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Moisture Absorption Effect on Thermal, Dynamic Mechanical and Mechanical Properties of Injection-Molded Short Glass-Fiber/Polyamide 6,6 Composites

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Abstract: Polymer composites of polyamide 6,6 reinforced with short glass fiber were prepared by injection molding, conditioned under dry, 50 % relative humidity and wet. Investigations by DSC, DMA and tensile tests were conducted. FLD study showed that more fiber degradation occurred during processing of the composites with higher fiber loading. DSC analysis revealed that the incorporation of glass fiber and moisture into the PA 6,6 matrix resulted in a remarkable decrease in the degree of crystallinity. DMA results revealed the glass transition temperatures were sensitive to moisture absorption and their values moved to a lower temperature upon exposure to moisture. Incorporation of glass fiber into the polyamide 6,6 gave rise to a significant improvement in tensile modulus and tensile strength, while tensile strain was reduced. Exposure to different environments from dry to wet conditions resulted in a decrease in the strength and modulus, while tensile strains decreased.

Keywords: Short-fiber composites, Mechanical properties, Differential scanning calorimetry (DSC), Dynamic mechanical thermal analysis (DMTA), Conditioning effect

Introduction

Thermoplastics such as poly(butylenes terephtalate), polypropylene and polyamides are excellent for use in composite materials for their performance-processability-profitability ratios. The mechanical properties of thermoplastic composites containing glass fibers have been the subject of much attention [1]. The properties of thermoplastic composites arise from the combination of fiber and matrix properties and the ability to transfer stresses across the fiber/matrix interphases [2].

In general, plastics and their corresponding composites are sensitive to changes in their environment and their mechanical properties may vary widely with conditions. In this respect, a very important role has been played by plasticization, the process of depression of glass transition temperature and reduction of mechanical properties associated with the absorption of moisture or, more generally, of low molecular weight penetrant [1,3,4]. It is well known that environmental conditions have a profound effect on the viscoelastic properties of polymers. For hydrophilic materials, moisture is found to reduce stiffness and increase creep, presumably through plasticization effect. The effects of constant moisture content on the mechanical properties of polymers have been widely studied and are fairly well understood [5]. In general, moisture diffusion in a composite depends on factors such as volume fraction of fiber, voids, viscosity of matrix, humidity and temperature [6].

Most polymers absorb moisture in humid atmosphere and when immersed in water. The absorption of moisture leads to the degradation of fiber matrix interfacial region and creating poor stress transfer efficiencies resulting in a reduction of mechanical and dimensional properties [7,8]. In fact, it is generally recognized that glass fiber-matrix interface is the determining factor of the reinforcement mechanism, particularly under wet conditions. The same observation was also reported by Thomason [9].

The influence of glass fiber as reinforcement in composites and the effect of conditioning (dry, 50 % R.H. and wet) on thermal, dynamic mechanical and tensile properties of the injection molded glass fiber reinforced polyamide 6,6 composites were investigated.

Experimental

Materials, Specimen Preparation and Conditioning

Materials used for the characterization were Technyl® A216 (unreinforced polyamide 6,6) and Technyl® A216 V30 NAT (short glass fiber reinforced polyamide 6,6 composites, 16 % fiber volume fraction, V_f). Composites with three different fiber volume fractions, V_f of 4 %, 8 % and 12 % were prepared by diluting of Technyl® A216 V30 NAT with Technyl® A216.

For the specimen preparation, a single gated double cavity, impact and tensile standard test bar mold was used in the molding, using Boy® 50 tonne clamping force injection molding machine. The dimensions of dumb-bell shaped tensile test pieces were in accordance with the ASTM Standard D638 [10].

For dry specimens, they were kept in vacuumed desiccators with silica gel immediately after the molding. For 50 % R.H. condition, the specimens were exposed to saturated sodium hydrogen sulphate ($NaHSO_4$) solution environment in the desiccators for at least a month [11]. For wet conditioning,

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