

# Contents

<b>List of Figures</b>	<b>vii</b>
<b>List of Tables</b>	<b>xi</b>
<b>Preface</b>	<b>xii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Background.....	1
<b>1.2 Magnetic hyperthermia.....</b>	<b>1</b>
1.2.1 Mechanism of induction heating.....	3
1.2.2 Reported materials used for the MHT applications.....	7
<b>1.3 Photocatalysis.....</b>	<b>9</b>
1.3.1 Principle of semiconductor photocatalytic process.....	9
1.3.2 Importance of electron and hole pairs (EHPs).....	11
1.3.3 Factors affecting the photocatalytic performance.....	12
1.3.4 Materials utilized for photocatalysis application.....	12
<b>1.4 Electrochemical energy storage devices (LIBs) .....</b>	<b>14</b>
1.4.1 Construction and principle of LIB.....	15
1.4.2 Desirable characteristics for the electrode materials .....	16
1.4.3 Materials utilized earlier as anode for LIBs.....	17

<b>1.5 Synthesis of nanocomposite materials.....</b>	<b>19</b>
<b>1.6 Structural and magnetic properties.....</b>	<b>20</b>
1.6.1 Iron carbide (Fe <sub>3</sub> C).....	21
1.6.2 Magnetite (Fe <sub>3</sub> O <sub>4</sub> ).....	22
<b>1.7 Scope of the present investigation.....</b>	<b>22</b>
<b>2 Materials synthesis and characterization</b>	<b>27</b>
2.1 Introduction.....	27
2.2 Materials.....	28
2.3 Synthesis method.....	28
2.4 Characterization techniques.....	30
2.4.1 X-ray diffraction (XRD).....	30
2.4.2 Transmission electron microscope (TEM).....	31
2.4.3 Zeta potential.....	31
2.4.4 X-ray photoelectron spectroscopy (XPS).....	32
2.4.5 Mössbauer spectroscopy.....	32
2.4.6 Magnetic properties measurement system (MPMS).....	32
2.4.7 Magnetic hyperthermia.....	32
2.4.8 <i>In-vitro</i> studies.....	33
2.4.9 Experimental details for the photocatalytic activity.....	34
2.4.10 Electrode assembly and electrochemical test.....	35

<b>3</b>	<b>Fe<sub>3</sub>C/C nanocomposite</b>	<b>37</b>
3.1	Introduction.....	37
3.2	Results and discussion.....	37
3.2.1	Phase identification by X-ray diffraction.....	37
3.2.2	TEM analysis.....	39
3.2.3	X-ray photoelectron spectroscopy.....	40
3.2.4	Magnetic measurement.....	42
3.2.5	Mössbauer spectroscopy.....	43
3.2.6	Investigation of colloidal stability.....	44
3.2.7	Magnetic hyperthermia studies.....	46
3.2.8	Biocompatibility study.....	48
3.3	Conclusions.....	50
<b>4</b>	<b>Zn substituted Fe<sub>3</sub>C (Zn<sub>x</sub>Fe<sub>3-x</sub>C; 0 &lt; x ≤ 1)</b>	<b>53</b>
4.1	Introduction.....	53
4.2	Results and discussion.....	54
4.2.1	Structural analysis by X-ray diffraction.....	54
4.2.2	Morphological analysis using TEM.....	57
4.2.3	XPS analysis.....	60
4.2.4	Mossbauer spectroscopy.....	62
4.2.5	Magnetic measurement.....	64
4.2.6	Calorimetric measurements for magnetic fluids.....	66
4.2.7	<i>In-vitro</i> study.....	69

4.3	Conclusions.....	71
<b>5</b>	<b>Ni-substituted (Fe<sub>3</sub>C/Fe<sub>3</sub>O<sub>4</sub>)/C nanocomposites</b>	<b>73</b>
5.1	Introduction.....	73
5.2	Results and discussion.....	74
5.2.1	Phase analysis.....	74
5.2.2	Morphological analysis.....	76
5.2.3	XPS analysis.....	78
5.2.4	Mossbauer spectroscopy.....	79
5.2.5	Magnetic properties analysis.....	82
5.2.6	Heating ability.....	84
5.2.7	Cytotoxicity studies.....	85
5.2.8	Band gap analysis.....	87
5.2.9	Fenton and Photo Fenton degradation of PNP.....	88
5.2.10	Fenton and Photo Fenton degradation of MO.....	91
5.2.11	Possible reaction mechanism.....	94
5.3	Conclusions.....	94
<b>6</b>	<b>Mn-substituted (Fe<sub>3</sub>C/Fe<sub>3</sub>O<sub>4</sub>)/C nanocomposites</b>	<b>97</b>
6.1	Introduction.....	97
6.2	Results and discussion.....	98
6.2.1	Structural and phase analysis.....	98
6.2.2	Transmission electron microscopy.....	100

6.2.3	XPS analysis.....	104
6.2.4	Mossbauer spectroscopy.....	106
6.2.5	Magnetic properties measurement.....	108
6.2.6	Heating efficacy.....	109
6.2.7	Cytotoxicity study.....	110
6.2.8	Evaluation of the electrochemical performance.....	111
6.3	Conclusions.....	118
<b>7</b>	<b>Overall conclusions and future prospects</b>	<b>121</b>
7.1	Conclusions.....	121
7.2	Suggestions for future work.....	124
	<b>References</b>	<b>117</b>