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SUSTAINABLE FIRE RETARDANTS FOR WOOD: BRIDGING THE GAP BETWEEN SAFETY AND SUSTAINABILITY

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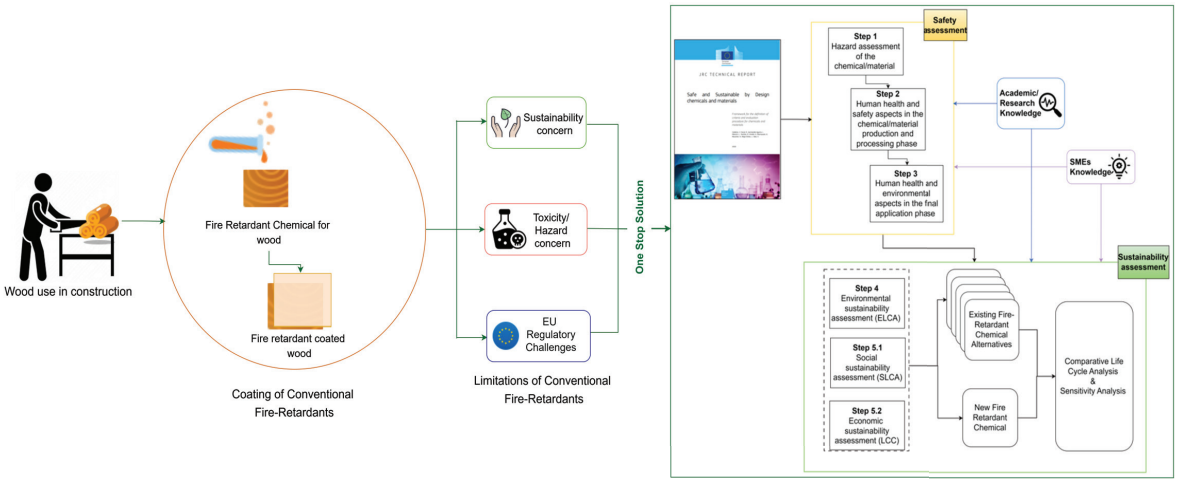
Abstract **–** Wood-based products contribute significantly to Latvia's and Estonia's GDPs, playing a crucial role in their economies. Wood is increasingly being promoted as a sustainable alternative in the construction sector as a renewable, easily processable, and high-strength material. However, its inherent flammability presents a major safety concern, necessitating the use of fire-retardant treatments. While effective in enhancing fire resistance, traditional fire-retardant development often poses environmental and human health risks due to their toxic components, less environmental friendliness, potential indoor air quality hazards, and economic infeasibility. With the increasing regulatory restrictions under European Union framework, there is a pressing need to meet the regulatory and market demands for environmentally friendly, efficient, and economically viable fire retardant. This review follows the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis) methodology to ensure a systematic and transparent selection of studies related to fire retardant chemicals for wood products. Through PRISMA screening and analysis, this paper provides a comprehensive evaluation of fire-retardant chemicals for wood, assessing their safety, fire performance, and environmental impact through the lens of the Safe and Sustainable by Design (SSbD) framework. The paper critically examines the limitations of conventional fire-retardants, including their toxicological concerns, persistence in the environment, and compliance challenges with EU regulations. The implementation of SSbD principles in fire-retardant design offers a viable pathway towards safer, high-performance, and sustainable solutions. By integrating regulatory compliance with sustainability-driven innovations, this review outlines key considerations for developing new fire-retardants that meet technical, safety and environmental standards. Research gaps, policy challenges, and industrial opportunities are highlighted to facilitate the wider adoption of sustainable fire-retardant solutions for wood applications. Ultimately, this review underscores the critical need for an industry-wide shift toward holistic, sustainable fire-safety strategies, ensuring that wood remains a viable and eco-friendly construction material without compromising fire protection standards.

Keywords **– Construction products; European regulations; Fire protection chemicals; Non-toxic flame-retardant coatings; PRISMA methodology; Safe and Sustainable by Design (SSbD)**



Safe and Sustainable by Design (SSbD) Framework for new Fire-retardant Chemical

Challenges, Regulatory Constraints, and Sustainable Frameworks for Developing Fire-Retardants in Wood Products.

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