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INFLUENCE OF ATMOSPHERIC CONDITIONS ON THE MECHANICAL PROPERTIES OF PET RUBBER COMPOSITES

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ABSTRACT

The aim of paper is to study the influence of environmental open air conditions on the PET-rubber composites. Two set of samples (Type I, Type II) were obtained with the same composition, but the composites of Type I are random mixed while Type II are layered. These samples were obtained by compression molding for 45 minutes, working in a temperature domain of 180°C-260°C. The samples were left free in atmospheric conditions (at temperature between 3°C- 30°C, under sun light and rain) for two months. These samples were mechanicaly tested and aging was evaluated.

KEYWORDS**:** recycling, PET-rubber composites, compression molding.

1. Introduction

Recycling plastic materials and rubber offers a solution which is satisfactory in terms of preventing environmental pollution.

The recycling of polymeric materials has been in substantial progress during the past few years. Particularly noteworthy has been the development of the Plastic Container Code System used by consumers and community groups to identify, separate, and recycle thermoplastic materials. Plastic recycling is complicated by the presence of fillers that were added to modify the original properties. The recycled plastic is less costly than the original material, and quality and appearance are degraded with each recycle. The recycling of thermoset resin (such as vulcanized rubber) is much more difficult since these materials are not easily remolded or reshaped due to their crosslinked or network structures. Some thermosets are ground up and added to the virgin molding material prior to processing; as such, they are recycled as filler materials. As a result, other methods to recycle the rubber must be found. Grinding is one method to recycle a thermoset. The ground rubber can be used alone or mixed with thermoplastics to achieve the desired properties, such as impact modification, [1-4].

Scrap tire rubber has many excellent mechanical properties in comparison to other materials. These include impact resistance, flexibility, abrasion resistance, and resistance to degradation. Therefore, the concept of using crumb rubber as an engineering material is justified. The structure of the rubber polymer itself makes recycling difficult. Tire rubber is a thermoset, meaning the polymer is crosslinked into a network. These crosslinks are usually covalent bonds between polymer chains, which are difficult to break by simple means. Once the polymer chains have been crosslinked, it is no longer possible to reform the material simply by heating the polymer, as it is done with thermoplastics like polyethylene terephthalate (PET). Crosslinking can be introduced into the polymer by heat and/or chemical means. In rubber, crosslinking is more commonly known as vulcanization, which uses heat and sulfur, [3-5].

The production of plastic materials, especially PET, is nowadays increasing, which will lead to an increasing quantity of plastic wastes. The polyethylenterephthalate is a sophisticated material with great resistance which is most effectively used for beverage containers: and it is one of the most important engineering thermal plastics used for fibers, films and bottles. The advantage of recycling the PET containers is huge, taking into account the impressive number of containers that can be used at acceptable cost. Many studies have been carried out in order to investigate the possibilities of recycling PET bottles for the production of injection-moldable, extrudable, and thermoformable PET resins. That could be used to make structural parts of vehicles, automotive textiles, bottles, food containers, and raw materials for polyurethane [6-10].

The objective of this paper is to develop new composites with the following materials: PET, rubber and HDPE as additive. Attempts are made, to quantify important molecular structure/physical properties relationships in the various blends, as well as critical rheological and processing parameters.

2. Experimental

2.1. Blending

The HDPE and PET bottles were first washed out of impurities and then cut in small pieces in order to obtain flakes and the recycled rubber was granulated using a milling machine; the rubber was granulated using a milling machine. Then materials were mixed and put into the die for obtained samples. Two set of samples (Type I, Type II) were obtained with the same composition (rubber: HDPE: PET = 85:5:10, wt. %), in the same working conditions. The composites of Type I are random mixed and of Type II are layered. Type II of samples is obtained as follows: the first layer HDPE + rubber, the second layer PET + rubber, and the third are similar with the first layer, [11, 12].

