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Study of the abrasion resistance under scratching of polybutyleneterephthalate–glass fiber composites

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The tribological behavior of injection molded polybutyleneterephthalate (PBT) and PBT–glass fiber (GF) composites, (PBT+20%GF) and (PBT+50%GF), has been studied by single scratch tests under progressively increasing load and by multiple scratch tests under constant load, as a function of sliding direction with respect to melt flow. Friction coefficients increase with increasing GF proportion and are higher in the direction perpendicular to flow. Permanent damage, determined from residual depth values, increases with GF content and is higher in the direction parallel to flow. The lowest permanent damage under progressively increasing load is found for PBT+20%GF, due to the combination of effective reinforcement and high viscoelastic recovery ability. Wear mechanisms are discussed from electronic microscopy (SEM) and energy dispersive X-ray (EDS) observations.

1. Introduction

Polybutylene terephthalate (PBT) is a semicrystalline, thermoplastic material currently used in a wide variety of industrial applications due its good mechanical properties such as high stiffness and tensile strength, good dimensional stability at high temperatures, low water absorption and good resistance to chemical degradation, among other characteristics. The main consumers of PBT and PBT–glass fiber reinforced composite components are the automotive, electrical and building industrial sectors. For many of such applications, a common cause of failure is the low surface resistance under sliding wear and abrasion conditions. PBT–GF composites have been widely studied for their microstructure, thermal, mechanical and rheological properties [1–16]. It is well known that the addition of short glass fibers can significantly strengthen neat PBT [3]. Increasing the volume fraction of fibers added to PBT increases linearly the modulus, the tensile and flexural strengths [11], and the fatigue resistance [2] of the composites. Fracture toughness of neat PBT can also be significantly increased by the addition of short glass fibers [4]. The effect of the injection molding parameters on the preferential fiber orientation with flow has also been determined. This effect determines the well-known anisotropic mechanical properties of these composite materials [5]. Liu et al. [8] found that glass fiber oriented parallel to flow in the region closer to the surface of the injected part, but were gradually reorienting to a perpendicular direction with respect to flow, with increasing distance from the skin surface.

In contrast, the number of studies on the tribological performance of PBT composites is still limited in comparison [17–25]. In order to improve the tribological performance of PBT, the different strategies used have been either the addition of fibers, particles and nanophases [24,25] or the application of surface protective coatings [26,27].

As the injection molding process induces a preferential orientation of polymer chains and glass fiber in anisotropic injected components, this orientation with respect to injection flow has been shown [28] to determine the final roughness of the injected pieces and thus, the tribological performance.

In the present study, the influence of glass fiber proportion and of sliding direction with respect to injection melt flow have been determined for PBT+20%GF and PBT+50%GF, and compared with unreinforced PBT, using constant load multiple scratch and single scratch progressively increasing load test configurations. While PBT+20%GF is one of the most commonly used PBT+GF composites, PBT+50%GF was selected in order to study the influence of the highest proportion of GF in the polymer matrix composite.

Surface damage mechanisms are discussed from electron microscopy observations, surface topography determinations and friction coefficients, residual depth values and cross section areas.

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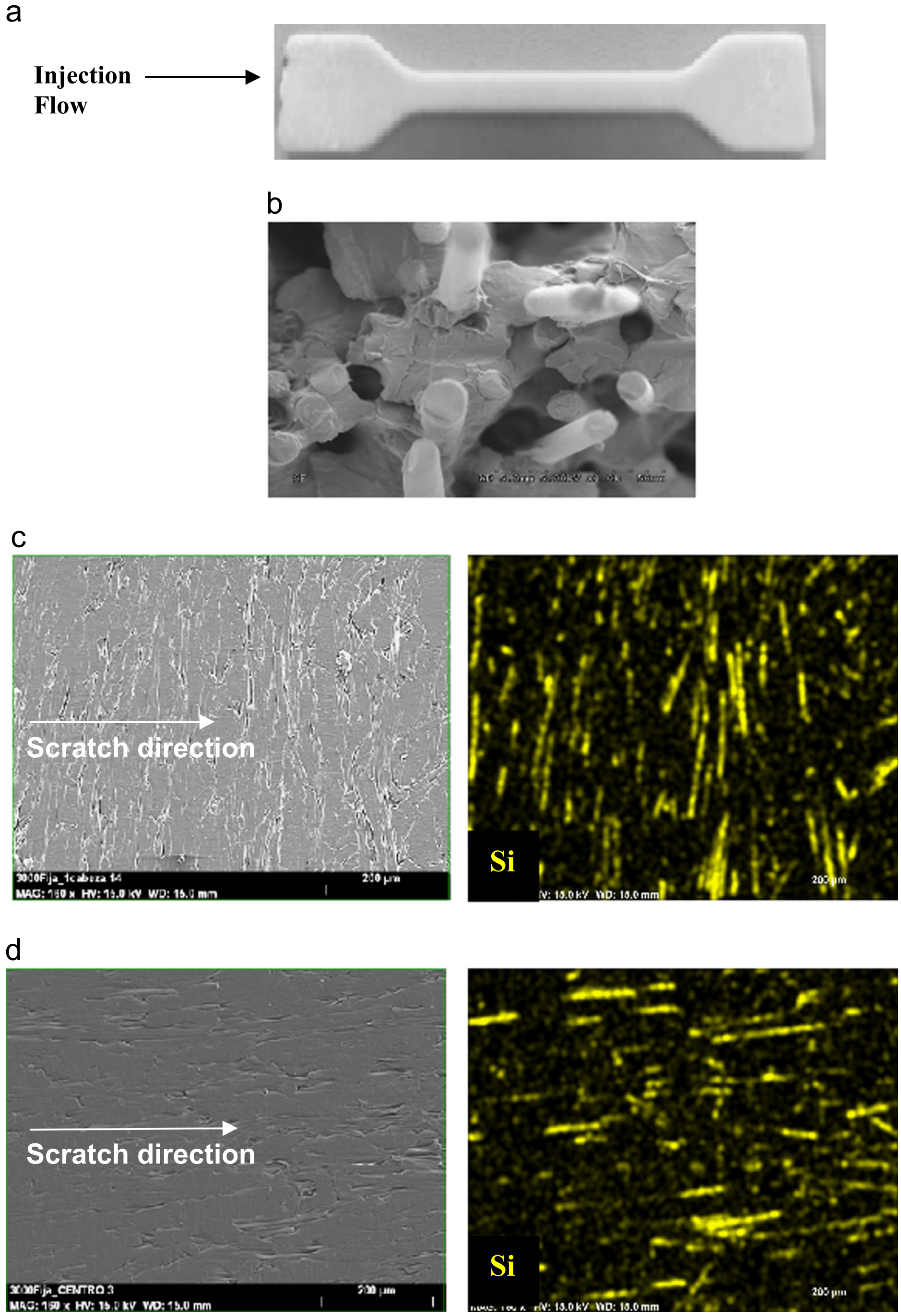

Fig. 1. (a) PBT+50%GF injected part and (b) SEM micrograph of the fracture surface. SEM micrographs and Si element maps showing scratch directions: (c) perpendicular and (d) parallel to injection flow.

Table 1
Surface roughness (R_a; μm) outside and inside the multiple scratch grooves after 15 scratches under 10 N.

	Material		
	PBT	**PBT+20%GF**	**PBT+50%GF**
	Outside the multiple scratch groove		
	0.10	0.29	0.48
Sliding direction	Inside the multiple scratch grooves		
Parallel	0.26	1.32	1.74
Perpendicular	0.27	1.60	1.85