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Ground Tire Rubber Recycling in Applications as Insulators in Polymeric Compounds, According to Spanish UNE Standards

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Abstract

In the present research, we investigated the conceivable outcomes of using ground tire rubber (GTR) particle polymeric blends. Special methods of restoring tires that are no longer in use include GTR retreading, GTR blending destined for recycling to attain raw substances utilized in other industrial application production processes, and the valorization of GTR for power/energy generation. The recycling of end-of-life tires enables the recovery of rubber, steel, and fibers, all of which are valid on the market as raw materials to be used for other processes. There are methods to recycle GTRs in a clean and environmentally friendly way. In the present research, several industrial applications of GTR polymer blends were developed and compared with standard values from the Spanish Association for Standardization (UNE) and the International Electrotechnical Commission (IEC). In order to analyze the viability in many of the industrial applications selected, certain compounds obtained from the GTR polymer blends were analyzed regarding their use in nine low requirement insulator applications. The research and analysis developed in this manuscript used standard values from the UNE and IEC, and these standard values were compared with the test values. The obtained results were used to provide an application list that could be helpful for industrial applications. In this research, the pre-owned polymers were as follows: polypropylene (PP), high-density polyethylene (HDPE), polystyrene (PS), acrylonitrile butadiene-styrene (ABS), ethylene vinyl acetate (EVA), polyvinyl chloride (PVC), and polyamide (PA). The filler used was GTR with particle sizes lower than 200 microns. The amounts of GTR particles in the compound materials were 0% (raw polymer), 5%, 10%, 20%, 40%, 50%, and 70% (the latter being found in polymeric blends). We discovered six plausible modern applications of GTR polymer blends as indicated by the UNE and IEC standards.

Keywords:
GTR recycling; rubber waste; electrical properties; mechanicalproperties; insulators; polymer composites; tire recycling

Introduction

Rubber waste is an extreme problem, mainly because rubber biodegradation requires a long duration and has dangerous environmental effects. Tires contain nearly 50% rubber, and the global production of rubber substances over the last several years was almost 30 Mt. Tire industries are the principle users of rubbers (65% of worldwide manufacturing) and generate huge amounts of rubber waste. Therefore, rubber recycling is frequently defined as tire recycling due to the composition of tires (nearly 50% rubber). Currently, 1.5 billion tires each year are discarded, containing up to 90% vulcanized rubber that cannot be recycled or reprocessed without problems due to the crosslinked structure. Currently, controlling where used tires end up has become a large challenge; therefore, rubber recycling is one of the issues being researched. Vulcanized rubbers are used in tire manufacturing processes because thermoset materials can sustain excessive mechanical and thermal conditions while their properties do not change with temperature shows the characteristic tire compositions for vehicles. Discarded tires have numerous properties and can, therefore, result in useful materials. The accumulation of tires causes fire hazards, and their combustion emits poisonous products that pollute the environment, which is unsafe for humans and animals. In addition, carbon dioxide released during a fire influences the greenhouse effect. The most efficient approach to avoid these issues would be changing used ground tire rubber into new materials with interesting properties. Research has been done on reusing end-of-life tires for energy recovery and pyrolysis. For instance, waste tires are used as a fuel source in concrete furnaces, which is more natural compared to coal ignition. However, many drawbacks have been reported as a burning tire releases hazardous gases and only recovers 25% of the energy used for rubber production.

Materials and Instruments

The polymers used in this study were: polyvinyl chloride (PVC); high-density polyethylene (HDPE); ethylene vinyl acetate (EVA) copolymer (18% of vinyl acetate and 82% ethylene); polypropylene (PP); acrylonitrile butadiene-styrene (ABS), which is composed of 30% acrylonitrile, 20% butadiene, and 50% styrene; polyamide 6 (PA 6), also known as nylon 6; polystyrene (PS). The properties of these seven polymeric materials are summarized. We analyzed the ground tire rubber (GTR) with a microparticle size under 200 µm using thermal gravimetric analysis (TGA) itest with the carbon black compound at approximately 35%. The GTR was ground by sieving into one particle size, lower than 200 microns.

Results and Discussion

When examining the chart of the elongation at break, it can be seen that the materials that have uncommon elongation at break attributes are featured. These are, noticeably, the EVA copolymer (>700%) and, as a runner up, the PP polymer (346.7%). With the increased addition of GTR particles, the lengthening properties of PP significantly fell. The polymer with better lengthening properties was the EVA with rates of GTR up to 10–20%. Enough elongation behavior was observed for the EVA compounds: EVA + 10% GTR: 438%; EVA + 20% GTR: 351.53%. For the PP with a similar GTR amount (10–20%), the stretching conduct was poor, arriving at 15% of the neat polymer without GTR (PP + 10% GTR: 41.73%; PP + 20% GTR: 33.89%).

Conclusions on the Applications

We found that the analyzed blends behaved, in general, as good electrical insulators; therefore they were accepted as good electrical insulators for low contents of GTR (5–10%). The mechanical properties analysis proved that there was a wide variety of GTR polymeric blends with a low decrease in their mechanical properties (tensile strength and elongation at break). However, elongation at break was revealed as an important criterion in electrical applications and has high requirements due to the service demands that these components must give. All analyzed GTR polymer blends (PA, PS, ABS, PP, PVC, EVA, and HDPE) obtained materials that were sufficiently insulating to constitute electrical insulators for different applications (conductivity < 10^{12} S/cm; resistivity > 10^{12} Ω·cm; tangent $\delta < 10^5$). The tangent of δ values in all the samples analyzed with 10% GTR produced results well below 10^5, as established by the analyzed UNE and IEC standards.

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