Studies on high modulus high tenacity polypropylene fibers and single polymer composites

by

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Certificate

This is to certify that the thesis entitled **"Studies on high modulus high tenacity polypropylene fibers and single polymer composites"** being submitted by Mr. **Samrat Mukhopadhyay**, to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in the Department of Textile Technology is a record of bonafide research work carried out by him. Mr. Mukhopadhyay has worked under our guidance and supervision and fulfilled the requirements for the submission of the thesis.

The results contained in the thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or Diploma.

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Abstract

High modulus and high tenacity polypropylene (PP) filaments have been produced by subjecting as-spun filaments to a two stage drawing on a conventional mode and subsequently drawing on a heater having a gradient of temperatures. A three element gradient heater is developed for the drawing process. PP of 35 and 17 MFI are studied. Results show that filament properties are significantly affected by gradient heater settings i.e. nature and extent of gradient and end temperatures. It has been demonstrated that very high draw ratios could be obtained through gradient drawing process.

Gradient heater could be considered to consist of a series of a large number of heaters one after the other with increasing temperature. At each heater point the filament is drawn due to higher temperature than the previous point. This allows an increase in the level of orientation with low relaxation of molecules. Thus an incremental drawing over the heater plate is achieved. The process allows drawing to be carried out in the melting range. PP filaments are drawn in the gradient of temperatures in the range of (160-160-168)°C over the heater plate. On a constant temperature heater plate, maximum temperatures attainable are limited to much below the melting point. Alternately a very large number of heater plates will be required in a typical multistage drawing process.

The gradient drawn PP samples showed high crystal perfection and crystallinity. A sample with x-ray crystallinity values of 73%, crystalline orientation function of 0.96, amorphous orientation value of 0.83 has been obtained. The melting half widths are typically in the range of 4°C, indicating very narrow crystal size distribution and high

degree of crystal perfection. Fibers having initial modulus of 17.5 GPa and tenacity of 730MPa have been prepared. A very low thermal shrinkage of 7% at 150°C indicates excellent dimensional stability. Dynamic mechanical studies showed high storage modulus retention at high temperatures and shallow and delayed tanδ peak indicating high amorphous orientation. The gradient drawing process has the advantage of being continuous in nature as compared to others, which are mainly batch processes.

These filaments are arranged in uniaxial direction and hot compacted under temperatures of approximately 154°C and pressure, to make a sheet like structure, using a constant loading device. Composites of 330 MPa strength and 25% elongation could be prepared. Morphology of the composites revealed excellent fiber-matrix adhesion. Initial experiments showed retention of filament properties to around 60% of those of the starting samples even at such high compaction temperatures, which gives the composite high strength. The matrix morphology undergoes a significant change in crystallinity upon compaction and is reflected in the thermo-mechanical properties.

CONTENTS

1 Introduction

1.1 Introduction 1
1.2 Scope of the work 2
1.3 About the thesis 3

2.Review of previous work

2.1 Introduction 5
2.2 Factors affecting properties of polypropylene fibers: 6
2.2.1 Feed Parameters 6
2.2.1.1 Molecular weight (MW) of the sample 6
2.2.1.2 Initial morphology 8
2.2.1.3 Polydispersity 8
2.2.1.4 Presence of entanglements 9

2.3 Processing parameters: 9
2.3.1 Spinning parameters 9
2.3.1.1 Spin line stress 9
2.3.1.2 Spinning temperature 10
2.3.1.3 Cooling procedure 10
2.3.1.4 Take up velocity 10

2.3.2 Post spinning parameters 12
2.3.2.1 Draw ratio, number of drawing stages and drawing speed 14
2.3.2.2 Drawing techniques 15
2.3.2.2.1 Tensile drawing 15
2.3.2.2.2 Zone drawing and zone annealing 15
2.3.2.2.3 Constant load oven drawing 17
2.3.2.2.4 Die drawing 17
2.3.2.2.5 Hot nip drawing 19

2.3.2.3 Temperature of drawing 19
2.3.2.4 Heat setting / annealing 21

2.4 Summary of Previous production of High Modulus Polypropylene Fibers 23
2.4.1 Crystallite and amorphous orientation 24
2.4.2 Amorphous modulus values 26
2.4.3 Degree of crystallinity 28
2.4.4 Presence of taut tie molecules 28

2.5 Fiber reinforced composite 29
2.5.1 Thermoplastic matrices and Polypropylene 30
2.5.2 Importance of the interphase 31
2.5.3 Processing conditions affecting the properties of the Composite 31
2.5.4 Single Polymer Composite 31

2.6 Conclusion and justification for present work 36

3. Experimental

3.1 Introduction 38
3.2 Materials 38
3.3 Monofilament preparation 38
3.4 Polymer MFI and Filament Characterisation 41
3.4.1 Melt Flow Index (MFI) 41
3.4.2 Sonic Modulus 41
3.4.3 Differential Scanning Calorimetry 41
3.4.4 Wide-Angle X-Ray Diffraction 42
3.4.4.1 Crystallinity and Crystallite Perfection 42
3.4.4.2 Crystalline Orientation Function 43
3.4.5 Birefringence and amorphous orientation function 44
3.4.6 Density and Density crystallinity 45
3.4.7 Volume fraction of Voids 45

3.5 Mechanical Properties 45
3.5.1 Quasi-Static Mechanical Properties 45
3.5.2 Dynamic mechanical properties 46

3.6 Thermal properties 46
3.6.1 Thermomechanical Analysis 46
3.6.2 Free Thermal Shrinkage 47

4. Gradient heater - design, process analysis, and selection of samples

4.1 Introduction 49
4.2 Initial experiments 49

4.3 Simulation of gradient profile 51
4.4 Fabrication and experiments on three element heater 53
4.5 Sample nomenclature and further selection 56
4.6 Conclusion 60

5. Structure, Morphology, Mechanical and Thermal properties

5.1 Introduction 62
5.2 Experimental 63
5.3 Results and discussion 65
5.3.1 DSC crystallinity, melting peak and peak half-width 65
5.3.2 Presence of multiple endotherms in DSC 69
5.3.3 Crystallite dimensions, crystallite and amorphous orientation and void fraction 70
5.3.4 Density and void fraction 73
5.3.5 Quasi-static tensile properties 75
5.3.6 Dynamic Mechanical Analysis 80
5.3.7 Free Thermal shrinkage studies 83
5.3.8 Thermomechanical analyses 85
5.3.9 Fracture morphology 88
5.3.10 Morphological changes during the gradient drawing process 90

5.4 Conclusions 91

6. Composites based on Gradient Drawn filaments

6.1 Introduction 93
6.2 Experimental 94
6.2.1 Materials 94
6.2.2 Characterisation of composites 96
6.2.2.1 Static Mechanical Properties 96
6.2.2.2 X-ray studies 97
6.2.2.3 Differential Scanning Calorimetry studies 97
6.2.2.4 Optical Microscopy 97
6.2.2.5 Morphology 98

6.2.3 Basis for preparation of single-polymer composites 98

6.2.4 Selection of material and process parameters 100
6.2.4.1 Consolidation Pressure 100
6.2.4.2 Consolidation Time and mode of transfer 101

6.2.4.3 The optimized temperature pressure cycle 102

6.3 Results and Discussion 103
6.3.1 Structure and Morphology 103
6.3.2 Tensile properties 108

6.4 Conclusion 113

7. Conclusions 115

References 117

Appendix 123