# Table of Contents

Declaration ..... i
Certificate ..... ii
Acknowledgment ..... iii
Abstract ..... vi
Abbreviations ..... viii
List of Figures ..... ix
List of Tables ..... xii
Table of Contents ..... xiii
Chapter 01. Introduction ..... 1
1.1 Preamble ..... 1
1.2 Objectives ..... 3
1.3 Research Methodology ..... 3
1.4 Thesis Organization ..... 4
Chapter 02. Literature review ..... 6
2.1 Preamble ..... 6
2.2 Introduction to Fibers ..... 6
2.3 Bibliometric studies ..... 8
2.4 State of Art Literature Review ..... 11
2.4.1 Fiber characterization ..... 12
2.4.2 Chicken Feather Fiber composite ..... 13
2.4.2.1 Matrix material ..... 13
2.4.2.2 Effect of fiber length. ..... 14
2.4.2.3 Methods of Manufacturing ..... 15
2.4.3 3D printing of composites ..... 19
2.4.3.1 Fused Deposition Method (FDM) ..... 21
2.5 Filament Extruder ..... 24
2.6 Literature review summary ..... 28
Chapter 03. Materials ..... 30
3.1 Introduction ..... 30
3.2 Chicken Feather Fiber (CFF) ..... 30
3.2.1 Physical properties of Chicken feather ..... 31
3.2.2 Morphology of Chicken feather ..... 32
3.2.3 Chemical structure of Chicken feather ..... 33
3.2.4 Mechanical properties of Chicken feather ..... 34

3.2.5 Thermal properties of Chicken feather ..... 35
3.2.6 Pre-processing of Chicken feather ..... 36
3.3 Poly-Lactic Acid (PLA) ..... 36
3.3.1 Pre-processing of Poly-Lactic Acid ..... 38
Chapter 04. Manufacturing of CFF/PLA composites ..... 39
4.1 Preamble ..... 39
4.2 Composite CFF/PLA Filament Extrusion ..... 39
4.2.1 Composite Filament Extruder ..... 40
4.2.2 Design of Filament Extruder ..... 42
4.2.2.1 Extruder Screw Design ..... 43
4.2.2.2 Barrel Design ..... 44
4.2.2.3 Heater Band ..... 44
4.2.2.4 Hopper ..... 44
4.2.2.5 Volumetric flow rate of the extruder ..... 45
4.2.2.6 Motor Capacity ..... 47
4.2.2.7 Extruder Nozzle Design ..... 47
4.2.2.8 Hot water bath ..... 49
4.2.2.9 Short fiber reinforced composite filament extruder assembly ..... 50
4.2.3 Preparation of CFF/PLA filament Samples ..... 52
4.3 Sample preparation by sandwich method ..... 54
Chapter 05. Characterization Techniques ..... 55
5.1 Preamble ..... 55
5.2 Mechanical Properties ..... 55
5.2.1 Tensile test ..... 56
5.3 Stereoscopic Microscopy ..... 57
5.4 Thermal Properties ..... 57
5.4.1 Digital Scanning Electroscopy (DSC) ..... 57
5.4.2 Thermogravimetric Analysis (TGA) ..... 58
5.4.3 Derivative Thermogravimetric Analysis (DTGA) ..... 59
5.5 Spectroscopic Technique ..... 59
5.5.1 Fourier Transform Infrared (FT-IR) Spectroscopy ..... 59
5.5.2 Ultraviolet-Visible (UV) Spectroscopy ..... 60
5.6 Other Studies ..... 60
5.6.1 Chemical solubility ..... 60
5.6.2 Electrical Resistance ..... 61
Chapter 06. Results and Discussion ..... 62
6.1 Preamble ..... 62

6.2 Test results of filament samples prepared using the filament extruder ..... 63
6.2.1 Tensile strength ..... 63
6.2.2 Visual Observation by stereoscopic microscope ..... 64
6.2.3 Differential Scanning Calorimetry (DSC) ..... 66
6.2.4 Thermogravimetric Analysis (TGA) ..... 68
6.2.4 Fourier transform infrared spectroscopy (FT-IR) ..... 70
6.2.5 Solubility in Alkaline Medium ..... 72
6.2.6 Electrical Resistance ..... 72
Chapter 07. Conclusion and Future Scope ..... 73
7.1 Conclusion ..... 73
7.2 Future Scope ..... 74
References ..... 76
APPENDIX 1 - List of Publications ..... 95