Synopsis

"Synthesis and characterization of aliphatic-aromatic polyesters"

Introduction

Aliphatic aromatic polyesters are a class of thermoplastic polyesters with a broad range of properties including high heat distortion, high rigidity and hardness, good mechanical strength and toughness, excellent surface appearance, good chemical resistance, stable electrical-insulation properties etc\(^1\). The principal polymers of this class are the poly (ethylene terephthalate), poly (butylene terephthalate) and poly (ethylene naphthalate)s.

Aliphatic-aromatic polyesters are obtained from aliphatic glycols and aromatic dicarboxylic acids or esters. Poly (ethylene terephthalate) was introduced commercially in 1953 as a textile fibre. It is a major industrial polymer used extensively in the form of fibres, films and as molding material. Poly (butylene terephthalate) was introduced in 1970 and grew rapidly as it found utility in various high volume automotive, electrical and other engineering applications\(^2\).

PBT is one of the most successful thermoplastic polyester\(^3\). It belongs to the class of semicrystalline polymers. It has a high melting temperature (222-224\(^\circ\)C) depending on degree of crystallization and annealing conditions and the heat of fusion is about 140 J/g. The glass transition temperature of PBT varies with crystallinity, annealing and method of measurement. Although the Tg value is reported between 30 and 50\(^\circ\)C, the crystallization of quenched samples occurs as low as 20\(^\circ\)C. Totally amorphous PBT has a Tg of 15\(^\circ\)C, estimated by extrapolation. It is a fast crystallizing polymer and hence well suited for extrusion and injection molding applications. Properties of PBT (especially above Tg) are influenced by the degree and nature of crystallization and on the morphology of the material i.e., the way in which the polymer chains are arranged in the amorphous and crystalline domains in the material\(^4\). At Tg (40\(^\circ\)C) the mobility of the polymer chains in the amorphous regions increases considerably, resulting in decrease in stiffness. Hence PBT is not suitable for applications involving high heat\(^5\).

The properties of PBT can be modified in many ways to meet the requirements of specific fields of application. Copolymerization, blending with other polymers and addition of additives are different ways to modify the properties of PBT.
It is well known that aromatic groups impart molecular rigidity, which contributes to improved properties of semicrystalline polymers. Cyclo-aliphatic diols also impart molecular rigidity.

Polyester derived from 1,4-cyclohexane dimethanol (CHDM), poly (cyclohexane dimethylene terephthalate) (PCT) has a high Tm ranging from 250-305°C depending on the cis/trans ratio. The Tg likewise increases from 60°C (cis) to 90°C (trans). Cycloaliphatic diols such as CHDM have been used for the purpose of improving the performance of polyesters. The improved impact properties of copolyesters of PET/PCT has been attributed to the conformational flexibility of the cyclohexane rings and its influence on chain mobility.

Polyesters of norbornane and norbornane condensed diesters and dimethanols have high second order transition temperature (Tg) and exhibit little tendency to crystallize. Varying the point of substitution in the norbornane moiety has little effect on the glass transition temperatures of the polyesters. Increasing the number of norbornane residues as polymer side chains results in a linear increase in the Tg.

Polyesters prepared from substituted 1,1-norbornane dimethanol has a Tg of 118°C. These polyesters can be used to prepare hard and transparent materials that neither crystallize nor are brittle. The polyesters containing norbornane moiety have not only high Tg but also possess excellent dimensional stability.

Polyesters of 2,2,4,4-tetramethyl-1,3-cyclobutanediol (TMCBD) reported are primarily high melting, semicrystalline materials. Melting points for the polyesters from dimethyl terephthalate and TMCBD, are 316-319°C (38/62 cis/trans), 296-308°C (cis) and >350°C (trans) and the Tg is 174°C. The properties of random copolyesters of TMCBD with small chain aliphatic diols over a range of compositions were studied by Kelsey et al. The new family of terephthalate-based copolyesters were found to exhibit high impact resistance combined with good thermal properties, ultraviolet stability, optical clarity, and low color. The copolymers were amorphous when the TMCBD contents was about 40-90 mol% of the total diol.