Functionalized Polyolefins as Advanced Polymer Compatibilizers for Boosting Crumb Rubber Performance in Bitumen

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Objective

Recently, propylene-based terpolymers with polar hydroxyl functionalities (**FPP**) have emerged as an effective alternative for compatibilizing crumb rubber modified bitumen (**CRMB**). Traditional bitumen modifiers such as styrene-*b*-butadiene-*b*-styrene (**SBS**) and ethylene-*co*-vinyl acetate (**EVA**) copolymers typically fail to incorporate more than 5 wt% of crumb rubber (**CR**) while maintaining a stable dispersion, especially in terms of hot storage stability. In contrast, FPP enables higher **CR** loading with improved dispersion stability.

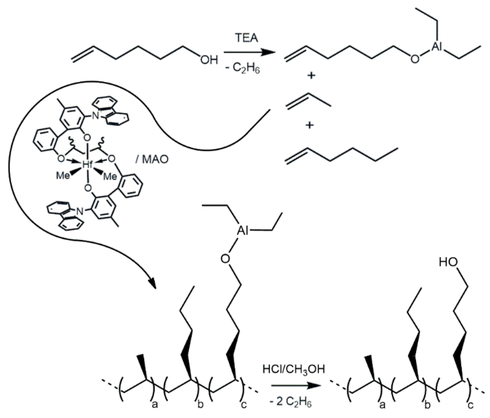
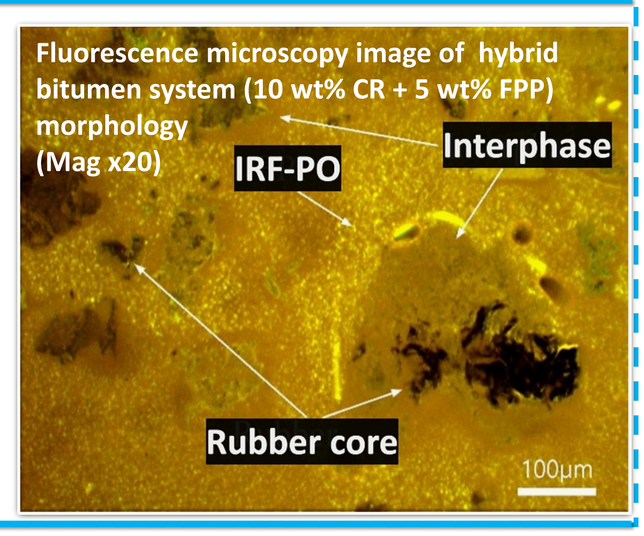


Figure 1. Schematic representation of the synthetic route towards poly(propylene-*co*-hex-1-ene-*co*-hex-5-en-1-ol) and the corresponding deashing process of the terpolymer



