Synthesis and Electrochemical Properties of $Li_4Ti_5O_{12}$ as Anode Material for Lithium Ion Batteries

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Introduction

Lithium Ion Batteries are the <u>most popular</u> consumer electronic batteries, having <u>High Energy Density and Low Self Discharge</u>

$Li_4Ti_5O_{12}$: Lithium Titanate (LTO) is anode material for Lithium Ion Batteries. It has <u>good safety characteristic</u> and <u>better cycling capability.</u>

Problems

Low Electrical Conductivity	Low Theoretical Capacity
~10^{-13} Scm^{-1}	~175 $mAhg^{-1}$

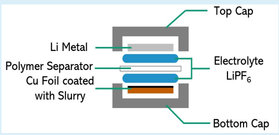
Aims

1. To determine which method of synthesis is best for producing LTO batteries
2. To investigate the effects of Fluorine doping on LTO

Methodology

Methods	LTO	Reactants	Conditions
Ball Milling	1	$4Li_2CO_3$, $5TiO_2$	Ball Milling 780°C, 6h
Solid State	2	$4LiNO_3$, $5TiOSO_4$, 9.5Citric acid, 50ml water	800°C, 3h
	3	$4LiNO_3$, $5TiOSO_4$, 9.5Citric acid, 50ml water, 20ml HCl	800°C, 3h
	4	4Li(Acetate), $5TiO_2$	800°C, 3h
Molten Salt	5	$5TiO_2$, 5LiCl, 5KCl	800°C, 6h, Filtration
	6	$5TiO_2$, 4.35LiCl, 1.15KCl, 4.5 LiOH	800°C, 6h, Filtration
	7	$5TiO_2$, 7.5LiCl, 7.5KCl	800°C, 6h, Filtration
	8	$5TiOSO_4$, 7.5LiCl, 7.5KCl	800°C, 6h, Filtration
Fluorine Doping	9	2g LTO 1 + 0.4g polyvinilidene fluoride	Grinding 750°C, 6h

Battery Preparation



- Scanning Electron Microscopy
- X-Ray Diffraction
- Galvanostatic Cycling
- Cyclic Voltammetry
- Impedance Spectroscopy

Characterization

X Ray Diffraction

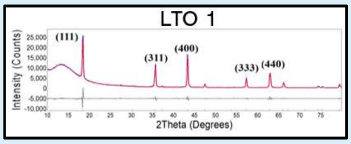
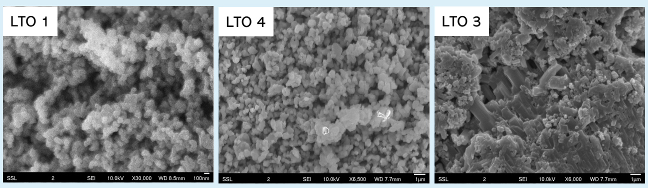


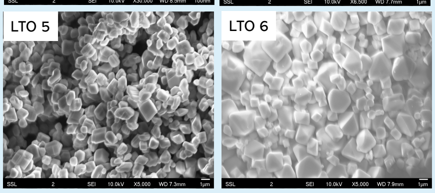
Fig 4: Good XRD of LTO (1)

Besides LTO 1, LTO 4, 6 and F showed high purity samples

All samples showed lattice parameter close to that of 0.8355nm, indicating good purity

Scanning Electron Microscopy





All except LTO 2 and 3 showed good SEM

LTO 1 and 4 did the best, with fine (100nm) and consistent particles

Electrochemical tests

Galvanostatic Cycling

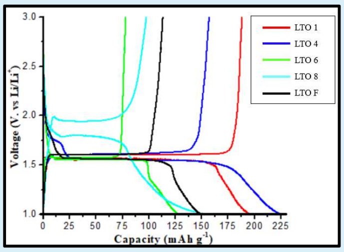


Fig 1a: Voltage against Capacity graph for LTO with good rate capability

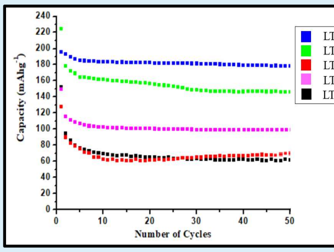


Fig 1b: The discharge capacities for 50 cycles for LTO 1, 4, 6, 8 and F

Figure 1a:
- LTO 4 showed highest initial discharge capacity (225$mAhg^{-1}$)
- LTO 1 (96.3%) and LTO 4 (75.8%) showed high coulombic efficiencies

Figure 1b:
- LTO 1 and 4 showed high capacity retention (less than 20% capacity fade)

Cyclic Voltammetry

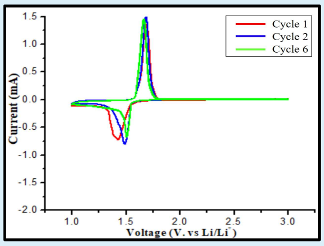


Fig 2: Typical good cyclic voltammogram

Cathodic Peak: ~1.43v
$Li_4Ti_5O_{12} + 3\ Li^+ \rightarrow Li_7Ti_5O_{12}$
Anodic Peak: ~1.69v
$Li_7Ti_5O_{12} \rightarrow Li_4Ti_5O_{12} + 3\ Li^+$

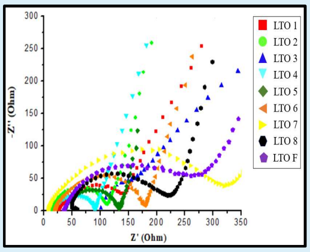
LTO 1, 4, 6, F shows a good cyclic voltammograms, explaining good rate capability.

LTO 1, 4, 6 and F showed good Lithium ion diffusion quotient [Tab 1]

LTO	1	2	3	4	5	6	7	8	F
D/$cm^2\ s^{-1}$	3.6 x 10^{-13}	1.7 x 10^{-15}	2.8 x 10^{-15}	3.3 x 10^{-13}	2.3 x 10^{-15}	3.0 x 10^{-13}	8.1 x 10^{-16}	3.9 x 10^{-15}	1.4 x 10^{-13}

Table 1: Lithium Ion Diffusion quotient

Impedance



Sample	R_{ct}/ Ω
LTO 1	108
LTO 2	86.02
LTO 3	7136
LTO 4	71.77
LTO 5	97.87
LTO 6	159.3
LTO 7	316.5
LTO 8	157.7
LTO F	200.8

Fig 3: Nyquist plots of LTO Table 2: Rct values of LTO

LTO 1, 2, 4, 5, 6, 8, F have good charge Transfer resistances

Conclusion

1. LTO 1, 4 and 6 performed best.
2. A grinding intensive methodology can improve the electrochemical performance of LTO

Credits

I would like to thank
1. Dr M.V. Reddy, mentor
2. Organizers of IPS
3. NUS, for their facilities
4. Catholic Junior College

For giving me this opportunity and supporting me.

Refences

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