TENSILE PROPERTIES FOR BLENDS OF POLYBUTHYLENE TEREPHTHALATE AND POLYAMIDE WITH ARAMID FIBERS

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ABSTRACT: The thermo-plastic materials are visco-elastic and, thus, their mechanical properties reflect both the characteristics of the viscous fluids and the elastic solids. When a thermoplastic material is working, it exhibits a viscous creep (that dissipates energy), an elastic strain (that stores some energy) and a plastic strain (that store or/and transform energy). The properties of the elaso-viscous materials depend on temperature, loading rate and time. This paper presents the differences in tensile properties for two polymeric blends (PBT + 10% aramid fibers and PA + 10% aramid fibers). The results are compared to those obtained for neat PBT (Crastin 6130 NC010, DuPont) and PA (Relamid B-2Nf, ICEFS Savinesti, Romania). Aramid fibers were produced by Teijin (Netherlands) and they have an average length of 125 μm.The traction tests were done with the help of the universal testing machine TESTOMETRIC M350-5AT, having a force cell of 5 kN, as recommended by SR EN ISO 527-2, in the Laboratory of Polymeric Materials Research (Faculty of Mechanical Engineering, "Dunarea de Jos" University of Galati).

KEY WORDS: PBT, PA, Aramid Fibers, Tensile properties

1 INTRODUCTION

The thermo-plastic materials are visco-elastic and, thus, their mechanical properties reflect both the characteristics of the viscous fluids and the elastic solids. The properties of the elaso-viscous materials depend on temperature, loading rate and time (Bourban, 2004; Brinson, 2008; Haudin ,1995; Mark, 2007). The short-term tensile characteristics of a material are probably the most commonly determined of all the properties that can be determined. Although there are many standards relating to tensile testing, all quantify a number of specific characteristics related to the strength and deformation of a material (Brown, 2002; Campo, 2008). Polymeric materials are non-linear and, consequently, their stress-strain characteristic are complex. The stress strain characteristics of polymeric materials are quite diverse and Brown (Brown, 2002) pointed out four main types: tough materials with a yield stress greater than the failure stress, tough materials with a yield stress lower than the failure stress, tough materials with the same yield and failure stress and brittle materials.

The additivation of polymers is a process offering a large opportunity for modifying their physical and mechanical properties. Polymeric blends and composites have become a huge resource of materials for all fields of human activities (Deanin, 2006; Le Blanc, 2010; Mikitaev, 2006; Tomar, 2008).

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Tensile tests, even if traction is not very often found in practice for polymeric materials, reveal the mechanical behavior of the materials and help ranking them for actual applications (Duan, 2001; Lauro, 2003; Serban, 2013).

2 MATERIALS AND TESTING METHODOLOGY

This paper presents the differences in tensile properties for two polymeric blends (Table 1). The results are compared to those obtained for neat PBT (Crastin PBT. Molding Guide) and PA (Relamid B-2Nf, ICEFS Savinesti, Romania). Aramid fibers were produced by Teijin and they have an average length of 125 μm (see Fig. 5). The traction tests were done with the help of the universal testing machine TESTOMETRIC M350-5AT (WinTest™ Analysis universal testing software), having a force cell of 5 kN, as recommended by SR EN ISO 527-2, in the Laboratory of Polymeric Materials Research (Faculty of Mechanical Engineering "Dunarea de Jos" University of Galati).

Figure 1. Example of sample made of tested on the traction machine (sample not included in the accepted

tests as the fracture is too close by the enlarged zone of the sample)

The testing strain rate was selected at 20 mm/min, as this value has been used in many research studies and it allows for ranking the tested materials (Brown, 2002; Brydson, 2008; Tomar, 2008).

