)
- Citric Acid Combustion Method (CAC)

Higher capacity of anode allows modern electronic devices to operate for longer periods of time

High cyclic stability allows modern electronic devices to go through more charge-discharge cycles

METHODOLOGY

Synthesis of $FeCo_2O_4$ by Molten Salt Method

LiOH, $FeSO_4$, NaCl, $CoSO_4$, KCl

650ºC for 3h, 3ºC temperature change/ min

OR

Synthesis of $FeCo_2O_4$ by Citric Acid Combustion

FeO, Cobalt (III) Acetate, Citric Acid

Heating at 200ºC

→ **Characterisation**

- X-Ray Diffraction (XRD)
- Scanning Electron Microscopy (SEM)

→ **Making of Slurry**

$FeCo_2O_4$ + NMP + Super P Carbon + PVDF Binder

→ **Fabrication of Anode**

Copper, Slurry, Foil

Heating at 75ºC-80ºC

→ **Assembly of Coin Cell**

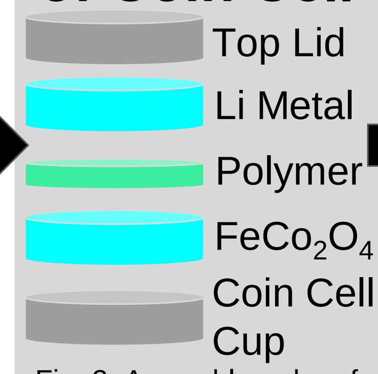

Fig. 2. Assembly order of CR2016 Coin Cell Battery

→ **Testing of Battery**

- Galvanostatic Cycling
- Electrochemical Impedance Spectroscopy

RESULTS AND DISCUSSION

XRD

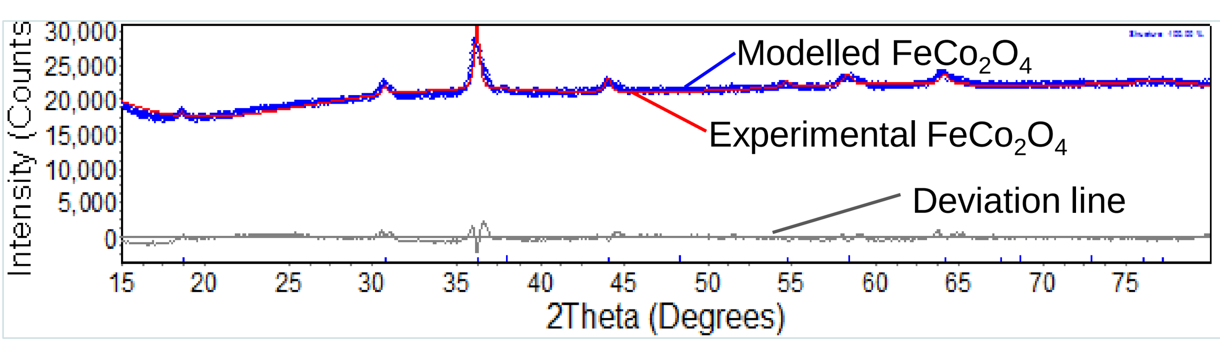

Fig. 3(a). XRD Pattern of $FeCo_2O_4$ synthesised by MSM

- Cubic Lattice, a= 8.199 Å

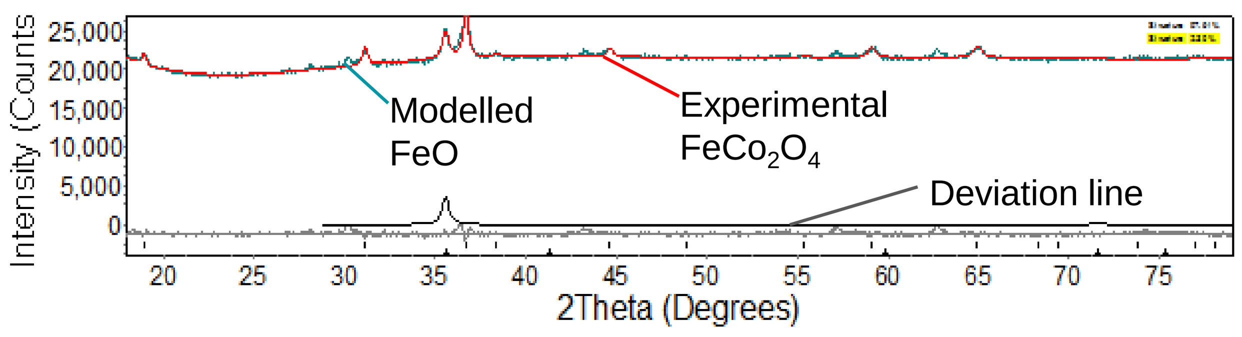

Fig. 3(b). XRD Pattern of $FeCo_2O_4$ synthesised by CAC

- Cubic Lattice, a= 8.117 Å

SEM

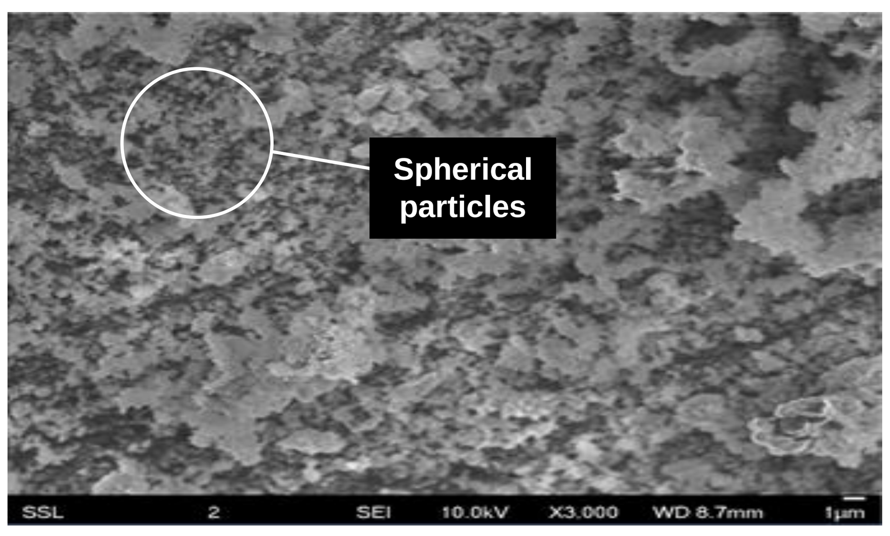

Fig. 4(a). SEM Image of $FeCo_2O_4$ by MSM under X3,000 magnification

Nearly spherical particles of about 0.5µm can be seen

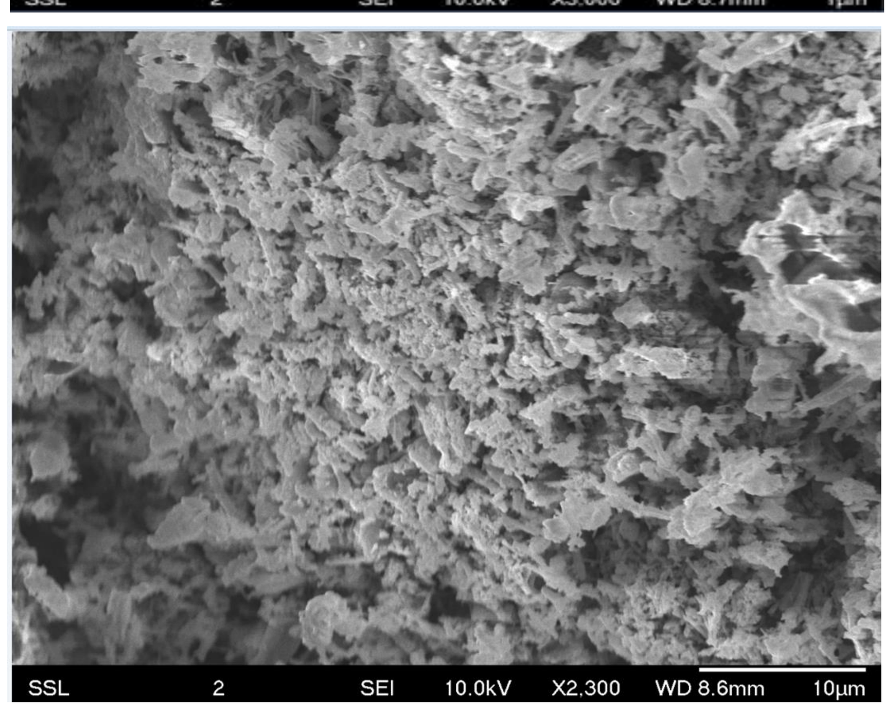

Fig. 4(b). SEM Image of $FeCo_2O_4$ by CAC under X2,300 magnification

