PhD Thesis Proposal

Title:

Thermo-Mechanical Devulcanization of Rubber Waste from Footwear: Toward Sustainable Material Recovery

Abstract:

The management of end-of-life footwear poses significant environmental and technical challenges due to the complex and cross-linked nature of the materials involved—particularly vulcanized rubber used in outsoles. Traditional recycling methods of rubbers, such as grinding and incorporation into polymer matrices, are limited in their circularity and scalability. This PhD project aims to develop an efficient, scalable, and environmentally friendly process for the **devulcanization** of waste rubber, especially from used shoes.
The central goal is to selectively cleave sulfur–sulfur (S–S) and carbon–sulfur (C–S) crosslinks without degrading the polymer backbone, thereby recovering functional rubber that can be reintegrated into production lines. This will involve:

- Developing a **novel experimental protocol** for devulcanization.
- **Characterizing** the recovered materials (and their blends with virgin rubber) using **thermal (TGA, DSC), mechanical, chemical (FTIR), and morphological (SEM)** analyses.
- Applying **Horikx's theory** to quantify devulcanization selectivity.
- Exploring the effects of **process variables** and **treatment media** (type/volume of fluid).

The study will focus particularly on general-purpose rubbers such as **NR, IR, BR, and SBR**, commonly found in footwear. Comparisons will be made with devulcanization data from other sources, such as used tires and production scraps.

Expected Outcomes:

- A reliable devulcanization protocol adaptable to mixed rubber waste streams from footwear.
- A methodology for quantifying and controlling the devulcanization degree and quality.
- Contributions to the scientific understanding of devulcanization mechanisms under thermo-mechanical conditions.
- Industrial guidelines for scaling up devulcanization processes for post-consumer rubber waste.

Key References:

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