Table 1. The tested materials

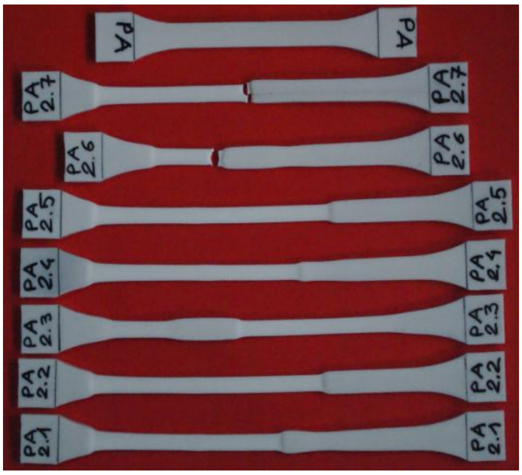
Material symbol	Composition (%wt)
PA	100% PA
PAX	PA + 10% aramid fibers + 0.5% black carbon
PBT	100% PBT
PBX	PBT + 10% aramid fibers + 1% PA + 1% black carbon

The polyamide is a thermostabilized grade of PA 6 (Relamid B-2Nf-T-(i)) (Mark, 2007)), generally having a good UV and weather resistance - RELAMID®, additivated with a small amount of black carbon. The material could be mold in simple or complex shapes. The thermal stabilization makes the final product have a better stability, especially for thermal aging, even when oxidative agents are present and a generally better behavior as compared to the produsts without this thermal treatment.

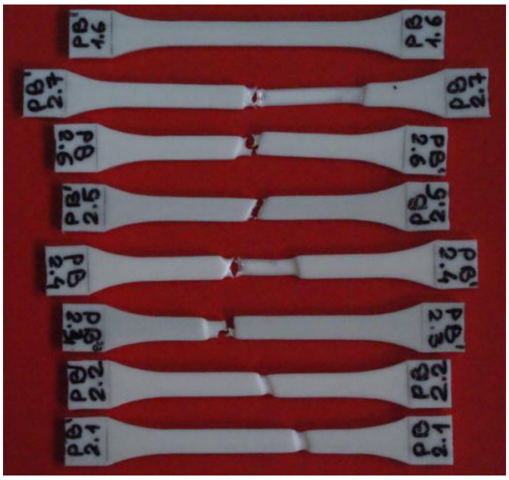
PBT samples were also heat treated as recommended by the producer (DuPont. Crastin® PBT) and the authors applied the same treatment for PBX blend.

3 RESULTS

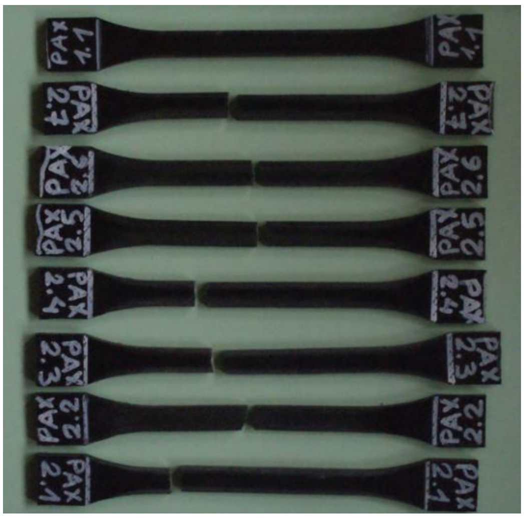
Figure 2 presents the samples after being tested for PA, PBT and their blends with 10% aramid fibers, respectively. Tests for PA were conducted only for 100% elongation as the authors were interested in applications with low values of strain.



