TECHNICAL GRADE FILAMENT FROM NYLON6 AND BLENDS OF NYLON6 & NYLON66

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by

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A thesis submitted
in fulfilment of the requirements
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DOCTOR OF PHILOSOPHY

To The

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DEDICATED TO MY

GRANDPARENTS
&
PARENTS

CERTIFICATE

This is to certify that the thesis entitled "TECHNICAL GRADE FILAMENT FROM NYLON6 AND BLENDS OF NYLON6 & NYLON66", being submitted by MR. KASINATH BHAUMIK,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. KASHINATH BHAUMIK has worked under our guidance and supervision and fulfilled the requirements for the submission of the thesis.

The results contained in this 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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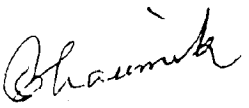

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ABSTRACT

Technical grade nylon filaments have been prepared from nylon6 and blends of nylon6 and nylon66 with a view to improve strength/modulus. Melt spinning and two zone drawing processes have been used to produce nylon filament/yarn. As-spun conditioned ($\sim$ 55 % RH) nylon 6 sample shows two tanδ peaks at $\sim$ 40 ^{o}C and $\sim$ 95 ^{o}C. The former peak corresponds to moisture- nylon-network structure, whereas, the peak at 95 ^{o}C relates to main α_a - relaxation in dry nylon6 (over $P_{2.5}$) sample.

It is observed that the process of drawing is very sensitive to the presence of moisture. Drawing at temperature above 100 ^{o}C with draw ratio as NDR in the first zone leads to decreased drwaing stress and removes the effect of variation of moisture. These filaments have higher molecular orientation, larger (γ + pleated α) phase content and are superior materials as compared to other conditions of drawing.

The response surface methodology for process optimization is successfully applied for optimization of two zone drawing process. The optimum properties, i.e. strength,modulus and elongation are in the range of 10.1 x 10^{8} N/m^{2} - 10.3x10^{8} N/m^{2} (10.0 - 10.2) gpd, 52x10^{8} N/m^{2} - 54x 10^{8} N/m^{2} and 13- 13.5 % respectively. The optimum process conditions, i.e. first zone draw ratio , first and second zone temperatures are in the range of 2.5 - 3.0, 100 - 125 ^{o}C

and 190 - 205 °C respectively. Improved properties of nylon6 filament under optimum conditions relate to superior molecular orientation and crystallinity.

It is observed that second zone temperature is critical in determining the changes in molecular weight and molecular weight distribution of nylon6 filament during the production. Drawing temperature of 200 °C is preferable due to higher molecular weight associated with solid state polymerization and minimum changes due to degradation. Significant degradation is observed at second zone drawing temperature of 150 °C. This is related to chain scission due to higher drawing stress.

In blending of nylon6 and nylon66, it is observed that nylon66 acts as nucleating agent for nylon6. Overall crystallization rate of either nylon decreases with blending and is minimum in the range of 30 - 50% of nylon66 in nylon6.

During melt spinning of blends sufficient uniformity is obtained indicating good mixing of components. The blend samples have improved drawability which is associated with interfacial slippage at the boundary between the components and increased crystal size distribution. Optimum blend filament properties are obtained for 30 - 50 % of nylon66 blend with tenacity of 10.1 gpd (1.0 GPa) and modulus of 70 gpd (7.0 GPa). These improvements in blend filaments are related to higher molecular orientation and smaller

fibrillar size. These blend samples show higher storage modulus and lower TMA shrinkage.

Thus improved technical grade filament from nylon6 and blends of nylons have been produced

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