SUSTAINABLE ANTIOXIDANTS FOR RUBBER

From wood to long-lasting rubber articles. ZEBRA additives for elastomeric applications.

INTRO

Rubber articles are exposed throughout their service life to several aggressive agents that may lead to hardening (or softening), loss of strength, cracking or surface degradation. For this reason, antioxidants are essential ingredients in rubber formulations. **ZEBRA-LIFE** project has explored whether lignin-derived bio-aromatic additives can be a renewable alternative to conventional fossil-based antioxidants.

WHO IS BEHIND THE ACHIEVEMENT

Centro Tecnológico Riojano S.A. (CTR) is a private technological centre established in 2000 in La Rioja (Spain). CTR has participated in **ZEBRA-LIFE** as the rubber end-user and validation partner, assessing the performance of the **ZEBRA** lignin-derived additives in rubber compounds, from laboratory-scale trials to industrial-scale mixing and validation. The evaluation comprised processing suitability, effects on vulcanisation and mechanical properties, antioxidant strength, staining and rubber-to-metal bonding activation.

WHAT WAS VALIDATED

The products tested were two lignin-derived antioxidants obtained by CENER from black liquor, a by-product from the pulp & paper industry. One is a low-molecular-weight fraction (LMW) and the other is a medium-molecular-weight fraction (MMW) with an additional refinement step. Their performance was evaluated in rubber compounds such as styrene-butadiene rubber (SBR) for tyre treads, chloroprene rubber (CR) for O-rings and natural rubber (NR) for bridge bearing pads, using the most relevant production processes used in the industry, namely extrusion, compression moulding and injection.

KEY FINDINGS

During the project's laboratory-scale phase, CTR tested different laboratory batches and provided feedback to CENER to improve the production process and adapt the additives to rubber requirements. The trials showed that both additives can be incorporated into rubber compounds, although their processing route is different: MMW can be added in the first mixing stage, at high temperature, while LMW should be incorporated in the second stage due to its higher temperature sensitivity. Furthermore, LMW presented another limitation, since it showed a tendency to stain other substrates that come into contact with the materials containing this additive.

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In the end-user validation phase, the additives scaled up by CENER to TRL6 were validated. The results confirmed antioxidant activity in rubber compounds and MMW showed particularly promising behaviour, reaching performance levels better than conventional benchmark antioxidants BHT and BKF. An additional finding was the potential of MMW as an adhesion promoter in rubber-to-metal bonding systems, an application of very high industrial relevance.

"The work carried out in ZEBRA-LIFE project has demonstrated that lignin-derived additives can be successfully incorporated into industrial rubber compounds, opening the door to more sustainable and circular solutions for the rubber sector without compromising performance"

Francisco Llaría, Technical manager, Centro Tecnológico Riojano.

NEXT STEPS

The next steps should focus on extending validation to additional rubber families and bonding systems, such as fabric-to-rubber or plastic-to-rubber. From a market perspective, further work on regulatory compliance will also be needed, as well as on long-term or very high temperature ageing performance. The results obtained so far indicate that lignin-derived additives can become a real renewable additive platform for rubber, provided that scale-up, consistency and application-specific validation continue to progress. Further work regarding their classification and evaluation of toxicological characteristics would be advisable as well.

By Francisco Llaría

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