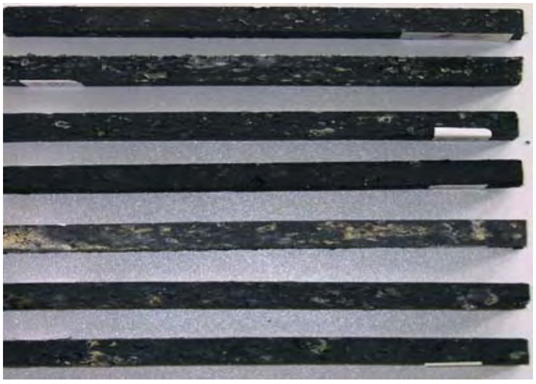

Fig. 1 *Samples with random mixed, Type I*

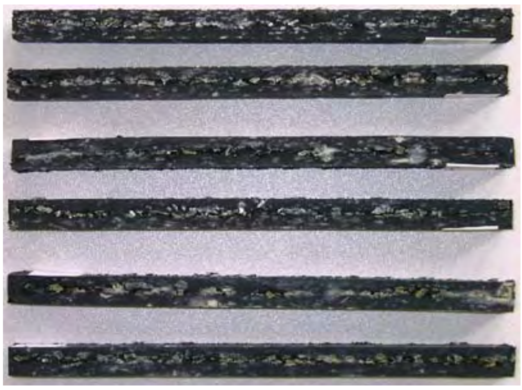

Fig.2. *Samples with layerd mixed, Type II*

2.2. Compression molding

Compression molding was performed in a heated press. The samples were obtained at high temperature (180^0C…260^0C, Table 1) using a thermostated heater, type ECv 200-300, with strict temperature control (± 5^0C). During molding, materials were heated for 45 minutes.

Table 1. Temperature preparation of samples

Sample No.	I1 II1	I2 II2	I3 II3	I4 II4	I5 II5	I6 II6	I7 II7	I8 II8	I9 II9
Temp. T(°C)	180	190	200	210	220	230	240	250	260

2.3. Testing

The samples were prepared using our prototype and these were tested. Compression testing were performed using a mechanical stand type MTS (Multi Tester System) with attached computer operating system. Some samples were left free in atmospheric conditions, at temperatures between 3°C-30°C, under sun light and rain, for two months. Other samples were left at room temperature for the same time.

3. Results and discussions

The mechanical properties of samples depend on temperature processing period, manufacturing conditions, composition, and environmental open air conditions. During compounding at an elevated temperature, a chemical reaction occurs at the interfaces, leading to increased adhesion between thermoplastic (HDPE, PET) and rubber phases.

The mechanical tests have been applied more samples, some were used for testing compression, making two measurements for each temperature. Compression force dependence on time is presented in Fig. 1, 2, 3, 4, which shows curves of the same shape. Under lower compression forces, the samples at temperature lower then 200°C still conserve a porous structure. At higher temperature samples prove to have the most compact structure.

As we have noticed virgin rubber is solid and glassy at a temperature of -195°C while at temperatures between 0°C and 10°C it is frail, and at temperatures over 30°C rubber becomes liquid. These features are no longer sustained when rubber is mixed with other materials such as PET and HDPE. In contact with the oxygen in the air, rubber is subject to aging. This is due to the fact that oxygen influences the double bonds in the virgin rubber. Recycled rubber contains small quantities of sulphur which make it elastic.

The absence of polar functional groups capable of forming hydrogen bonds with molecules of water and the high packing density of the macromolecules on the supermolecular level (there is marked ordering even in amorphous regions) create steric and kinetic hindrances for penetration of molecules of low-molecular-weight substances in PET. This results in low energy of the surface reaction with water and the poor capacity of polyester fibres to sorbs low-molecular-weight substances, primarily moisture.

Another distinctive feature of PET is the higher rigidity in comparison with rubber and HDPE. The equilibrium moisture content in sorption-desorption of moisture from air is low for PET. In the domain temperature 3°C - 30°C at which the samples were exhibited, and relative humidity, equilibrium sorption of moisture is relative lower.

However, the absorbed water from the atmosphere produces changes of the matrix and interfaces. Through this, the humidity can affect the mechanical properties of composites.

The orientation of PET pellets in composite influence meaningful the resistance on humidity and temperature.

If we compare the layered and random mixed samples let in indoor conditions, it is observe that the layered samples are more resistant at compression test, Fig. 3, 4.

The results are not the same in atmospheric conditions. In this case, the layered samples have a lower resistance than random mixed samples, Fig. 1, 2. Between layers, the water molecules sorptions produce the delaminating of composite.

