CONTENTS

Chapter 1 : General Introduction	**1-45**
1.1: Overview	2
1.2: Base Oil	4
1.2.1: Classification based on chemical structure	4
1.2.2: Classification based on American Petroleum Institute (API) standard	7
1.3: Castor Oil (CO)	8
1.4: Engine Oil (EO)	10
1.5: Nano-additives: Newer class of oil additives	13
1.6: Influence of nano-additives on the rheology of base oil and its nanofluids	19
1.6.1: Rheology	19
1.6.2: Newtonian and non-Newtonian flow behaviour of fluids	20
1.6.3: Factors influencing rheology of nanofluids	23
1.7: Influence of nano-additives on the thermal conductivity of base oil and its nanofluids	24
1.7.1: Thermal conductivity	24
1.7.2: Thermal conductivity mechanism of nanofluids	26
1.7.3: Factors influencing thermal conductivity of nanofluids	28
1.8: Present research	29
1.9: References	31
Chapter 2 : Materials and Methods	**46-68**
2.1: Base Oils	47
2.1.1: Castor Oil (CO)	47
2.1.1.1: Properties of CO	48
2.1.1.2: Specific gravity measurement	48
2.1.1.3: Hydroxyl number measurement	49
2.1.1.4: Saponification value measurement	50
2.1.1.5: Iodine value measurement	51
2.1.1.6: Acid value measurement	52
2.1.1.7: Viscosity measurement	52

2.1.2: Engine Oil (EO)	53
2.1.2.1: Measurements of EO properties	54
2.2: Methods used for characterization of nano-additives/nanofluids	56
2.2.1: X-Ray Diffraction (XRD) Analysis	56
2.2.2: Scanning Electron Microscopy (SEM)/ Energy Dispersive Spectroscopy (EDS) Analysis	57
2.2.3: Rheology measurements	58
2.2.4: Thermal conductivity measurements	59
2.3: Instruments/equipments used to synthesize nano-additives and nanofluids	61
2.3.1: Hydrothermal reactor	61
2.3.2: Probe sonicator	62
2.3.3: Analytical balance	63
2.3.4: pH meter	64
2.3.5: Universal Oven	64
2.3.6: Vacuum Oven	65
2.4: References	66
Chapter 3 : Nano-additives for development of Castor oil and Engine oil- based Nanofluids	**69-82**
3.1: Alumina (Al_2O_3) nanoparticles	70
3.1.1: Synthesis of Al_2O_3 nanoparticles using hydrothermal technique	70
3.1.2: Characterization of Al_2O_3 nanoparticles	71
3.2: Zinc oxide (ZnO) nanoparticles	73
3.2.1: Synthesis of ZnO nanoparticles using hydrothermal technique	73
3.2.2: Characterization of ZnO nanoparticles	73
3.3: Graphene nanoplatelets (GNP)	76
3.3.1: Characterization of GNP nanoparticles	76
3.4: Multiwalled carbon nanotubes (MWCNT)	78
3.4.1: Characterization of MWCNT nanoparticles	78
3.5: References	80

Chapter 4 : Castor oil-based nanofluids containing Al_2O_3, ZnO, GNP and MWCNT nano-additives **83-122**

4.1: Preparation of Castor oil-based nanofluids containing Al_2O_3, ZnO, GNP and MWCNT nano-additives 84

4.2: CO-based nanofluids containing Al_2O_3 nano-additives (Al_2O_3/CO nanofluids) 86

4.2.1: Flow characteristics of Al_2O_3/CO nanofluids using rheometry 86

4.2.2: Thermal conductivity characteristics of Al_2O_3/CO nanofluids 91

4.3: CO-based nanofluids containing ZnO nano-additives (ZnO/CO nanofluids) 93

4.3.1: Flow characteristics of ZnO/CO nanofluids using rheometry 93

4.3.2: Thermal conductivity characteristics of ZnO/CO nanofluids 98

4.4: CO-based nanofluids containing GNP nano-additives (GNP/CO nanofluids) 100

4.4.1: Flow characteristics of GNP/CO nanofluids using rheometry 100

4.4.2: Thermal conductivity characteristics of GNP/CO nanofluids 105

4.5: CO-based nanofluids containing MWCNT nano-additives (MWCNT/CO nanofluids) 107

4.5.1: Flow characteristics of MWCNT/CO nanofluids using rheometry 107

4.5.2: Thermal conductivity characteristics of MWCNT/CO nanofluids 112

4.6: Results and discussion 114

4.7: Chapter Conclusion 118

4.8: References 120

Chapter 5 : Engine oil-based nanofluids containing Al_2O_3, ZnO, GNP and MWCNT nano-additives **123-160**

5.1: Preparation of engine oil-based nanofluids containing Al_2O_3, ZnO, GNP and MWCNT nano-additives 124

5.2: EO-based nanofluids containing Al_2O_3 nano-additives (Al_2O_3/EO nanofluids) 126

5.2.1: Flow characteristics of Al_2O_3/EO nanofluids using rheometry 126

5.2.2: Thermal conductivity characteristics of Al_2O_3/EO nanofluids 131
5.3: EO-based nanofluids containing ZnO nano-additives (ZnO/EO nanofluids) 133
5.3.1: Flow characteristics of ZnO/EO nanofluids using rheometry 133
5.3.2: Thermal conductivity characteristics of ZnO/EO nanofluids 138
5.4: EO-based nanofluids containing GNP nano-additives (GNP/EO nanofluids) 140
5.4.1: Flow characteristics of GNP/EO nanofluids using rheometry 140
5.4.2: Thermal conductivity characteristics of GNP/EO nanofluids 145
5.5: EO-based nanofluids containing MWCNT nano-additives (MWCNT/EO nanofluids) 147
5.5.1: Flow characteristics of MWCNT/EO nanofluids using rheometry 147
5.5.2: Thermal conductivity characteristics of MWCNT/EO nanofluids 152
5.6: Results and discussion 154
5.7: Conclusion 157
5.8: References 159
Chapter 6 : Summary and Conclusions **161-171**
List of Publications 172
List of Presentations 172