Merged and unevenly formed particles of undeterminable size

Galvanostatic Cycling

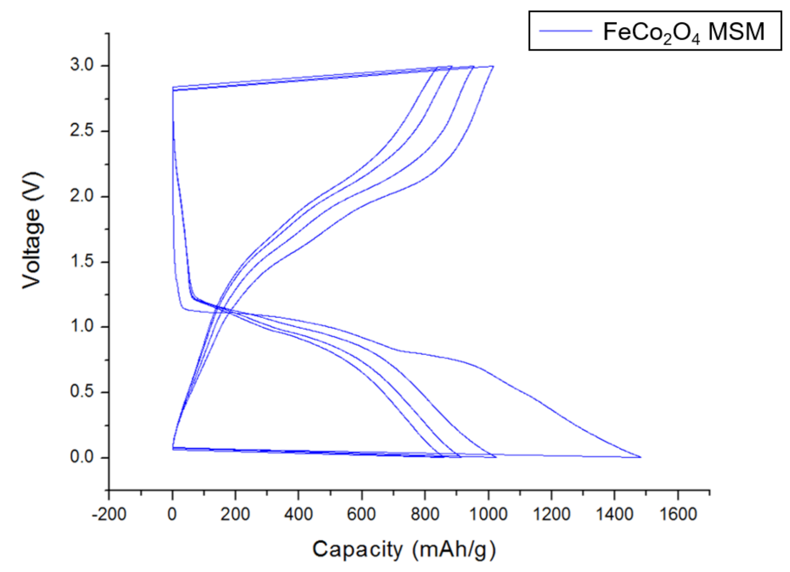

Fig. 5(a). Graph of Capacity against Voltage for 1st, 2nd, 5th and 10th Charge-Discharge cycles (MSM)

Cycle Number (Step)	Previously Reported ($FeCo_2O_4$)	1 (Discharge)	2 (Discharge)
Capacity /mAh/g	827	≈1490	≈1025
Cycle Number (Step)	**Previously Reported (Graphite)**	**5 (Discharge)**	**10 (Discharge)**
Capacity /mAh/g	372	914.05	859.09

Table 1(a). Table of Capacity and Voltage values for 1st, 2nd, 5th and 10th Charge-Discharge cycles (MSM)

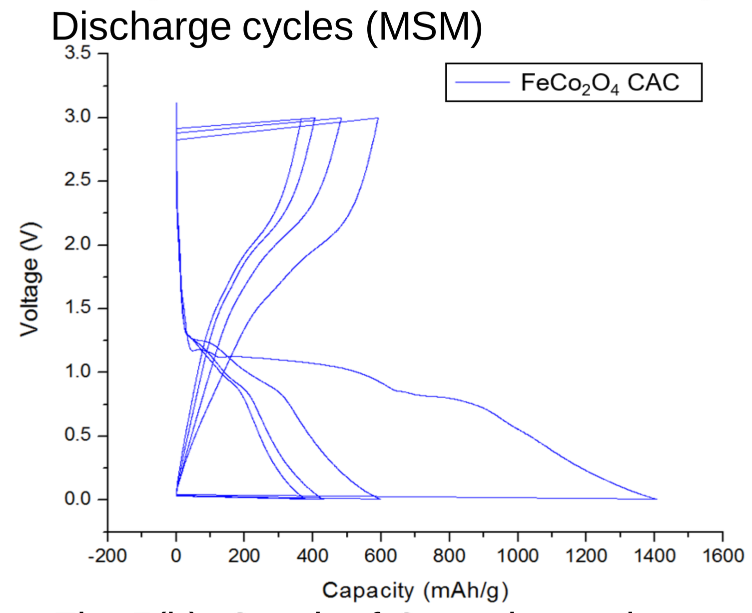

Fig. 5(b). Graph of Capacity against Voltage for 1st, 2nd, 5th and 10th Charge-Discharge cycles (CAC)

