CORRELATION OF SOME PHYSICAL CHARACTERISTICS OF POLY (ETHYLENE TEREPHTHALATE) FIBRES AND FILMS WITH THEIR STRUCTURE AND MORPHOLOGY

By

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CERTIFICATE

This is to certify that the thesis entitled "CORRELATION OF SOME PHYSICAL CHARACTERISTICS OF POLY(ETHYLENE TEREPHTHALATE) FIBRES AND FILMS WITH THEIR STRUCTURE AND MORPHOLOGY" being submitted by Mr. S.K. Sett, 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. S.K, Sett has worked under my 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 in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The studies presented in this thesis relate to poly(ethylene terephthalate)(PET) films and fibres, undrawn and drawn to different extents and then heat-set in the taut and free-to-relax conditions. The main objective of the studies was to obtain correlations of some physical characteristics like intrinsic birefringence and shrinkage behaviour with their respective structures and morphologies. Some aspects of drawing were also studied.

Thin, narrow rectangular tapes of melt-cast PET were uniaxially drawn to different extents in water and in air. Some of the drawn tapes were heat-set in silicone oil isothermally at temperatures between 100 to 250 °C for 5 minutes. The samples were characterised using standard techniques like X-ray diffraction, optical microscopy, infra-red spectroscopy, differential scanning calorimetry, etc. From the data obtained, the intrinsic birefringence of the crystalline and amorphous phases of PET were estimated. The differences in the intrinsic birefringence values obtained from the data for the as-drawn and heat-set samples were explained in terms of morphology-dependence of birefringence. For example, good correlation was observed between crystal perfection index and intrinsic crystalline birefringence. Further support for the high values of intrinsic birefringence of PET was obtained when filaments with birefringence of 0.26 could be produced by stretching of spun

yarns at high temperature and then subjecting them to suitable heat-setting treatments. A number of anamolies that exist in the literature in this area can be explained on the basis of this approach.

The shrinkage characteristics in water, air and silicone oil of PET filament yarns and films, before and after drawing to different draw ratios, were studied over a wide temperature range. There were significant differences in the shrinkage behaviours of films and fibres and these were explained on the basis of the stress that is generated during production and the consequent differences in the structures of these products. The shrinkage behaviour of samples which had not been drawn or drawn to low draw ratios could be explained as arising from the deformation of a rubber-like network while for samples with high draw ratio, the crystallites were shown to play an important role in inhibiting shrinkage.

The drawing characteristics in water and in air of the film and the filaments were also studied and the roles played by drawing rate, fibre structure and temperature of drawing were identified. At drawing temperatures above glass transition temperature, flow drawing was seen to occur at low drawing rates when the samples could be drawn to high draw ratio without developing crystallinity or orientation. The partially oriented PET yarn, spun at 3000 m/min, did not flow-draw because of the pre-orientation that was present in this yarn.

Finally the various film samples were subjected to methyl amine treatment at room temperature. Methylamine, which acts as

a selective etching agent, has been shown to be very sensitive to residual stresses present in the sample. The longitudinal and transverse cracks, that were formed in the film, were investigated with the help of a scanning electron microscope and could be related to the morphological entities in the sample and the way these entities were coupled together.

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