Elastic recovery at basalt fiber and montmorillonite reinforced Polyamide 6

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STATEMENT OF PURPOSE
The aim of this research was the investigation of the effect of basalt fiber (BF) reinforcement and the presence of a nanomaterial on the tensile elastic recovery of polyamide 6 (PA 6). For the measurements a relatively simple and fast cyclic method was applied. The results proved that both the micro and nanoparticles can increase the elastic behavior of the PA 6 significantly.

INTRODUCTION
Today, fiber reinforced thermoplastics have become part of daily life, especially in the field of sport equipment and vehicle components. These materials are gradually replacing the thermoset composites because of their mass production can be solved easier and cheaper. Based on these facts there is intensive research on these materials especially on their hybrids with nanoparticles [1-3].
Because of the novelty of these three-phase materials, their time-dependent properties are not enough deeply researched, however this knowledge is necessary for a proper engineering design [2-4].
As the viscoelastic properties of a polymer matrix composite depend on the applied loads, on every load level there has to be made a one cycle test to characterize the instantaneous elastic, the time-dependent viscoelastic and the time-dependent viscous (or relaxation) deformation components. This characterization method could be quite long, therefore the researchers introduced the rate of elastic recovery. At this cyclic measurement the tensile load is increased by the cycles but between each cycle a certain time is applied for the recovery of the time-dependent viscoelastic deformations (elastic deformation). The elastic recovery can be calculated as the rate of the elastic deformation (sum of instantaneous and time-dependent viscoelastic deformation) and the total deformation. As it is shown in Figure 1 the plastic deformation is a cumulative parameter since in this case the reference point is always the zero-point independently from the value where the current cycle begins [5, 6].

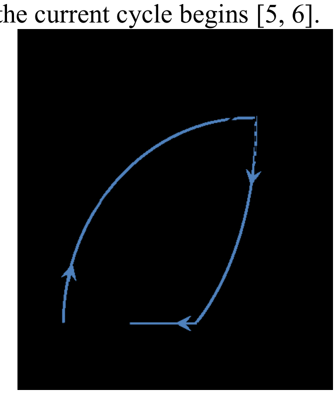

Figure 1 Strain-stress curves for cyclic loading, at increasing load levels

APPROACH
In this study cyclic tensile tests were carried out on polyamide 6 (PA 6) matrix chopped basalt fiber (BF) and montmorillonite (MMT) co-reinforced composites, respectively. In case of the hybrid composite the content of the nanoparticles was 1 wt%. The surface treatment of montmorillonite and sample preparation were carried out according to a previous research [7]. Cyclic tensile tests were performed on a Zwick Z020 universal loading machine. The relaxation time was set to be 30 s and the load was increased by 100 N in each cycle.

RESULTS AND DISCUSSION
The residual strain measured after the relaxation time (plastic deformation) was marked as ε_{30s}. Figure 2 shows the ε_{30s} values as a function of the stress. It is visible that at basalt fiber reinforced PA 6 higher residual strains appear at higher stresses. That means the deformation behavior is closer to the linear than at the neat matrix. It can also be

concluded, that the MMT containing hybrid showed the best properties. For instance at 60 MPa stress level its residual strain is still under 0.1%.

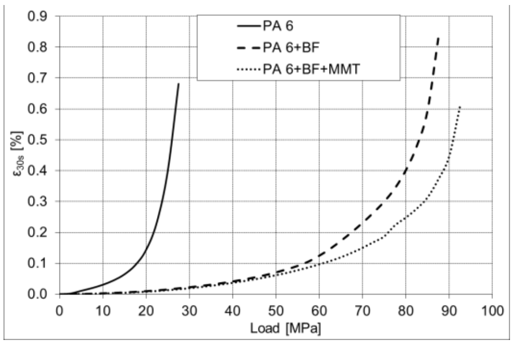

Figure 2 The residual strain measured after the relaxation time (30 s) in case of PA 6 and its composites

From the measured total deformations and the respective residual (plastic) deformation the elastic recovery can be calculated according to Equation 1.

[redacted] (1)

The elastic recoveries of the materials are plot in Figure 3. As it was expected, the elastic recovery decreased faster for the PA 6 than for composites as a function of the load. In case of the composites at 40 MPa load level the elastic recovery is still around 95%.

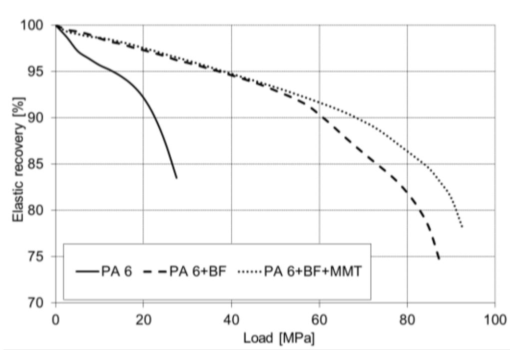

Figure 3 Elastic recovery of PA 6 and its composites

CONCLUSIONS

With a relatively simple and fast cyclic method the structure-mechanical behavior relationship was deeply analyzed for PA 6 and its fiber and hybrid reinforced composites. It was found that the fibrous reinforcement increased the rate of elastic deformation component while the viscous component was decreased. The presence of the nanoparticles in the fiber reinforced composite enhanced these effects.

KEYWORDS

nanocomposite, hybrid composite, mechanical properties, elastic recovery

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