Mechanical Performance and Thermo-Oxidative Aging of Natural Rubber Blends Filled with Recycled Thermoplastic Vulcanizate- ACEX136

This work investigates the effect of recycled thermoplastic vulcanizate (rTPV), used as an elastomeric filler, on the mechanical properties, thermo-oxidative aging behavior, and thermal stability of natural rubber (NR) blends. Due to the increasing demand for sustainable and recyclable elastomeric materials, recycled TPVs represent a promising alternative for partial replacement of conventional fillers and commercial thermoplastic vulcanizates. The prepared NR blends contained different amounts of rTPV ranging from 0 to 55 phr and were compared with selected commercial TPVs, namely Sarlink ST75, Forprene 6NE, and Milastomer 6032.
Mechanical properties were evaluated before and after thermo-oxidative aging. Tensile strength and elongation at break were significantly influenced by increasing rTPV loading. The results showed that higher rTPV contents caused a gradual decrease in tensile strength and elongation at break. This behavior can be attributed to restricted mobility of polymer chains, reduced elasticity of the matrix, and the elastomeric filler effect caused by the presence of recycled TPV particles in the NR matrix. The most significant reduction in elongation at break was observed after thermo-oxidative aging, confirming the sensitivity of elastomeric systems to thermal degradation processes and structural changes occurring during aging.
Despite the decrease in mechanical performance at higher filler loadings, blends containing moderate amounts of rTPV maintained properties comparable to selected commercial TPVs. This finding indicates the possibility of using recycled TPV as a sustainable elastomeric component without a substantial loss of mechanical performance.
Hardness measurements showed that increasing rTPV content resulted in higher hardness values of the prepared blends. This increase is associated with the incorporation of a more rigid dispersed phase into the NR matrix. At the same time, thermo-oxidative aging caused only slight changes in hardness, indicating relatively stable structural behavior of the investigated systems during thermal exposure.
Thermal behavior of the blends was analyzed using thermogravimetric analysis (TG) and differential scanning calorimetry (DSC). TG curves revealed differences in decomposition temperatures and residual mass between NR/rTPV blends and commercial TPVs, indicating that recycled TPV significantly affects thermal degradation behavior and residue formation. DSC analysis confirmed differences in thermal transitions and phase behavior of the investigated systems caused by the presence of recycled TPV and varying compatibility between blend components.
The obtained results demonstrate that recycled thermoplastic vulcanizate can be successfully used as an elastomeric filler in natural rubber blends. Moderate rTPV loadings provided acceptable mechanical performance while simultaneously contributing to improved sustainability and recycling potential of elastomeric materials. The study also contributes to a better understanding of the thermo-mechanical behavior of NR/rTPV systems under thermo-oxidative aging conditions.

Conclusion
The results confirmed that recycled thermoplastic vulcanizate significantly influences the mechanical and thermal behavior of natural rubber blends. Increasing rTPV content reduced tensile strength and elongation at break, while hardness increased with filler loading. Thermo-oxidative aging mainly affected elongation behavior, whereas hardness remained relatively stable. TG and DSC analyses confirmed differences in degradation and thermal transition behavior between NR/rTPV blends and commercial TPVs. The study demonstrates the potential application of recycled TPV as a sustainable and cost-effective alternative in elastomeric systems.