VALIDATION OF LIGNIN-DERIVED ANTIOXIDANTS FOR OXIDATION STABILITY IN FUELS AND LUBRICANTS

Pilot-scale trials assess their solubility, compatibility and performance against commercial antioxidants

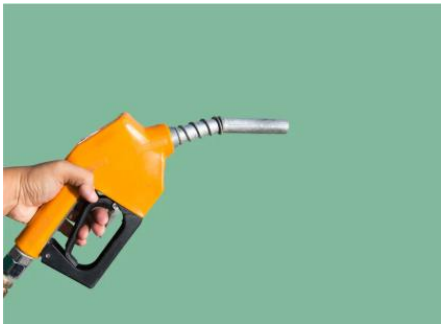
INTRODUCTION

The transition towards products with a higher renewable content is not limited to the main raw materials used in fuels and lubricants. Additives also play an essential role, because they help final formulations meet the technical requirements needed for their use. One of these requirements is oxidation stability, which is key to preserving product properties during storage and operation. From this perspective, the ZEBRA-LIFE project is relevant for REPSOL because it explores whether lignin-derived antioxidants can contribute to future fuel and lubricant formulations.

WHO IS BEHIND THE MILESTONE

REPSOL led Work Package 4 and carried out the validation of ZEBRA-LMW in fuels and lubricants. The work focused on representative applications where antioxidant additives are needed to maintain performance: diesel containing 7% v/v FAME, engine oils, turbine oils and transformer oils. These environments were selected because they provide demanding and application-relevant conditions to assess solubility, compatibility and oxidation stability.

WHAT WE ARE VALIDATING



The validation assessed ZEBRA-LMW fractions produced at pilot scale and their ability to be incorporated into real formulations. The purpose was not only to check intrinsic antioxidant activity, but also to determine whether the material could be formulated in fuels and lubricants and move towards performance equivalent to current antioxidant solutions. For fuels, ethanol as a carrier and distilled LMW fractions were evaluated. For lubricants, different distillation conditions were used to obtain lighter fractions with improved compatibility.

KEY FINDINGS

The results showed that solubility and composition are decisive factors. In fuels, no solubility issues were observed when ethanol or the distilled LMW fraction was used, and the distilled fraction was directly soluble at the selected dosage. In lubricants, compatibility depended on the campaign and application: some engine and turbine oil formulations showed turbidity, while the third-campaign distillate was soluble in engine oil at the tested dosages, although

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turbine oil showed a solubility limit. In terms of oxidation stability, early fuel campaigns showed little or no antioxidant activity, while later distillates showed improved potential. However, compared with commercial antioxidants, the third-campaign distillate displayed a more moderate antioxidant performance in diesel containing FAME. In lubricants, activity was generally lower than commercial antioxidants across engine, turbine and transformer oils at the tested dosages.

"The transition towards more renewable fuels and lubricants also depends on the additives that enable these products to meet their technical requirements. Through ZEBRA, we are evaluating lignin-derived antioxidants as a potential route to provide oxidation stability while moving towards more sustainable formulations".

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NEXT STEPS

The next step is to continue improving the product before moving towards further validation. The work points to purification, distillation or fractionation as key routes to reduce process by-products, improve solubility and increase antioxidant performance. These improvements will be necessary to develop renewable additive solutions that help fuel and lubricant formulations meet technical requirements while delivering performance comparable to that of current antioxidants.

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