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FORMULATION OF LOW-CARBON HOT-MELT ADHESIVES: INTEGRATING ROSIN ESTER TACKIFIERS WITH METALLOCENE-POLYETHYLENE AND BIO-POLYAMIDE FRAMEWORKS

ABSTRACT
Low-carbon hot-melt adhesives are critical for decoupling industrial manufacturing from fossil fuels. Traditional formulations heavily rely on petroleum-derived polymers, generating substantial greenhouse gas emissions. By incorporating renewable biopolymers and natural tackifiers like colophony, low-carbon alternatives drastically reduce cradle-to-gate carbon footprints. They allow sectors like packaging and electronics to meet stringent net-zero targets while maintaining industrial-relevant tensile and lap shear strength suitable for packaging applications.

This study initially focuses on the development of a rosin ester compatible with metallocene-polyethylene (mPE), and its incorporation into this type of framework. Specifically, varying ratios of this rosin derivative and a C5 hydrocarbon tackifier were systematically screened to tune cohesive stiffness versus ductility, targeting the same tensile strength-elongation envelope observed in commercial mPE-based HMAs.

Guided by the performance window defined for the mPE system, we then replaced the synthetic polyolefin phase with a custom-formulated bio-based polyamide. Advancing towards a fully sustainable architecture and successfully achieving a 100% bio-derived hot-melt adhesive system. This secondary system was similarly optimized to balance tensile profiles and structural flexibility, successfully achieving a high-performance hot-melt adhesive.

The results demonstrate that the optimized 100% bio-derived hot-melt adhesive system achieved cohesive and adhesive strength profiles comparable to the commercial mPE baseline. This transition demonstrates a critical strategy for decoupling high-performance packaging adhesives from fossil feedstocks without compromising vital interfacial bonding or thermo-mechanical stability.