a) Samples made of PA were tested till 100% strain



b) Samples made of PBT

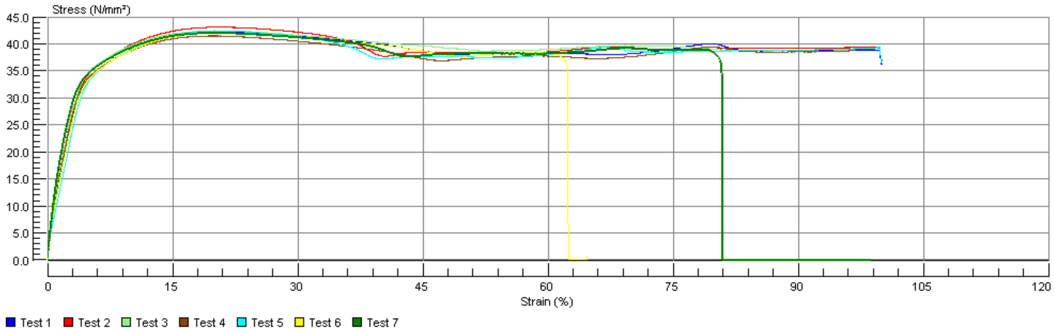


c) Samples made of PA + 10% aramid fibers

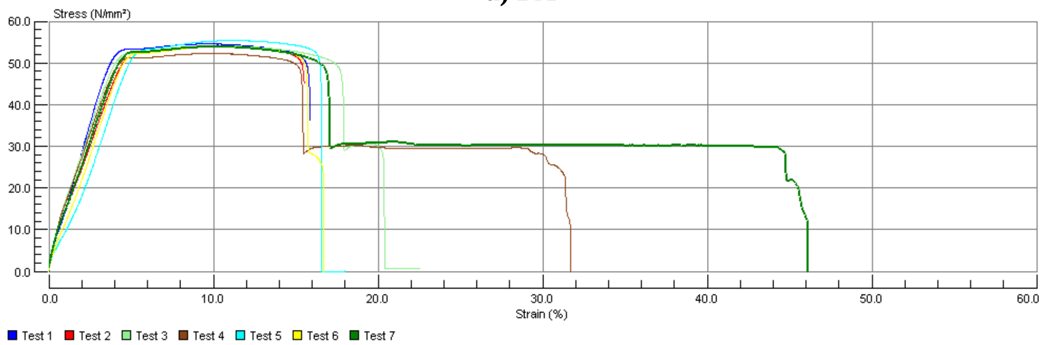
d) Samples made of PBT + 10% aramid fibers

Figure 2. Samples included in the evaluation of the mechanical characteristics

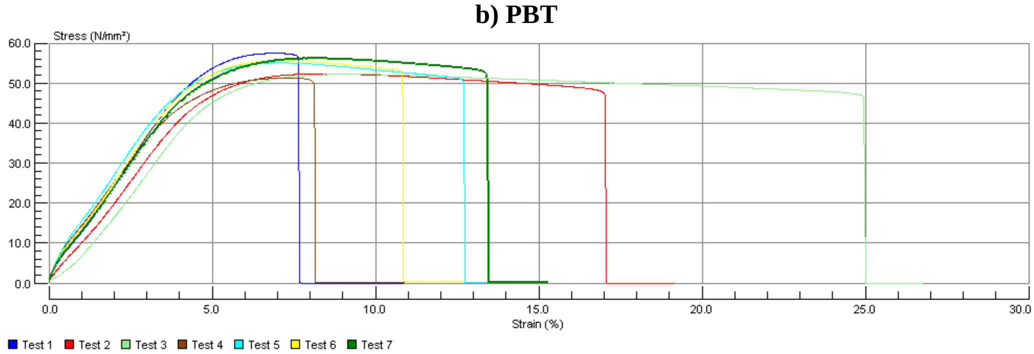
Figure 3 presents the set of tests for each tested material. One may notice a typical behavior as material with higher yield point than the break one for the polymers and typical plots force - strain (%) for the two polymeric blends, but with different slopes. Analyzing plots in Figure 3, one may notice that both polymers could be included in the group of tough materials with the yield stress greater than the stress at break, but PA has a very small difference between these two characteristics and PBT a difference of about 20 MPa. The blend PBT + 10% aramid fibers could be included in the group of brittle materials, but PA + 10% aramid fibers in that of tough materials with the same stress value at yield and break. As pointed out by Greenhalgh (Greenhalgh, 2009), the mechanical behavior of a polymeric blend is hard to be estimated without testing.



