PacifiCan-MMRI Accelerating Circular Economy (ACE) TechBrief Report

THE UNIVERSITY OF BRITISH COLUMBIA

Materials & Manufacturing Research Institute
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Project title: Curing and Characterization of Tire Tread Reclaimed Rubber towards Enhanced Physical Properties

Industry partner(s): Circular Rubber Technologies (CRT)

Researchers: M. Amini and M. Arjmand

Introduction & Background:

The growing need for sustainable materials in the rubber industry has led to efforts to reclaim and reuse rubber in various products. CRT Company has been working on these efforts, focusing on reclaiming rubber to produce materials that meet market demands while also reducing environmental impact. The primary objective of this project was to analyze and compare the mechanical and morphological properties of various formulations incorporating CRT's and competitor (B11) reclaimed rubber. These formulations included tread components for passenger car tires. The results of this study offer valuable insights into the performance and potential applications of CRT's reclaimed rubber across a range of rubber products.

Sample Preparation:

The samples were prepared using an internal mixer (Banbury) following a systematic procedure. Initially, styrene butadiene rubber (SBR) and reclaimed rubber (RR) were introduced into the mixer separately and blended for three minutes at 60 rpm and 130 °C. For the sample coded "reference", only SBR was used. For the sample coded "B11", SBR was combined with reclaimed rubber sourced from a CRT's competitor. For the final sample, SBR and CRT-derived reclaimed rubber were used. To ensure a total of 100 PHR of rubber, the amounts of CRT and B11 reclaimed rubber were adjusted based on their respective polymer contents. Subsequently, carbon black and oil were added, with the mixing process continuing for another 3 minutes. Afterward, all remaining chemicals, except sulfur, were incorporated and mixed for an additional 4 minutes. The master mixture was then drained and allowed to rest for 2 hours. After this resting period, it was returned to the mixer along with the final chemicals, including the curing agents and sulfur, and mixed for three minutes at 90 °C. Table 1 shows detailed formulations for all samples. Prepared samples with RR showed good flexibility and mechanical properties, as can be seen in Figure 1.

Table 1. Formulations of the compounds

	Reference	Competitor (B11)	CRT
		PHR	
Polymer content reclaim	NA	55%	58%
RNR40B11 - NL	0	36.50	0
CRT-RR	0	0	34.48
SBR	100.00	80.00	80.00
N375	50.00	50.00	50.00
Paraffin Wax	2.50	2.50	2.50
ZnO	5.00	5.00	5.00
Stearic Acid	2.00	2.00	2.00
TMQ	2.00	2.00	2.00
TBBS	1.50	1.50	1.50
Sulfur	1.50	1.50	1.50

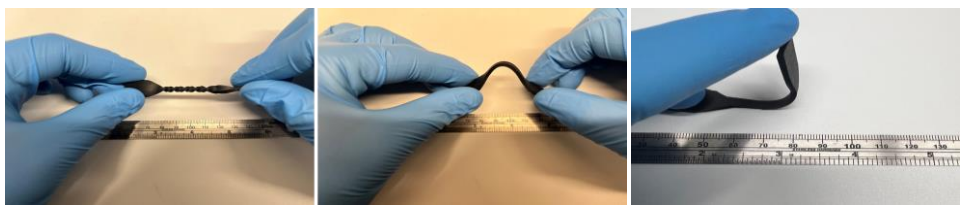

Figure 1. Developed RR-based elastomers with excellent flexibility, adaptable to various deformations

Characterization Methods:

The composite materials' morphology was examined using field emission scanning electron microscopy (TESCAN Mira 3). The mechanical properties, including Young's modulus, yield stress, ultimate tensile strength, and elongation at break, were evaluated using a tensile testing machine (Zwick/Roell Z010, Germany).

The specimens, 3 mm thick and shaped according to ASTM D412 standards, were tested at 25 °C under a constant load rate of 200 mm/min. For accuracy, three dumbbell-shaped samples were used.

Morphology Assessment:

The SEM images (Figure 2) clearly demonstrate that the addition of reclaimed rubber to the rubber matrix leads to an increase in surface roughness, the presence of cracks, and other surface defects. These changes in surface morphology suggest that while reclaimed rubber can enhance certain properties, such as cross-link density and hardness, it may also introduce heterogeneities that could weaken the material's overall integrity [1].

