

Contents

Abstract	i
Certificate I	vii
Certificate II	ix
Acknowledgements	xi
Dedication	xiii
Contents	xv
List of Figures	xxi
List of Tables	xxv
Nomenclature	xxix
1 Introduction	1
1.1 Importance of reusing industrial wastes	1
1.2 Industrial lime sludge waste and its reuse	2
1.3 Use of industrial wastes in polymeric composites	3
1.4 Potential use of lime sludge as a filler in polymeric composites	6
1.5 Outline of the thesis	7
2 Literature Survey	9
2.1 Composites	10
2.2 Classification of polymeric composites	11
2.2.1 Particulate composites	12
2.2.2 Fibre reinforced composites	16
2.2.3 Multi component hybrid composites	20

2.3	Role of compatibilizers in composites	21
2.4	Industrial waste based composites	24
2.5	Industrial lime sludge waste	27
2.6	Prediction of composite properties	29
2.7	Opportunities for research and development	30
2.8	Aim of the thesis	32
2.8.1	Hypothesis	32
2.8.2	Objectives	32
3	Materials and Methods	33
3.1	Materials	33
3.2	Sample preparation	34
3.2.1	Raw lime sludge filled HDPE composites	34
3.2.2	Stearic acid coated lime sludge filled HDPE composites	35
3.2.3	Lime sludge filled maleic anhydride grafted HDPE (MAPE) composites	37
3.2.4	Lime sludge filled HDPE-MAPE blends	37
3.2.5	Lime sludge filled HDPE-PP blends	37
3.2.6	Lime sludge filled coir-epoxy composites	38
3.2.7	Lime sludge filled coir-HDPE composites	39
3.3	Mechanical property testing	40
3.4	Thermal property testing	44
3.4.1	DSC analysis	44
3.4.2	TG analysis	44
3.5	Characterization techniques	45
3.5.1	FTIR spectroscopy	45
3.5.2	XRD analysis	45
3.5.3	ICP-OES analysis	45
3.5.4	SEM analysis	46
3.5.5	Water absorption measurement	47
4	Raw lime sludge filled HDPE composites	49
4.1	Characterization of lime sludge	49
4.1.1	SEM Analysis	50
4.1.2	XRD Analysis	50
4.1.3	ICP-OES Analysis	51
4.1.4	TG Analysis	52

4.2	Lime sludge-HDPE composites	53
4.2.1	Mechanical properties	53
4.2.2	Thermal properties	61
4.3	Morphological Analysis of lime sludge-HDPE composites	65
4.4	Water absorption properties	68
4.5	Regression analysis	68
4.6	Summary	71
5	Stearic acid coated lime sludge filled HDPE composites	75
5.1	Stearic acid coating on lime sludge - FTIR spectroscopy	76
5.2	Mechanical and morphological Properties	76
5.2.1	Tensile strength	77
5.2.2	Tensile modulus	80
5.2.3	Elongation at break	82
5.2.4	Flexural strength	82
5.2.5	Flexural modulus	84
5.2.6	Impact strength	84
5.3	Thermal Properties - TG analysis	84
5.4	Water absorption properties	86
5.5	Regression Analysis	88
5.6	Comparison with popular theoretical models	89
5.6.1	Relative tensile strength	91
5.6.2	Relative Young's modulus	92
5.6.3	Relative elongation at break	95
5.7	Summary	96
6	Analysis of lime sludge filled various hybrid composites	101
6.1	Lime sludge filled HDPE-MAPE composites	101
6.1.1	Mechanical properties	102
6.2	Lime sludge filled HDPE-PP blends	109
6.2.1	Mechanical properties	110
6.2.2	Thermal properties	113
6.3	Lime sludge filled coir-HDPE-MAPE hybrid composites	117
6.3.1	Effect of fibre loading on coir-HDPE composites	118
6.3.2	Effect of MAPE on coir-HDPE composites	121
6.3.3	Effect of lime sludge on coir-HDPE-MAPE composites	121
6.4	Lime sludge filled epoxy composites	124

6.5	Lime sludge filled coir fibre epoxy composites	126
6.5.1	Mechanical properties	126
6.5.2	Thermal properties	130
6.6	Summary	132
7	Conclusions and Future Work	135
7.1	Conclusions	135
7.2	Future research work	139
A	Mechanical properties of composites	141
A.1	Mechanical properties - raw lime sludge composites	141
A.1.1	Tensile strength	141
A.1.2	Tensile modulus	142
A.1.3	Elongation at break	142
A.1.4	Flexural strength	142
A.1.5	Flexural modulus	143
A.1.6	Impact strength	143
A.2	Mechanical properties - coated lime sludge composites	144
A.2.1	Tensile strength	144
A.2.2	Tensile modulus	144
A.2.3	Elongation at break	144
A.2.4	Flexural strength	145
A.2.5	Flexural modulus	145
A.2.6	Impact strength	145
A.3	Mechanical properties - lime sludge filled HDPE-PP composites	146
A.3.1	Tensile strength	146
A.3.2	Tensile modulus	146
A.3.3	Elongation at break	146
A.3.4	Shore D hardness	147
A.4	Shore D hardness of lime sludge-HDPE composites	147
A.5	Lime sludge filled HDPE-MAPE composites	148
A.5.1	Tensile strength	148
A.5.2	Tensile modulus	149
A.5.3	Elongation at break	150
A.5.4	Flexural strength	151
A.5.5	Flexural modulus	152
A.5.6	Impact strength	153

A.6	Lime sludge filled CF-HDPE-MAPE composites	154
A.6.1	Tensile strength	154
A.6.2	Tensile modulus	155
A.6.3	Elongation at break	155
A.6.4	Flexural strength	156
A.6.5	Flexural modulus	156
A.6.6	Impact strength	157
A.7	Lime sludge filled epoxy composites	157
A.7.1	Tensile strength	157
A.7.2	Tensile modulus	158
A.7.3	Elongation at break	158
A.8	Lime sludge filled coir-epoxy composites	159
A.8.1	Tensile strength	159
A.8.2	Tensile modulus	160
A.8.3	Elongation at break	160
A.8.4	Flexural strength	161
A.8.5	Flexural modulus	161
B	List of Publications	163
B.1	Journal Publications:	163
B.2	Book Chapter:	163
	Bibliography	165