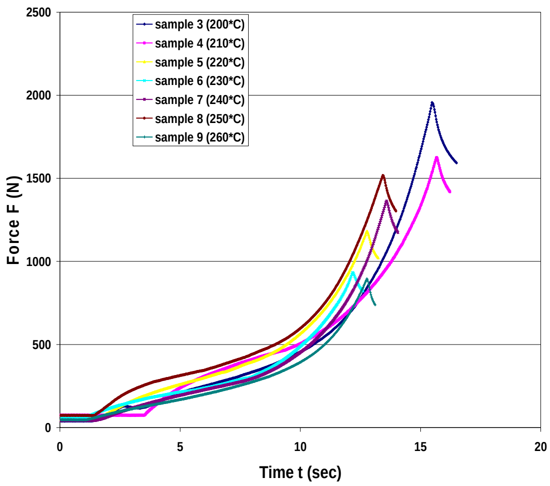

***Fig. 1.** Compression graphical representation for the layers samples let in atmospheric conditions*

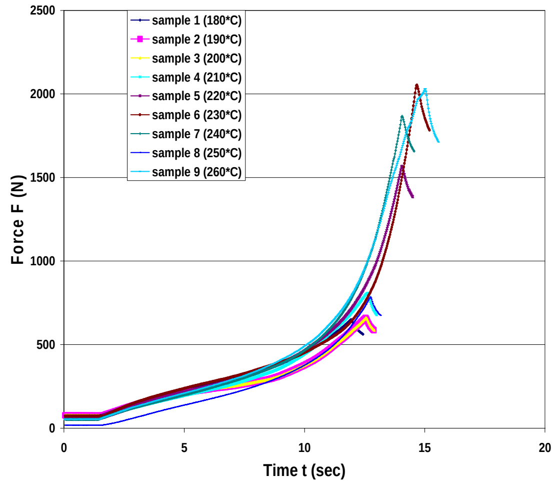

***Fig. 2.** Compression graphical representation for the random mixed samples let in atmospheric conditions*

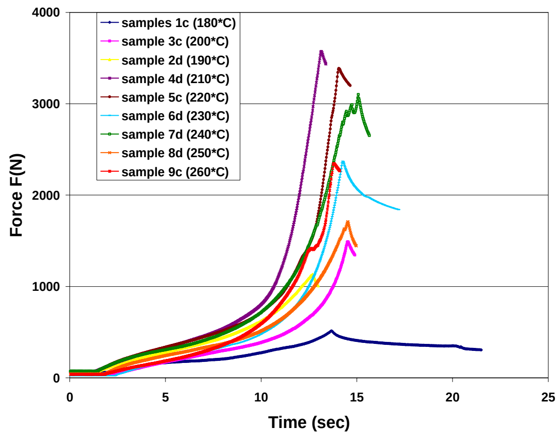

***Fig. 3**. Compression graphical representation for the layers samples let in indoor conditions*

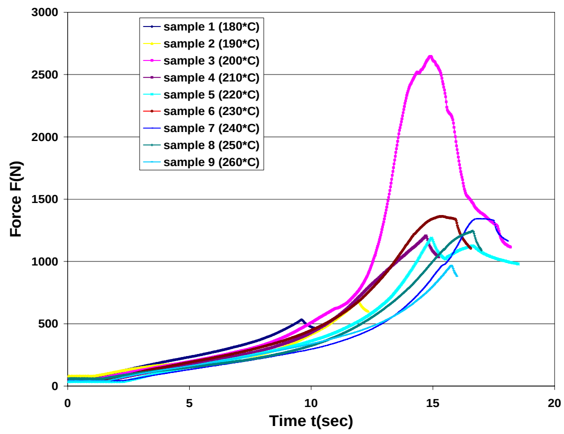

***Fig. 4.** Compression graphical representation for the random mixed samples let in indoor conditions*

4. Conclusions

This work has evaluated methods of using recycled scrap rubber and PET in the development of new materials on a laboratory scale. Specifically, the recycled ground rubber was blended with PET and HDPE to form a thermoplastic elastomer appropriate for use in paving the yards, playgrounds in parks; also in construction industry as thermal and phonic insulators, successfully replacing different types of floor. In addition, this work has converted a thermoset material into a thermoplastic elastomer, which can be reused and converted into new products.

The study on the mechanical properties of layered composites and random composites indicates that:

- PET-rubber composites can be used with a small amount of HDPE without the use of supplementary additives;
- The mechanical properties of the composites strongly depend on the moulding temperature and environmental open air conditions;
- In the range of medium to high deformation forces and at increasing temperature, also during longer load time, a viscous deformation overlays the elastic deformation;
- The layered samples can be used for paving inside, but the samples with random mixture for paving outside.

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