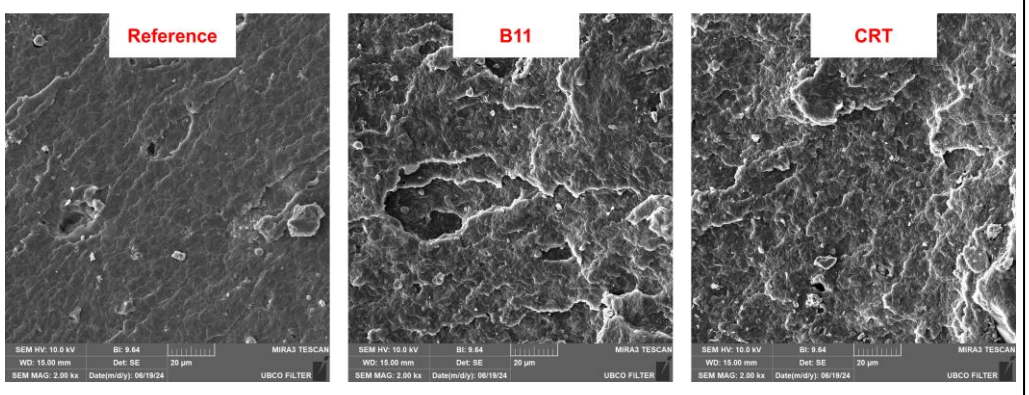

Figure 2. SEM images of fabricated samples

Mechanical Properties:

The mechanical properties of the rubber samples, illustrated by the stress-strain curves (Figure 3), reveal a complex relationship between the addition of reclaimed rubber and the material's tensile strength and elongation at break. Generally, adding RR improved the mechanical properties such as tensile strength. This trend suggests that the addition of reclaimed rubber reinforces the rubber matrix, resulting in a stronger material. The pre-existing cross-links in the reclaimed rubber likely contribute to this enhanced tensile strength.

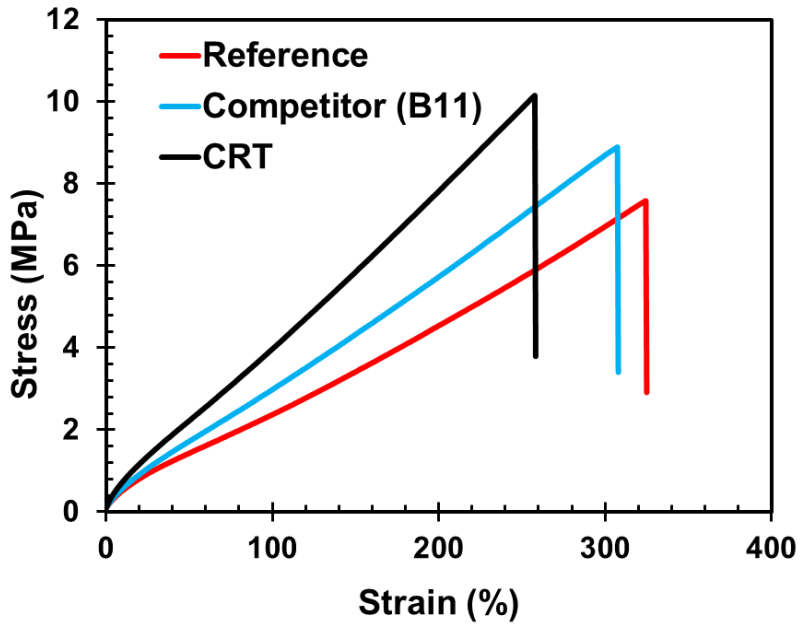

Figure 3. Stress-strain curves for all samples

Conclusion:

This study offers a comprehensive evaluation of CRT's reclaimed rubber, focusing on its performance across various rubber formulations, including tread. The findings indicate that CRT's reclaimed rubber generally enhances properties such as mechanical properties.

Reference:

[1] Jiang Y, Wang J, Wu J, Zhang Y. Preparation of high-performance natural rubber/carbon black/molybdenum disulfide composite by using the premixture of epoxidized natural rubber and cysteine-modified molybdenum disulfide. Polymer Bulletin 2021;78:1213–30

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