Results and discussion

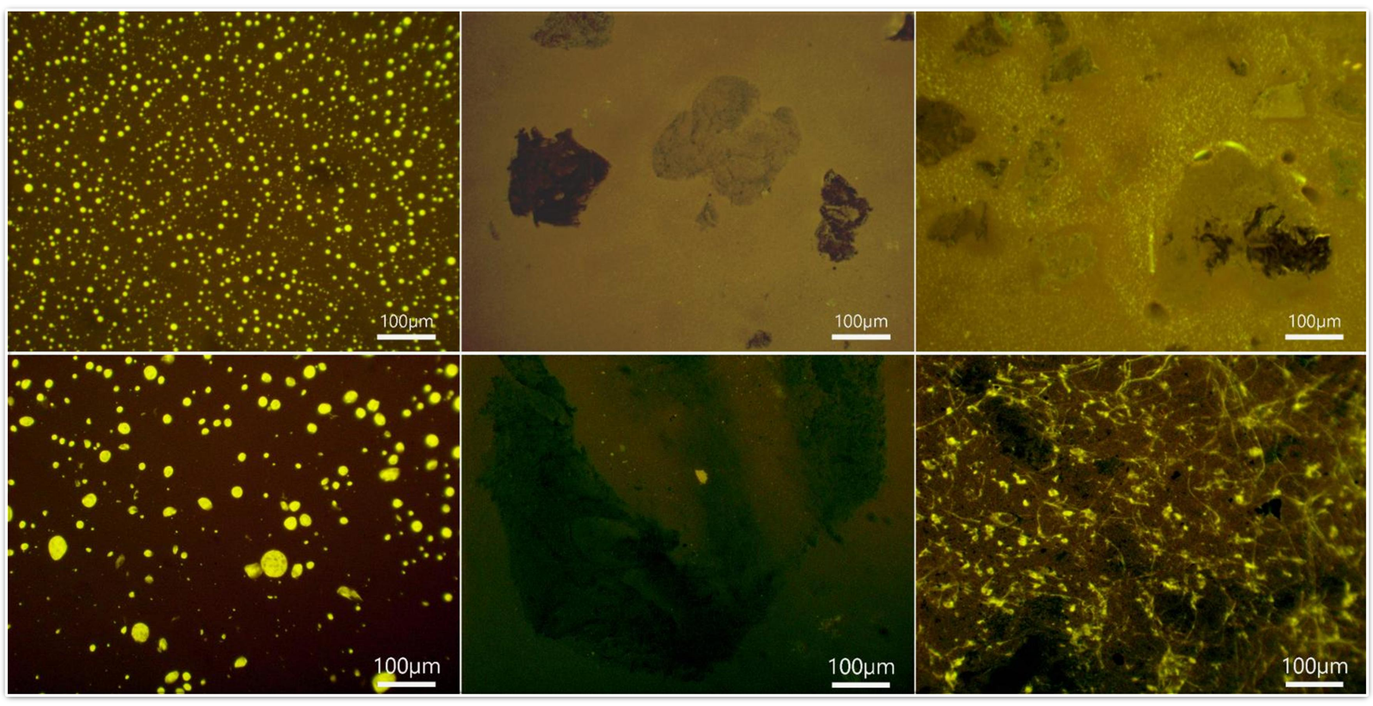


Figure 2. Fluorescence micrographs of bitumen compositions (a) **5 wt% FPP**, (b) **10 wt% CR**, (c) **10 wt% CR + 5% FPP**, and corresponding RTFO-aged compositions (d) **5 wt% FPP**, (e) **10 wt% CR**, (f) **10 wt% CR + 5% FPP**

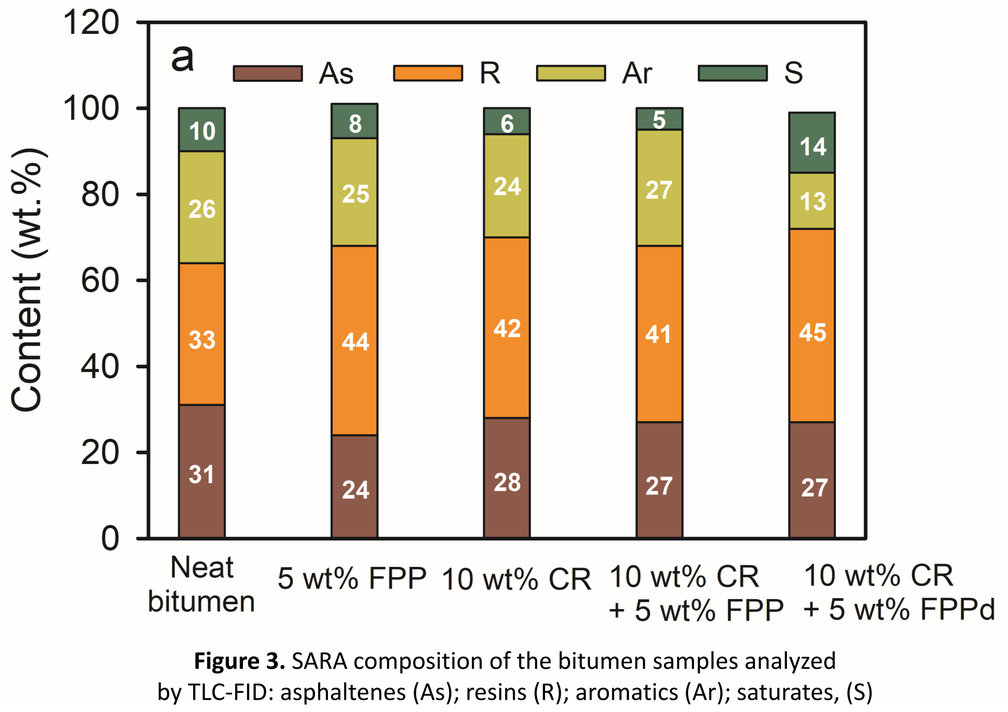


Figure 3. SARA composition of the bitumen samples analyzed by TLC-FID: asphaltenes (As); resins (R); aromatics (Ar); saturates, (S)

