Eco-friendly and ready-to-market polyurethanes for LED encapsulation: substitution of toxic catalyst and fossil-based raw materials with a design of experiment approach

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In recent years, the use of polyurethanes (PUs) has witnessed a significant surge in industrial applications owing to their versatile synthesis routes and tunable physicochemical properties [1]. However, the widespread use of PU-based materials across various fields has raised notable environmental concerns, primarily associated with the extensive consumption of fossil-based raw materials and the utilization of mercury-based catalysts, which are now subject to stringent regulations imposed by European legislation [2]. Consequently, there is an urgent need to explore alternative reagents and catalysts with the aim of enhancing the sustainability of PUs by reducing resource consumption and minimizing the carbon footprint [3].

In this contribution, a commercial PU resin formulation for LED encapsulation has been investigated to implement bio-based and recycled components and remove the toxic catalyst while maintaining optimal characteristics in terms of optical transparency, physical and chemical properties. Specifically, a facile and solvent-free procedure will be presented for a new and eco-friendly PU formulation tailored for the optoelectronic sector. To achieve this goal, an Experimental Design (DoE) approach was successfully applied, and fossil-based components have been successfully substituted with bio-based and recycled alternatives in the optimized formulation. Bis(2-hydroxyethyl) terephthalate (BHET) was directly incorporated into the formulation as an example of waste-derived materials. Moreover, a combination of organobismuth and organozinc catalysts was effectively employed as a mercury alternative.

The optimized formulations not only retained market-level optical transparency but also maintained the desired physical and chemical characteristics throughout the optimization process, comparable to those of the commercial counterpart. This achievement paves the way for the development of a commercially viable, environmentally friendly PU formulation ready for market adoption.

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[2] The European Parliament and the Council of the Europian Union, 2017. Regulation (EU) 2017/852 of the European Parliament and Council of 17 May 2017 on mercury, repealing Regulation (EC) No. 1102/2008. Off. J. Eur. Union.
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