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Dye Uptake and Thermal Behavior of Fibre Grade PET Containing Boltorn H40 as a Nanomaterial

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Abstract

In this work, various loads of nanomaterials and aliphatic dendritic polymerswere mixed with fibre grade PET (Polyethylene terephthalate) to study its dye ability, thermal and thermal-mechanical properties. A twin screw extruder equipped with sheet (profile) die was used for mixing the compounds. Thermal behaviour of the neat PET and the compounded sheet samples were studied using differential scanning calorimeter and dynamic mechanical thermal analysis. It was observed that the T_g of samples decreased gradually by increasing the load of Boltorn H40 as a nanomaterial additive while the T_m remained almost the same. The difference between the glass transition temperature for neat PET and the compounded sample including 3% additive was about seven degrees. In spite of the decline in T_g, the moduli of samples containing additive increased as revealed by DMTA analysis. The presence of this dendritic polymer in compounded PET acted as a cross linking or antiplastisizing agent and made the fibre grade PET compounds more compact than pure PET. So the disperse dye molecules neither were able to stay between the molecules of compounded PET nor were able to trap between the dendritic branches.

Keywords: Dendritic Polymer; PET; Disperse Dye; DSC; DMTA

1 Introduction

PET (Polyethylene terephthalate) is widely used as a synthetic fibre with an increasing demand. Due to the hydrophobic nature of PET, as well as to its very dense structure, PET dyeing and printing are usually limited to disperse dyes [1].

However, the low solubility of these dyes in aqueous baths results in poor affinity towards PET fibres. Alternatively, with the aids of dyeing assistants, the dye uptake can be improved. These materials can accelerate the transfer of dye from the bath to the fibre structure. These auxiliaries, otherwise known as carriers, are able to swell the fibre, resulting in reduction in intermolecular forces and acting as molecular lubricant [2]. However, use of these toxic compounds, usually from amides, alcohols and phenols, is banned due environmental concerns [2].

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Along with the use of carriers with less toxicity, other approaches have recently been taken into consideration to enhance the dyeing properties of PET. Highly functionalized materials [3-5], such as dendritic polymers can potentially be useful for this purpose. These materials contain a large number of branching points and functional end groups, leading to unique physical and chemical properties.

Burkinshaw *et al.* [6] studied the dyeing behavior of a hyperbranched polymer, compounded with polypropylene (PP) prior to fibre spinning. They reported that the presence of hyperbranched polymer mostly increased the dye ability of modified PP fibre compared to the unmodified one. They suggested that the increase of dye uptake could be certified to the introduction of polar groups provided by the hyperbranched polymer. It was reported that for modified fibre, not only the dye uptake was increased but also the wash fastness and mechanical properties remained constant compared to that of unmodified polypropylene.

We have previously studied the behavior of a dendritic polymer into PET sheet films [7]. The compounds were prepared by pressing the mixed PET and Hybrane H 1500 a polyester amide dendritic polymer. Dyeing with disperse Yellow 114 dye at different conditions showed that incorporation of additive was promising. The increased K/S values, as an indication of dye uptake were discussed based on the variations made in crystallinity and T_g of the as prepared sheet films.

The present work aims at investigating the influence of compounded PET with Boltorn H40 as a nanomaterial on dye uptake towards dyeing with three disperse dyes. Thermal behavior as well as thermal – mechanical behavior of neat PET and compounded samples was also studied.

2 Experimental

2.1 Materials

Fiber Grade PET chips (TG-641), were provided by Shahid Tondgoyan Petrochemical Company (Iran). The specifications include: Intrinsic Viscosity (IV) = 0.60 – 0.66 dl/g, water content = 0.25 wt% and melting point = 250±2 °C.

Boltorn H40 (Table 1 and Fig. 1) was supplied by Perstorp Specialty Chemicals AB, Sweden. This nanomaterial as a dendritic polymer is an aliphatic polyester with a highly branched structure [8]. It has 64 OH functional end groups, its viscosity is 10 Pa s and the T_g is 40 °C. Its schematic structure shows its regularity as well as its compact structure.

Three disperse dyes including yellow, red and blue were used in this study. Table 2 and Fig. 2 and 3 show the specifications of dyes and the chemical structures of yellow and blue dyes. Terasil Yellow 4G and Terasil Red R, are monoazo dyes but the blue one has an anthraquinone structure.

2.2 Compounding Procedure

Fibre grade PET chips were dried in an oven at 80 °C for 24 h prior to mixing. A BrabenderDES 25 extruder (Germany) with two corotating screws and a sheet (profile) die was used for this purpose. The L/D ratio (length/diameter) was 30 and the five heat zones were set at 235, 245, 255, 265 and 270 °C with a rotor speed of 90 rpm. The concentrations of nanomaterial additive