Cycle Number (Step)	Previously Reported ($FeCo_2O_4$)	1 (Discharge)	2 (Discharge)
Capacity /mAh/g	827	≈1400	598.55
Cycle Number (Step)	**Previously Reported (Graphite)**	**5 (Discharge)**	**10 (Discharge)**
Capacity /mAh/g	372	431.15	379.45

Table 1(b). Table of Capacity and Voltage values for 1st, 2nd, 5th and 10th Charge-Discharge cycles (CAC)

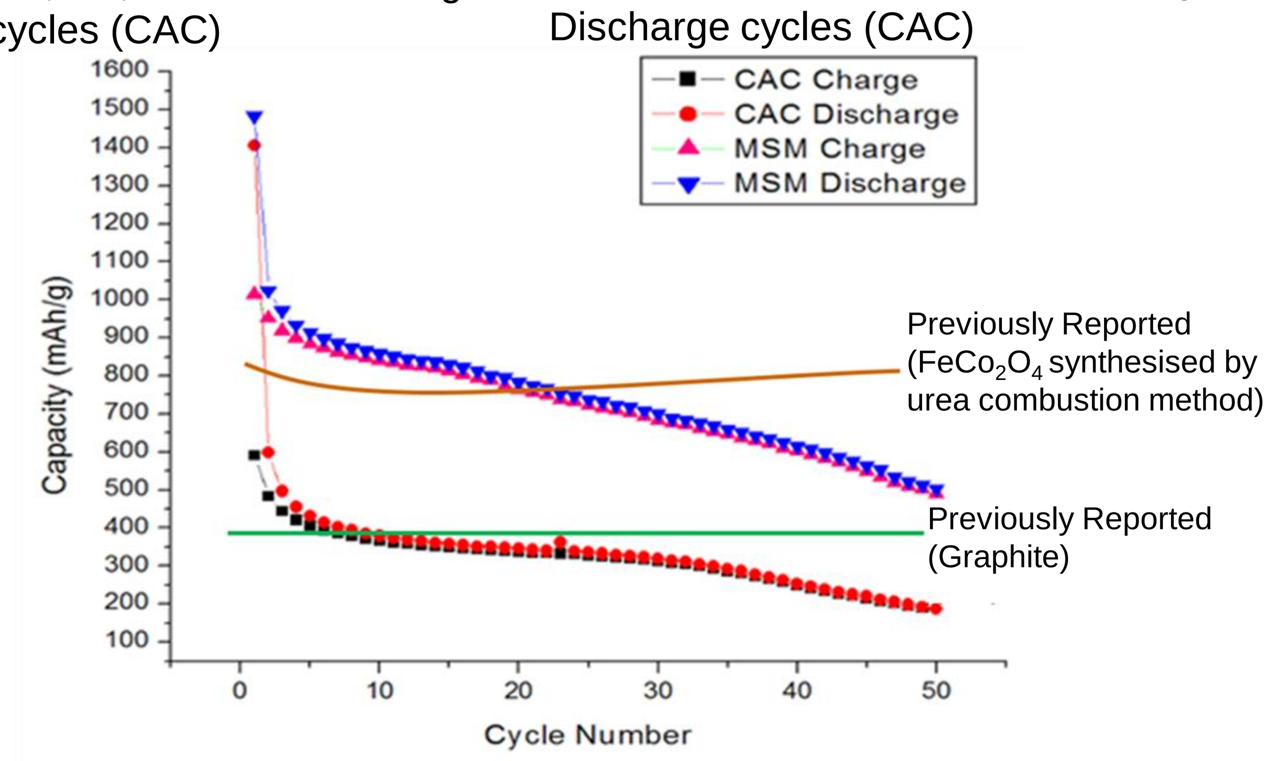

Fig. 5(c). Graph of Cycle Number against Charge-Discharge Capacities for first 50 cycles and previously reported capacity graph (MSM, CAC, urea combustion method[3] and graphite[5].

