

LIST OF FIGURES

Figures	Caption	Pages
Figure 2.1	Dendrite growth on the Li surface [Tarascon and Armand, 2001; Orsini <i>et. al</i> , 1999]	12
Figure 2.2	The vanadate diagram [http://en.wikipedia.org/wiki/Vanadate]	15
Figure 2.3	Crystallographic representation of LiNiVO ₄ structure [Reddy <i>et. al</i> , 2008]	16
Figure 2.4	Raman scattering spectrum of LiNiVO ₄ [Chitra <i>et. al</i> , 2000]	17
Figure 3.1	The prepared LiNiVO ₄ cathode material samples with the raw materials	35
Figure 3.2	Sample preparation for LiNiVO ₄ prepared by the sol gel method	37
Figure 3.3	Sample preparation for LiNiVO ₄ prepared by the polymer precursor method	39
Figure 3.4	Sample preparation for LiNi _{1-x} Mn _x VO ₄ prepared by the sol gel method	41
Figure 3.5	Sample preparation for LiNi _{1-x} Mn _x VO ₄ prepared by the polymer precursor method	43
Figure 3.6	(a) The mixed solution after all raw materials are added; (b) The mixed solution under heating	44
Figure 3.7	(a) The solution turns dark blue after continuous heating; (b) The mixed solution becoming gel-like solution; (c) The gas evolving process throughout the sample	44
Figure 3.8	The sample after sintering process (a) LiNiVO ₄ system; (b) LiNi _{1-x} Mn _x VO ₄ system	44
Figure 3.9	The X-ray diffraction patterns of (a) the as-prepared LiNiVO ₄ precursor and the precursor quenched at (b) 500 °C, (c) 600 °C, (d) 700 °C, and (e) 800 °C, and (f) 1000 °C [Lu and Liou, 1999]	47
Figure 3.10	XRD database 38-1395 for LiNiVO ₄	49
Figure 3.11	TGA/DTA curve for LiNiVO ₄ precursor [Liu <i>et. al</i> , 2002]	50

Figure 3.12	SEM micrographs of LiNiVO_4 prepared by (a) HT-solid state method and the solution precipitation method: (b) pH 3; (c) pH7; (d) pH 11 [Fey and Chen, 1999]	52
Figure 3.13	Scanning electron micrographs of LiNiVO_4 powder prepared by the hydrothermal method at 200 °C. The concentrations of the precursor solution for (a) 0.3 M and (b) 0.6 M [Lu <i>et. al</i> , 1999]	52
Figure 3.14	The Transmission Electron Microscopy (TEM) analyser, LEO-Libra 120	53
Figure 3.15	TEM photograph of LiNiVO_4 powder [Subramania <i>et. al</i> , 2006]	54
Figure 3.16	The etching preparation for TEM analysis	55
Figure 3.17	Cyclic voltammogram of C/ LiNiVO_4 cell employing a Li^+ ion conducting PVdF-HFP based micro-porous polymer electrolyte at a scan rate of 1 mV/s [Kalyani <i>et. al</i> , 2002]	56
Figure 3.18	The sample before grinding; (b) The sample after grinding; (c) The sample after mixing with the TAB binder; (d) The sample for pressing on the hydraulic pump	57
Figure 3.19	The cyclic voltammetry (CV) testing diagram [Kalyani <i>et. al</i> , 2002]	58
Figure 4.1	Mixed phase for the (LiNiVO_4 - SG) system at 500 °C	62
Figure 4.2	XRD pattern for the (LiNiVO_4 - SG) system	63
Figure 4.3	TGA and DTGA curve of the LiNiVO_4 – SG precursor	67
Figure 4.4	Surface morphology of LiNiVO_4 - SG system (a) LiNiVO_4 - SG at 500°C; (b) LiNiVO_4 - SG at 600 °C; (c) LiNiVO_4 - SG at 700 °C; (d) LiNiVO_4 - SG at 800 °C with 500X magnification	69
Figure 4.5	TEM images of LiNiVO_4 - SG system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C	70
Figure 4.6(a)	EDAX analysis of the $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ at 500 °C	73
Figure 4.6(b)	EDAX analysis of the $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ at 600 °C	74
Figure 4.6(c)	EDAX analysis of the $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ at 700 °C	75
Figure 4.6(d)	EDAX analysis of the $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ at 800 °C	76
Figure 4.7	Cyclic voltammograms for Li/ LiNiVO_4 - SG electrode system in 1 mol dm^{-1} LiPF_6 in 1:2 by (vol/ vol%) EC/DMC at scan rate of 1 mV/s (a) cathode sintered at 600 °C; (b) cathode sintered at 800 °C	77