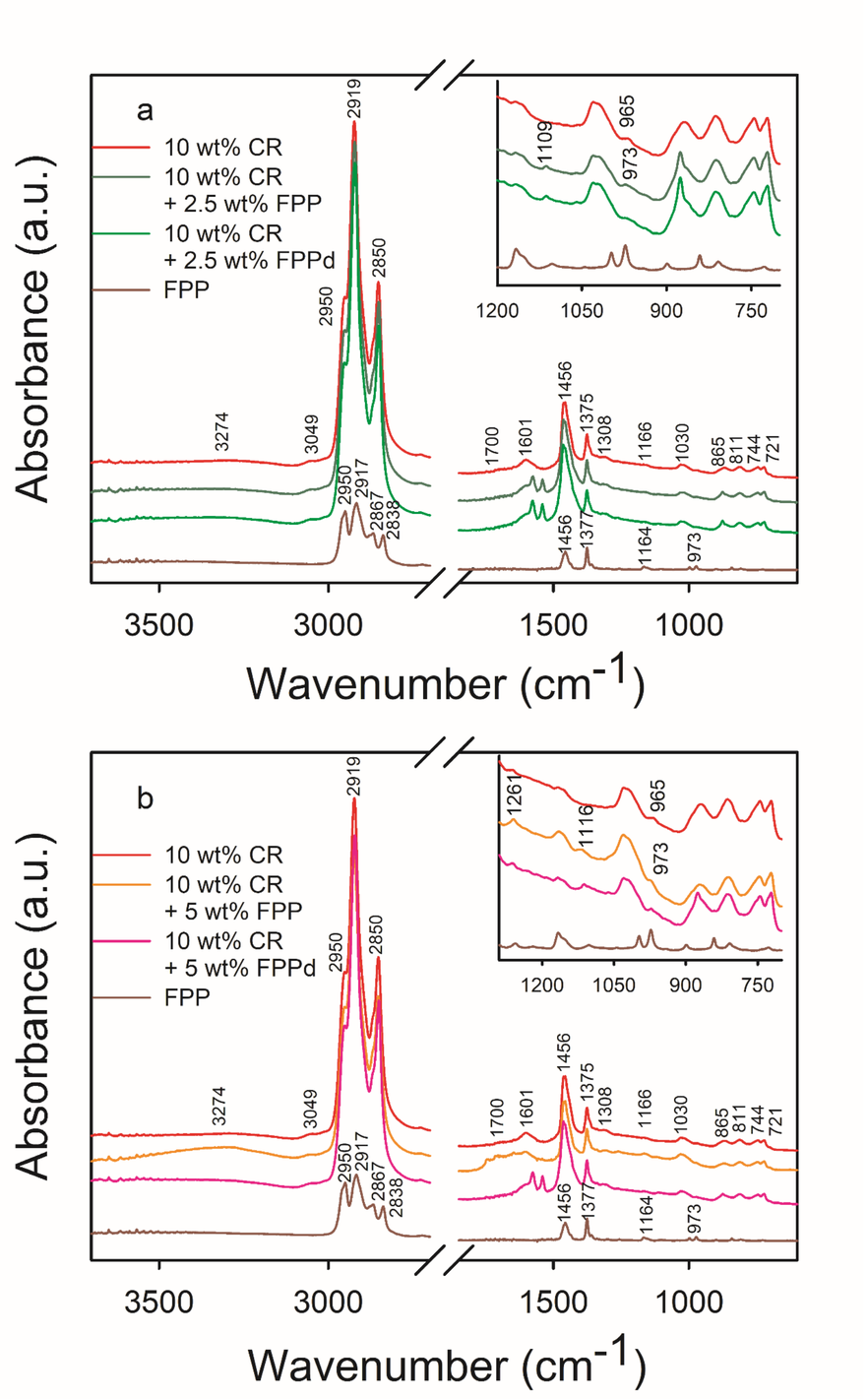


Figure 4. ATR-FTIR spectra comparison of bitumen compositions and the compatibilizer (a) **10 wt% CR**, **10 wt% CR + 2.5 wt% FPP**, **10 wt% CR + 2.5 wt% FPPd**, **FPP**; (b) **10 wt% CR**, **10 wt% CR + 5 wt% FPP**, **10 wt% CR + 5 wt% FPP**