Electrochemical Impedance Spectroscopy

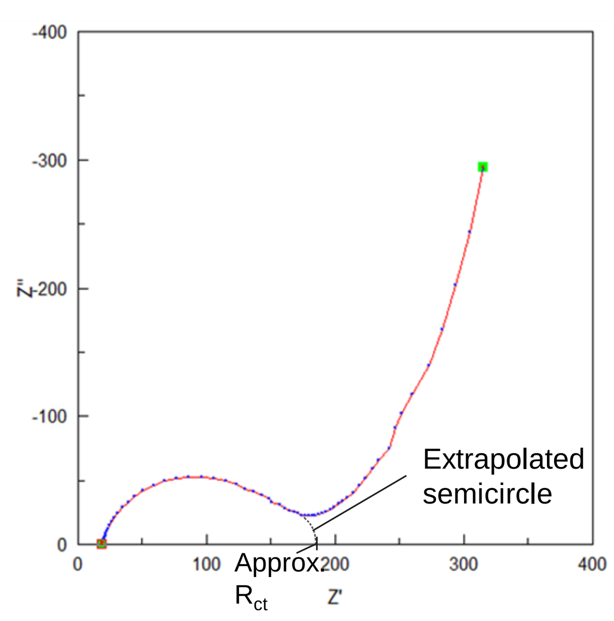

Fig. 6(a). Nyquist Plot of impedance on complex plane for $FeCo_2O_4$ by MSM

- R_{ct} is approximately 180Ω

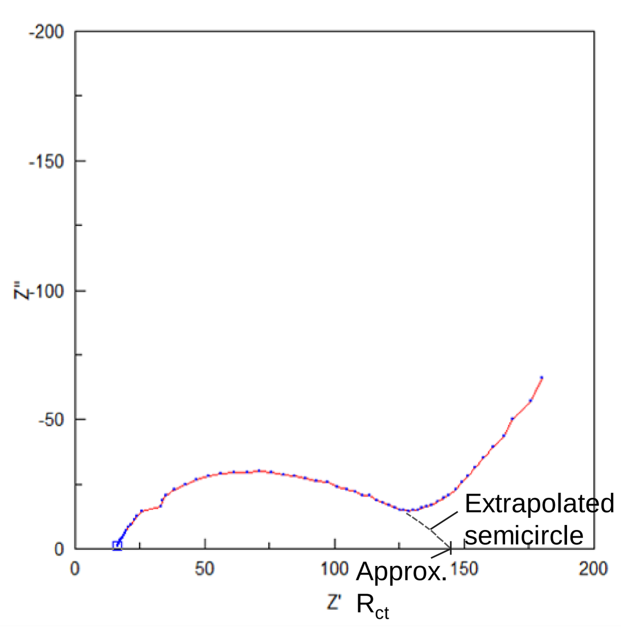

Fig. 6(b). Nyquist Plot of impedance on complex plane $FeCo_2O_4$ by CAC

- R_{ct} is approximately 150Ω

R_{ct} of Graphite: 2Ω [5]

R_{ct} of Graphite < R_{ct} of $FeCo_2O_4$

CONCLUSION

- Successful synthesis and characterisation of $FeCo_2O_4$
- Both have potential to replace graphite
  - High 1st cycle capacity, but high mean capacity fade and R_{ct}
- MSM proved to be a more effective method of synthesis
  - MSM had much higher cyclic stability than by CAC
  - Could be due to structural and morphological differences affected by purity of the sample

FUTURE WORK

- Investigate the usage of different methods or metal salts to synthesise $FeCo_2O_4$ (Chemical/ Physical)
- Investigate the effect of varying the temperature of melting the reactants of $FeCo_2O_4$
- Investigate why $FeCo_2O_4$ could have an experimental capacity so much greater than previously reported
- Investigate the introduction of a carbon coating on the anode

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