

Contents

Certificate	iii
Declaration by the Candidate	iv
Copyright Transfer Certificate	v
Acknowledgments	vii
Contents	ix
List of Figures	xvii
List of Tables	xxi
List of Abbreviations	xxiii
Preface	xxv
Chapter 1 Introduction	1
1.1 Background.....	1
1.2 Research Objectives.....	3
1.3 Scope and Methodology	4
1.4 Organization of Thesis.....	7
Chapter 2 Literature Review	9
2.1 Introduction.....	9

2.2	Dust Generation in Haul Roads.....	15
2.2.1	Estimating Dust Concentration Using Visual Method.....	16
2.3	Nature and Characteristic of Haul Road Dust.....	18
2.4	Impact of Dust.....	22
2.5	Why Dust Control is Important.....	25
2.6	Dust Control Methodology.....	26
2.6.1	Administrative method.....	26
2.6.2	Mechanical method.....	27
2.6.3	Watering Method.....	27
2.6.4	Chemical method.....	28
2.7	Chemical Dust Suppressants.....	29
2.7.1	Water attracting salt.....	29
2.7.2	Ligno-sulphonates.....	30
2.7.3	Bitumen emulsions.....	31
2.8	Polymers as Dust Suppressant.....	31
2.9	Research Gap.....	35
2.10	Introduction on Polymers.....	35
2.11	Initiator for Polymerization.....	36
2.11.1	Ceric Ammonium Nitrate.....	36
2.12	Polymerization Techniques.....	37
2.12.1	Free radical polymerization mechanism.....	38

2.13 Graft Co-Polymers.....	38
2.14 Co-Polymers	40
2.15 Polyacrylamide (PAM).....	41
2.15.1 Polyacrylamide (PAM) as a dust suppressant.....	41
2.15.2 Environmental Effects of Polyacrylamide.....	42
2.16 Polysaccharides.....	43
2.16.1 Amylopectin.....	44
2.16.2 Guar gum	45
2.17 Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid (PAMPS)	47
Chapter 3 Methodology and Experimentation	49
3.1 Experimental Details.....	49
3.2 Mine Description	49
3.2.1 Climatic condition.....	49
3.3 Methods of Haul Road Dust Sample Collection.....	51
3.4 Chemical Materials	52
3.5 Synthesis of Polymers.....	52
3.5.1 Synthesis of Polyacrylamide (PAM)	53
3.5.2 Synthesis of Hydrolyzed Polyacrylamide (H-PAM)	55
3.5.3 Synthesis of Amylopectin-grafted-Polyacrylamide (AP-g-PAM).....	55
3.5.4 Synthesis of Hydrolyzed-Amylopectin-grafted-Polyacrylamide (H-AP-g-PAM)	57

3.5.5.	Synthesis of Guargum-grafted- Polyacrylamide (GG-g-PAM)	58
3.5.6.	Synthesis of Hydrolyzed Guargum-grafted-Polyacrylamide (H-GG-g-PAM)	59
3.5.7.	Synthesis of Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid-co- Polyacrylamide (PAMPS-co-PAM)	60
3.5.8.	Hydrolyzed poly(2-acrylamido-2-methyl-1-propanesulfonic) acid -co- Polyacrylamide (H-PAMPS-co-PAM).....	61
3.6	Characterization of Haul Road Dust	61
3.6.1	Size distribution.....	62
3.6.1.1	<i>Sieving analysis</i>	62
3.6.2	EDX spectroscopy.....	63
3.7	Characterization of Synthesized Polymers.....	63
3.7.1	¹ H NMR spectroscopy.....	64
3.7.2	FTIR spectroscopy	65
3.7.3	Thermogravimetric analysis (TGA)	66
3.7.4	Intrinsic viscosity	66
3.7.5	Molecular weight measurement	68
3.7.6	Neutralization Equivalent.....	68
3.7.6.1	<i>Titration Process</i>	69
3.8	Calculation for Polymer Dosage	70
3.9	Laboratory Experimentation on Moisture Retention of Dust Samples	70
3.10	Calculation for Moisture Retention Efficiency	74
3.11	Prediction of Haul Road Dust Emission Rate	75

