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Sri Lankan Vein Graphite: A Natural Resource Driving Innovation in Industrial Tires

Introduction

Sri Lanka is well known for its natural rubber and the world's only commercial deposits of vein graphite—two rare resources with significant industrial value. For decades, these sectors have operated independently. Recent research at the University of Moratuwa demonstrates how combining these materials can generate a new class of high-performance industrial tire compounds with improved safety, reliability, and export value. This article highlights the key findings, industrial relevance, and the national value addition potential of incorporating Sri Lankan vein graphite into solid industrial tire compounds.

The Challenge of Heat in Solid Tires

Solid industrial tires—used in forklifts, port vehicles, mining platforms, and material-handling equipment—are one of Sri Lanka's major manufactured exports.

Unlike pneumatic tires, they contain no air and depend entirely on thick rubber layers to manage load and deformation. Under heavy duty cycles, these layers accumulate heat due to Road-tire friction, and Hysteresis, from the energy lost during repeated deformation of rubber. Because rubber is a poor conductor of heat, internal temperature can rise to dangerous levels, leading to Layer separation, Blowouts under heavy loads and Reduced service life.

Globally, manufacturers employ various approaches such as silica blends, specialized carbon black, and optimized tread patterns to reduce heat. However, very few studies have attempted to use high-purity natural graphite—a material Sri Lanka uniquely possesses—to enhance thermal conductivity of solid tire compounds

Vein Graphite: A Unique Sri Lankan Advantage

Among natural minerals, graphite stands out for its exceptional thermal conductivity, chemical stability, and mechanical strength. Sri Lanka is home to the world's purest form of graphite—vein graphite, mined from places such as Bogala. Unlike synthetic graphite, vein graphite requires minimal processing, making it both economical and environmentally attractive.

The study explored the use of vein graphite powder as a filler material in the cushion layer of solid tires. By blending graphite powder into the rubber compound, researchers aimed to improve the tire's ability to conduct heat away from the critical zones.

The Science Behind the Innovation

The research systematically added different proportions of Sri Lankan vein graphite powder (0–10%) into solid tire compounds and studied changes in:

1. **Mechanical Properties** – Tensile strength decreased slightly with higher graphite content due to weak bonding between rubber and graphite particles. However, hardness (stiffness) increased, which can be beneficial in heavy-duty applications.
2. **Curing Characteristics** – Curing (vulcanization) is the process of crosslinking rubber to make it durable. The addition of graphite slightly altered cure times but also improved flowability, indicating potential for optimizing manufacturing efficiency.
3. **Thermal Properties** – This was the most significant result. At 10% graphite content, thermal conductivity increased by 66% compared to unmodified rubber compounds.

This means heat can escape faster, dramatically reducing the risk of overheating.

The increase in thermal performance comes with a modest reduction in tensile strength due to the non-reactive surface of graphite particles. Under typical industrial tire standards, the observed reduction is not considered structurally unsafe for cushion layers because the tensile strength remains within the acceptable range for solid tire formulations. Critical structural load is primarily borne by the base and tread layers.

The thermal benefits significantly reduce heat-induced failure modes such as blistering and delamination. However, further work is needed to improve filler–rubber adhesion so the mechanical compromise can be fully eliminated.

Ongoing Research and Development

To address bonding limitations, researchers are investigating:

- Binder coatings,
- Silane-based adhesion promoters, and
- Polymeric surface treatments

These treatments aim to create chemical bridges between graphite and rubber, improving both tensile strength and thermal performance.

An industrial partner had collaborated in supplying materials and validating manufacturability, and their support is gratefully acknowledged.

Economic Value: Moving from Raw Material Export to High-Value Manufacturing

Sri Lanka traditionally exports both rubber and graphite primarily as raw or semi-processed materials. The price difference is substantial:

- Raw graphite sells at a modest per-ton price.
- A tire compound incorporating graphite increases in value several fold before reaching the global market as a finished industrial tire.

This research demonstrates a direct pathway to retaining value locally by:

1. Using Sri Lankan graphite within Sri Lankan tire manufacturing,
2. Increasing performance, which raises product marketability, and
3. Reducing waste and warranty claims through better heat management.

Conclusion

The research demonstrates a powerful synergy between two uniquely Sri Lankan natural resources: natural rubber and vein graphite. By integrating graphite into solid tire compounds, Sri Lanka can:

- Improve the safety and durability of industrial tires,
- Move further up the value chain,
- Reduce dependence on imported specialty fillers, and
- Strengthen the national brand in advanced material innovation.

The work also opens new research and development pathways—such as coated graphite fillers—that can position Sri Lanka as a global contributor to high-performance tire technology.

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