

RESUMO - CIÊNCIA DOS MATERIAIS

MECHANICAL PROPERTIES OF SBR COMPOSITES REINFORCED WITH TONER WASTE

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This study explores the incorporation of toner waste (TW) from printer cartridges as an alternative reinforcing filler in styrene-butadiene rubber (SBR) composites, focusing on their mechanical performance and sustainability. Composites were prepared with TW contents ranging from 0 to 50 phr and characterized according to ASTM standards for tensile strength, tear resistance, hardness, and abrasion tests.

The results demonstrated that intermediate TW contents (30–40 phr) significantly enhanced mechanical properties. Hardness values increased from 50 to 55 Shore A, tensile strength rose from 1.08 to 1.73 MPa, and tear resistance improved from 21.93 to 33.08 N. These improvements were associated with efficient filler dispersion within the matrix and a higher crosslink density ($0.94 \rightarrow 1.18 \times 10^{-4} \text{ mol}\cdot\text{cm}^{-3}$), which strengthened the polymer–filler interaction and promoted better stress transfer.

The TW particles acted as partial reinforcing agents, limiting polymer chain mobility and improving rigidity without excessively compromising elasticity. However, when the filler concentration exceeded 40 phr, a tendency for agglomeration was observed, which resulted in reduced reometric torque and higher abrasion loss ($158 \rightarrow 202 \text{ mm}^3/40 \text{ m}$). Despite this, the 40 phr formulation exhibited an excellent balance between stiffness, toughness, and resistance to wear, confirming its potential as an optimized composition.

After accelerated aging tests, all composites showed decreased tensile properties due to thermo-oxidative degradation; nevertheless, samples containing higher TW content retained better performance compared to the unfilled matrix. This result indicates a protective barrier effect of TW, reducing oxygen diffusion and delaying degradation. The presence of metallic oxides and silica within the waste may have contributed to this behavior, acting synergistically with the vulcanization system.

Overall, the incorporation of TW up to 40 phr proved to be technically viable and environmentally promising for industrial applications requiring mechanical strength and durability, such as shoe soles or vibration-damping components. In addition to reducing the environmental impact associated with toner disposal, the reuse of this solid residue supports circular economy principles and aligns with several United Nations Sustainable Development Goals (SDGs), particularly

SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production).

Palavras-chave: sbr rubber; toner waste; mechanical properties; reinforcement; sustainability.