Chapter 4 Characterization of Haul Road Dust and Synthesized Polymers.....81

4.1	Introduction.....	81
4.2	Characterization of Haul Road Dust.....	81
4.2.1	Size distribution.....	81
4.2.2	EDX spectroscopy.....	82
4.3	Characterization of Synthesized Polymers.....	85
4.4	¹ H NMR Spectroscopy.....	85
4.4.1	Polyacrylamide (PAM).....	85
4.4.2	Hydrolyzed Polyacrylamide (H-PAM).....	86
4.4.3	Amylopectin-grafted- Polyacrylamide (AP-g-PAM).....	87
4.4.4	Hydrolyzed -Amylopectin-grafted- Polyacrylamide (H-AP-g-PAM).....	88
4.4.5	Guargum-grafted- Polyacrylamide (GG-g-PAM).....	88
4.4.6	Hydrolyzed-Guargum-grafted-Polyacrylamide (H-GG-g-PAM).....	89
4.4.7	Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid-co-Polyacrylamide (PAMPS-co-PAM).....	90
4.4.8	Hydrolyzed Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid -co- Polyacrylamide (H-PAMPS-co-PAM).....	91
4.5	FTIR Spectroscopy.....	91
4.5.1	Polyacrylamide (PAM).....	91
4.5.2	Hydrolyzed Polyacrylamide (H-PAM).....	92
4.5.3	Amylopectin-grafted-Polyacrylamide (AP-g-PAM).....	93
4.5.4	Hydrolyzed-Amylopectin-grafted-Polyacrylamide (H-AP-g-PAM).....	94

4.5.5	Guargum-grafted-Polyacrylamide (GG-g-PAM).....	95
4.5.6	Hydrolyzed-Guargum-grafted-Polyacrylamide (H-GG-g-PAM).....	96
4.5.7	Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid-co-Polyacrylamide (PAMPS-co-PAM)	97
4.5.8	Hydrolyzed Poly (2-acrylamido-2-methyl-1-propanesulfonic) acid -co-Polyacrylamide (H-PAMPS-co-PAM).....	98
4.6	Thermogravimetric Analysis (TGA).....	99
4.7	Intrinsic Viscosity Measurement.....	105
4.7.1	Polyacrylamide (PAM).....	105
4.7.2	Hydrolyzed Polyacrylamide (H-PAM)	106
4.8	Molecular Weight Measurement.....	112
4.9	Neutralization Equivalent Measurement.....	112

Chapter 5 Working Principle of Synthesized Polymers Acting as Dust Suppressant

..... 115

5.1	Introduction	115
5.2	Chemistry behind PAM to work as a dust suppressant.....	115
5.3	Chemistry behind AP-g-PAM to work as a dust suppressant	116
5.4	Chemistry behind GG-g-PAM to work as a dust suppressant.....	117
5.5	Chemistry behind PAMPS-co-PAM to work as a dust suppressant	118
5.6	Chemistry behind the hydrolyzed polymers acting as dust suppressant	119

Chapter 6 Experimental Results on Effectiveness of Polymeric Dust Suppressants 121

6.1	Introduction.....	121
6.2	Comparison of Moisture Retention Efficiency of Dust Suppressants	121
6.2.1	Moisture retention efficiency of dust suppressants at 25 °C	122
6.2.2	Moisture retention efficiency of dust suppressants at 35 °C	123
6.2.3	Moisture retention efficiency of dust suppressants at 45 °C	125
6.3	Comparison of Dust Emission Rates for Different Dust Suppressants	127
6.3.1	Estimation of dust emission rate.....	127
6.3.2	Dust emission rate for different dust suppressants at 25 °C	128
6.3.3	Dust emission rate for dust suppressants at 35 °C.....	129
6.3.4	Dust emission rate for dust suppressants at 45 °C.....	131
6.4	Selection of Best Performing Polymer	133
6.4.1	At low Temperature (25 °C) & after 8 hour of application	133
6.4.2	At moderate Temperature (35 °C) & after 7 hour of application	133
6.4.3	At high Temperature (45 °C) & after 2 hour of application	134
	Chapter 7 Conclusions.....	135
7.1	Conclusions.....	135
7.2	Suggestions for Future Studies	137
	References.....	139
	Publications	151