

Development and Characterization of Castor Oil-Based Biopolyurethanes for High-Performance Coatings and Waterproofing Applications

Authors : Julie Anne Braun, Leonardo D. da Fonseca, Gerson C. Parreira, Ricardo J. E. Andrade

Abstract : Polyurethanes (PU) are multifunctional polymers used across various industries. In construction, thermosetting polyurethanes are applied as coatings for flooring, paints, and waterproofing. They are widely specified in Brazil for waterproofing concrete structures like roof slabs and parking decks. Applied to concrete, they form a fully adhered membrane, providing a protective barrier with low water absorption, high chemical resistance, impermeability to liquids, and low vapor permeability. Their mechanical properties, including tensile strength (1 to 35 MPa) and Shore A hardness (83 to 88), depend on resin molecular weight and functionality, often using Methylene diphenyl diisocyanate. PU production, reliant on fossil-derived isocyanates and polyols, contributes significantly to carbon emissions. Sustainable alternatives, such as biopolyurethanes from renewable sources, are needed. Castor oil is a viable option for synthesizing sustainable polyurethanes. As a bio-based feedstock, castor oil is extensively cultivated in Brazil, making it a feasible option for the national market and ranking third internationally. This study aims to develop and characterize castor oil-based biopolyurethane for high-performance waterproofing and coating applications. A comparative analysis between castor oil-based PU and polyether polyol-based PU was conducted. Mechanical tests (tensile strength, Shore A hardness, abrasion resistance) and surface properties (contact angle, water absorption) were evaluated. Thermal, chemical, and morphological properties were assessed using thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). The results demonstrated that both polyurethanes exhibited high mechanical strength. Specifically, the tensile strength for castor oil-based PU was 19.18 MPa, compared to 12.94 MPa for polyether polyol-based PU. Similarly, the elongation values were 146.90% for castor oil-based PU and 135.50% for polyether polyol-based PU. Both materials exhibited satisfactory performance in terms of abrasion resistance, with mass loss of 0.067% for castor oil PU and 0.043% for polyether polyol PU and Shore A hardness values of 89 and 86, respectively, indicating high surface hardness. The results of the water absorption and contact angle tests confirmed the hydrophilic nature of polyether polyol PU, with a contact angle of 58.73° and water absorption of 2.53%. Conversely, the castor oil-based PU exhibited hydrophobic properties, with a contact angle of 81.05° and water absorption of 0.45%. The results of the FTIR analysis indicated the absence of a peak around 2275 cm⁻¹, which suggests that all of the NCO groups were consumed in the stoichiometric reaction. This conclusion is supported by the high mechanical test results. The TGA results indicated that polyether polyol PU demonstrated superior thermal stability, exhibiting a mass loss of 13% at the initial transition (around 310°C), in comparison to castor oil-based PU, which experienced a higher initial mass loss of 25% at 335°C. In summary, castor oil-based PU demonstrated mechanical properties comparable to polyether polyol PU, making it suitable for applications such as trafficable coatings. However, its higher hydrophobicity makes it more promising for watertightness. Increasing environmental concerns necessitate reducing reliance on non-renewable resources and mitigating the environmental impacts of polyurethane production. Castor oil is a viable option for sustainable polyurethanes, aligning with emission reduction goals and responsible use of natural resources.

Keywords : polyurethane, castor oil, sustainable, waterproofing, construction industry

Conference Title : ICPPC 2024 : International Conference on Polyurethane Polymers and Composites

Conference Location : Amsterdam, Netherlands

Conference Dates : November 04-05, 2024