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SUSTAINABILITY ASSESSMENT OF FIRE-RETARDANT CHEMICALS: THE CRITICAL ROLE OF FUNCTIONAL UNIT SELECTION IN AN LCA-BASED STUDY

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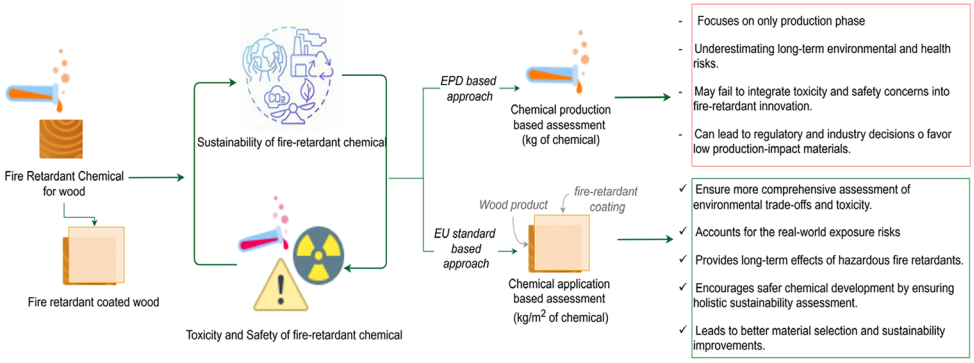
Abstract – The sustainability assessment of fire-retardant chemicals for wood requires careful consideration of their environmental impact, toxicity, and safety. However, the selection of an appropriate functional unit in Life Cycle Assessment (LCA) remains a critical yet often overlooked factor that can significantly influence decision-making. Current methodologies primarily rely on Environmental Product Declarations (EPDs), which assess impacts per kilogram of fire-retardant chemical produced. While useful for material-level comparisons, this approach may mislead the assessment of the environmental burden of fire-retardant applications, as it fails to consider the actual treated surface area and fire performance requirements. Alternatively, a functional unit aligned with European fire performance standards, such as EN 16755, which assesses fire-retardant-treated wood in real-world conditions, provides a more application-oriented perspective by considering the impact per square meter of treated wood. This study conducts a comparative LCA of business-as-usual (BAU) fire retardants using both functional units to demonstrate how the choice of functional unit can significantly impact environmental sustainability results and conclusions. The results highlight that an EPD-based approach can overlook the full environmental and health impacts of fire retardants, especially when they contain hazardous substances. In contrast, a functional unit aligned with technical applications and performances ensures a more consistent representation of environmental trade-offs and human health considerations. The misalignment of functional units can lead to regulatory and industry decisions that favour materials with lower production-phase impacts but higher long-term environmental and health risks. Given these challenges, a unified approach to functional unit selection is urgently needed in the sustainability assessment of fire retardants, especially for toxic chemicals now addressed within the Safe and Sustainable by Design (SSbD) principles, offering a framework for developing both safer and environmentally sound alternatives. In this direction, this study underscores the necessity of the application of a more robust, standardized approach for new chemical products in order to straighten material innovation towards safer, more sustainable products like the case of novel fire-retardants.

Keywords – Chemical alternatives; environmental impact; fire safety; functional unit; toxicity; wood products.



Comparative LCA of BAU fire retardants

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