

Abstract

Natural and Petroleum-Based Resins: Impact on SBR Dynamics by Solid-State NMR Spectroscopy and Relaxometry [†]

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In the tire industry, tackifying resins are essential ingredients because they modulate green tack and green strength of the uncured rubbers, facilitating their manipulation and preventing creep and tear of the final products. From a molecular perspective, the presence of the resin alters the dynamics of the polymer chain, resulting in the modification of the rheological and viscoelastic behavior of the rubber compounds. Since the mechanical response of the final compounds varies depending on the type of resin added, it is important to dissect the molecular origins of such differences. In this research, we compared the effect of a natural- and a petroleum-origin resins on the dynamics of Styrene–Butadiene Rubber (SBR) in compounds of interest for the tire industry. To this end, we employed a variety of Solid-State Nuclear Magnetic Resonance (SS-NMR) experiments at variable temperature. These include ¹H Field Cycling NMR, DIPolar chemical SHIFT correlation, and Centerband-Only Detection of Exchange experiments. These techniques enabled the study of polymer dynamics on a wide range of motion time scales, from the fast segmental motions related to glass transition to the slower and collective motions of the polymer chains. In addition, measurements of ¹H T_1 and $T_{1\rho}$ relaxation times provided information on the polymer-resin miscibility on the nanometer scale, which is essential for achieving compounds with the desired mechanical properties. Dipolar-Filtered Magic Sandwich Echo experiments were also carried out to obtain information on the presence of domains with different degrees of mobility, as well as on the onset of their motions with temperature. The SS-NMR results were compared with those from dynamic-mechanical, rheometric, calorimetric, and chemical characterization. This approach provided valuable information to elucidate the complex relationship between molecular and macroscopic properties in rubber compounds, aiding the design of formulations with improved performances.



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