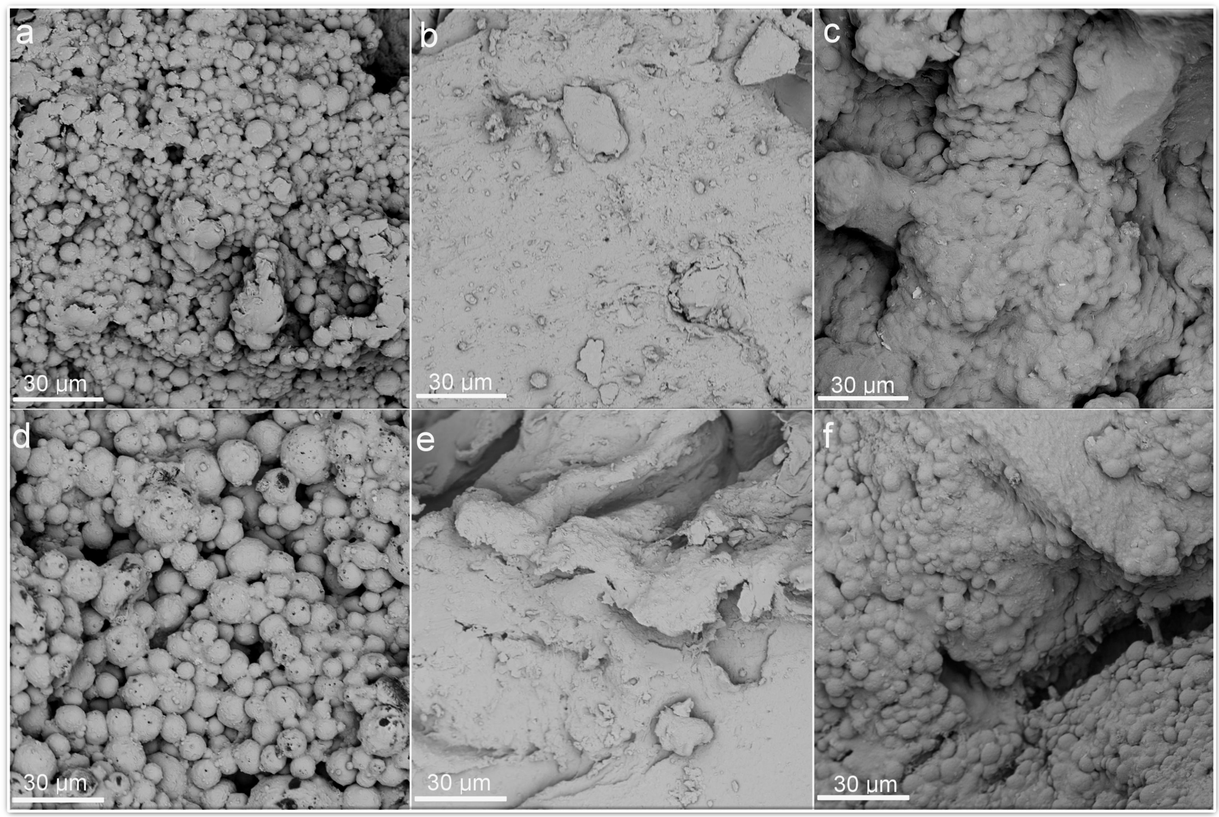


Figure 5 SEM microphotographs of undissolved solid fractions (UF) obtained via Soxhlet extraction from: (a) **5 wt% FPP**, (b) **10 wt% CR**, (c) **10 wt% CR + 5% FPP**, and corresponding aged compositions (d) **5 wt% FPP**, (e) **10 wt% CR**, (f) **10 wt% CR + 5% FPP**

Conclusion

- The addition of FPP into both neat bitumen and CRMB causes notable structural changes in materials' matrix, affecting distribution of SARA components, morphology, thermal stability, performance after short-term aging and physicochemical interactions between constituents.
- Hydroxyl groups in the FPP terpolymer tend to associate with (AlOx(OH)y)z residues formed during synthesis, promoting more efficient crosslinking than the H-bonded hydroxyl clusters found in FPPd. These clusters likely originate from the exclusion of (AlOx(OH)y)z residues during the acid-based deashing process.

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