Figure 5.1	XRD pattern for the (LiNiVO ₄ - PP) system	81
Figure 5.2	TGA and DTGA curve of the LiNiVO ₄ -PP precursor	85
Figure 5.3	Surface morphology of LiNiVO ₄ - PP system (a) at 500 °C; (b) at 600 °C; (c) at 700 °C; (d) at 800 °C with 500X magnification	87
Figure 5.4	TEM images of LiNiVO ₄ - PP system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C	88
Figure 5.5	Cyclic voltammograms for Li/ LiNiVO ₄ - PP electrode system in 1 mol dm ⁻¹ LiPF ₆ in 1:2 by (vol/ vol%) EC/DMC at scan rate of 1 mV/s (a) cathode sintered at 500 °C; (b) cathode sintered at 700 °C	89
Figure 6.1	XRD pattern for V1 system	94
Figure 6.2	XRD pattern for V2 system	94
Figure 6.3	XRD pattern for V3 system	95
Figure 6.4	XRD pattern for V4 system	95
Figure 6.5	Lattice constant, <i>a</i> and cell volume, <i>V</i> for LiNi _{1-x} Mn _x VO ₄ - SG (0 ≤ <i>x</i> ≤ 1) system at 600 °C	98
Figure 6.6	Lattice constants and the volumes of crystal cell for LiNi _{1-x} Mn _x VO ₄ -SG (0 ≤ <i>x</i> ≤ 1) by sol- gel method calcined at 600 °C. For Lai <i>et. al</i> , (2002b) temperature is 750 °C	99
Figure 6.7	TGA and DTGA curve of the LiNi _{1-x} Mn _x VO ₄ - SG precursor	102
Figure 6.8	Surface morphology of LiNi _{0.75} Mn _{0.25} VO ₄ - SG system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C with 500X magnification	103
Figure 6.9	TEM images of LiNi _{0.75} Mn _{0.25} VO ₄ - SG system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C	105
Figure 6.10(a)	EDAX analysis of the LiNi _{0.75} Mn _{0.25} VO ₄ at 500 °C	107
Figure 6.10(b)	EDAX analysis of the LiNi _{0.75} Mn _{0.25} VO ₄ at 600 °C	108
Figure 6.10(c)	EDAX analysis of the LiNi _{0.75} Mn _{0.25} VO ₄ at 700 °C	109
Figure 6.10(d)	EDAX analysis of the LiNi _{0.75} Mn _{0.25} VO ₄ at 800 °C	110

Figure 6.11	Cyclic voltammograms for Li/ $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – SG electrode system in 1 mol dm^{-1} LiPF_6 in 1:2 by (vol/ vol%) EC/DMC at scan rate of 1 mV/s (a) cathode sintered at 500 °C; (b) cathode sintered at 800 °C	111
Figure 7.1	XRD pattern for V5 system	116
Figure 7.2	XRD pattern for V6 system	116
Figure 7.3	XRD pattern for V7 system	117
Figure 7.4	XRD pattern for V8 system	117
Figure 7.5	Lattice constant, a and cell volume, V for $\text{LiNi}_{1-x}\text{Mn}_x\text{VO}_4$ system at 600 °C	120
Figure 7.6	Lattice constant, a and cell volume, V for $\text{LiNi}_{1-x}\text{Mn}_x\text{VO}_4$ – PP system at 600 °C. For Lai <i>et. al.</i> , (2002b) temperature is 750 °C.	121
Figure 7.7	TGA and DTGA curve of the $\text{LiNi}_{1-x}\text{Mn}_x\text{VO}_4$ - PP precursor	124
Figure 7.8	Surface morphology of $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – PP system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C with 500X magnification	125
Figure 7.9	Surface morphology of (a) LiNiVO_4 - SG system; (b) LiNiVO_4 - PP system; (c) $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – SG system; (d) $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – PP system at 700 °C with 1.00 kX magnification	127
Figure 7.10	TEM images of $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – PP system at (a) 500 °C; (b) 600 °C; (c) 700 °C; (d) 800 °C	128
Figure 7.11	Cyclic voltammograms for Li/ $\text{LiNi}_{0.75}\text{Mn}_{0.25}\text{VO}_4$ – PP electrode system in 1 mol dm^{-1} LiPF_6 in 1:2 by (vol/ vol%) EC/DMC at scan rate of 1 mV/s (a) cathode sintered at 500 °C; (b) cathode sintered at 800 °C	129