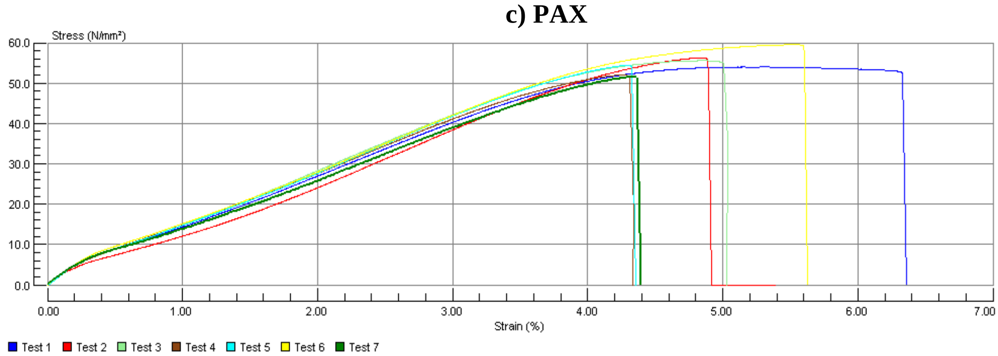
a) PA



b) PBT



c) PAX



d) PBT + 10% aramid fibers

Figure 3. Dependence of strain on applied load (v=20 mm/min)

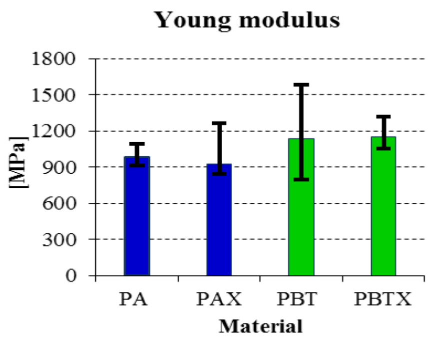


Figure 4. Young modulus for the tested materials (v=20 mm/min)

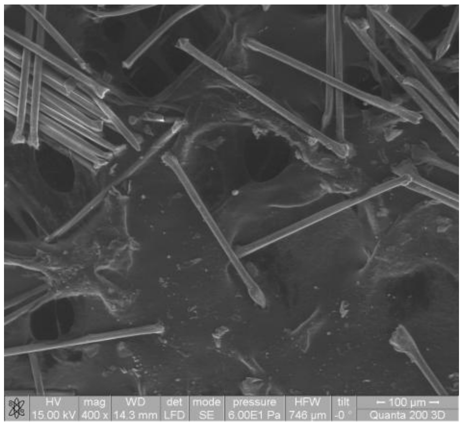


Figure 5. Aramid fibers before being added into the polymer (background: adhesive carbon tape G3939A)

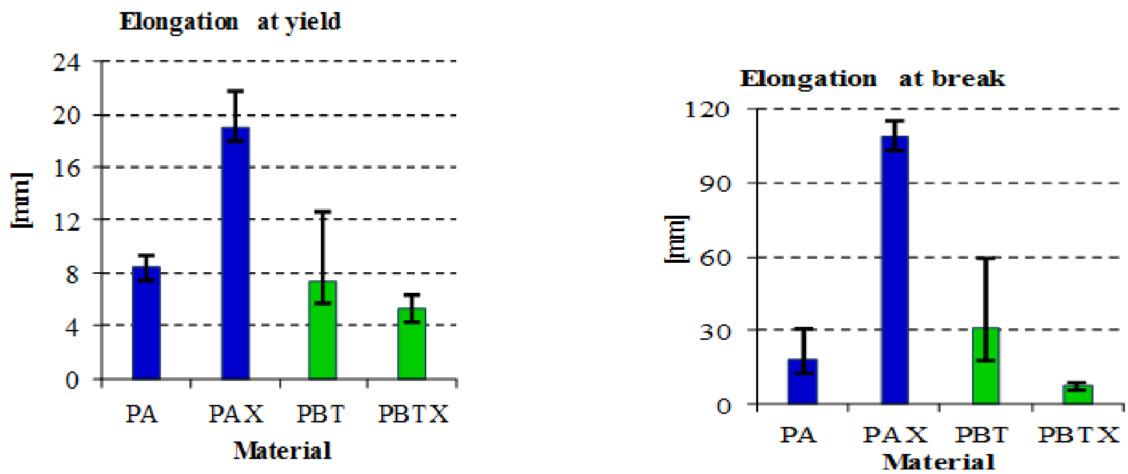


Figure 6. Elongation at yield (a) and elongation at break (b)

