The Development, Evaluation and Application of Thermoplastic Elastomers from Recycled Materials

The aim of this project is to develop and evaluate thermoplastic elastomers (TPE) produced from recycled materials, and defining suitable applications in industry for these materials. Compositions of thermoplastic elastomers have been produced by blending thermoplastics with rubber, creating a material with rubberlike properties, but which is processable using mass-production methods that are also used for thermoplastics. Examples of applications in which thermoplastic elastomers are used are grips and handles, wire and cable, automotive, footwear and sporting goods. Thermoplastic elastomers are relevant in industry mainly to replace the non-recyclable thermoset rubber. Rubber can not be melt-processed like thermoplastics, and has to either be ground and mixed in another material such as a thermoplastic or raw unvulcanized rubber, or it has to be devulcanized. These are the only ways to process vulcanized rubber into new products. For this research both high-density polyethylene (HDPE) and polypropylene (PP) was used in combination with recycled natural rubber sourced from end-of-life aircraft tires. The recycled rubber granulate is used in three different forms, namely raw granulate, ground rubber powder and devulcanized. The devulcanized rubber is used in compositions, and compared to re-vulcanized compositions.

Figure 1: Recycled plastic

Figure 2: Recycled rubber

A comparative analysis is made by varying the plastic-to-rubber ratio, plastic type, rubber type and vulcanization treatment. The effect of these variable factors and the resulting material properties were compared with the commercially available TPE's. With varying plastic content of 10% to 50%, a range of 30 different compositions in total have been produced and tested, after which applications have been defined for the TPE's as well as recommendations on further expansion of this research. The tensile strength, tear strength, elongation, abrasion, rebound and hardness of all compositions are compared, of which the most significant findings are summarized. The comparison between vulcanized and devulcanized compositions showed an larger improvement of properties of polyethylene compositions compared to polypropylene compositions after vulcanization. There can be additional crosslinking possibilities for polyethylene, to a further increase in properties compared to polypropylene. The vulcanized samples showed better mechanical properties compared to the devulcanized samples because vulcanization introduced crosslinks which results in additional mechanical strength to mainly the rubber phase in the material. Compared to the devulcanized samples, ground as well as granulate rubber samples gave inferior properties because of the irregularity introduced with the higher particle size and distribution of the ground and granulated rubber part. To furthermore study and confirm these findings, the range of compositions should be varied, to extend the range of samples and confirm conclusions as well as the trends in mechanical properties. Furthermore, research with a focus on the crosslinking of polyethylene could prove useful, to find the extent of the mechanical properties of TPE’s with polyethylene as well as provide a new application for recycled PE.

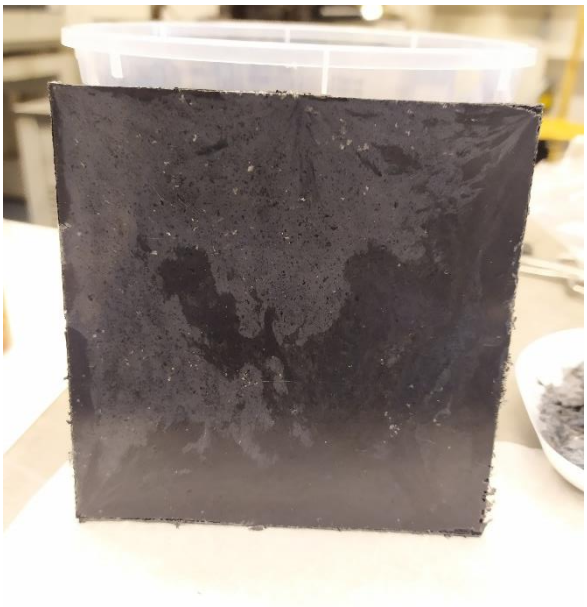

Figure 3: Moulded sample of polyethylene and ground rubber powder

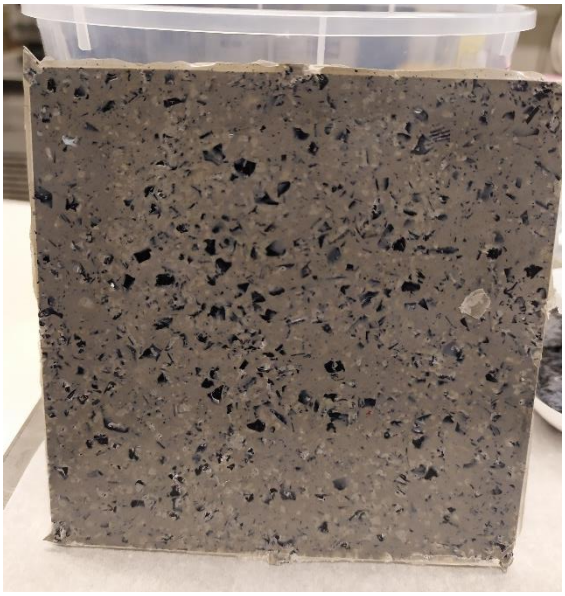

Figure 4: Moulded sample of polypropylene and raw rubber granulate

The challenges during the processing and production of the test samples included inhomogeneity due to difference in particle size in the rubber granulate as well as shrinkage of primarily the thermoplastic phase. In further research the processing conditions can be varied to find optimal processing conditions to prevent these occurrences.