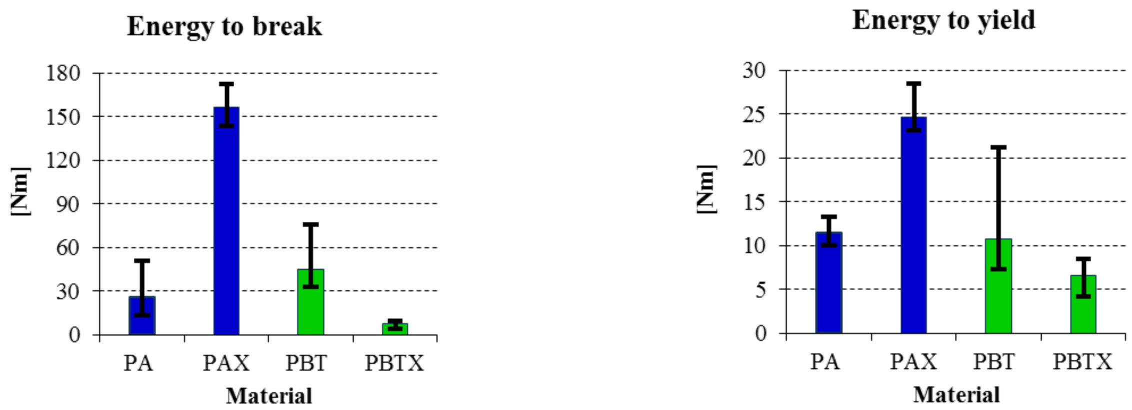


Figure 7. Energy at yield (a) and energy at break (b) for the tested materials

Young modulus is less affected by adding aramid fibers, for both PA and PBT (see Fig. 4). For PA, the aramid fibers make the elongation at yield and the elongation at break increase, but their effect is reverse for PBT. The values for energy to yield and energy to break are strongly affected by the addition of aramid fibers (Fig. 7). These fibers increase both the energy to yield and the energy to beak for PA, but their addition in PBT produces lower values. Stress at yield are less influenced for the materials with PBT, but yield begins at a lower value for PA with aramid fibers (Fig. 8).

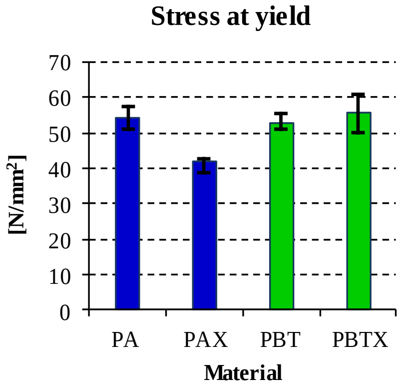


Figure 8. Values characterizing the stress at yield of the tested materials

4 CONCLUSIONS

Based on the test results, the authors pointed out that PA has a more plastic behavior (it is more easy to be deformed) as compared to PBT and the blend PBT +10% aramid fibers. Thus, the elongation at yield for PA este approximately 3 times greater than that of PBT, for the selected test speed of 20 mm/min.

As concerning the energy at break, PA has greater values than PBT, with or without fibers. For the selected strain rate, PBT has an energy at break lower (3 times) and this is why this polymer and its blends are not recommended for elements resisting at impact.

Young modulus is less sensitive to the addition of aramid fibers, but PBT has higher values, with approximately 20%, and larger scattering ranges. These different aspects have to be taken into account by designers.

The average value of stress at yield is higher with approximately 20% for PBT as compared to PA, but the test values are well grouped around the average value.

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