Challenge and Ambition

WP8 RUBBER
CHALLENGE

In order to achieve the necessary green and digital transition, this important sub-sector of the chemical industry must address some significant challenges, which include:

- **Environmental concerns** are paramount for the rubber sector throughout the entire lifecycle of rubber products, from the carbon footprint of their production, to the accumulation of microplastics from road vehicle tyre wear, and additionally the phasing out of the most harmful substances in consumer products.

- The sector still relies heavily on fossil-based raw materials, and while **more promising sustainable alternatives are emerging**, they still represent a small fraction of the global rubber market. Similarly, recent advanced manufacturing and digital fabrication only fully realize their sustainability potential when combined with eco-design principles and novel and more sustainable materials. On the other hand, the complexity of rubber recycling and end-of-life management makes it challenging to close the loop for rubber materials and products, with downcycled recycled materials typically being used for low-value applications. Pyrolysis and devulcanization are up-and-coming technologies that still face challenges in terms of energy efficiency, cost competitiveness, scalability and end-product quality.

- Lack of universally accepted **standardized protocols** (e.g., for life cycle assessment and recyclability) **as well as regulatory obstacles** and complexities create market confusion, hinder the reliable benchmarking of new materials and slow the adoption of circular and sustainable products.

- **Digitization** is not a goal in itself, but **it is the necessary enabler for achieving quality, performance, safety and sustainable objectives.** The rubber sector is increasingly focusing on digitalization and automation developments, but there remain some challenges related with its heterogeneity in terms of resources (legacy production systems where digital tools are difficult to integrate and initial required investment are barriers especially for the SMEs), implantation of digital technologies (from Industry 2.0 to Industry 4.0 enterprises) and skill gap (there is a shortage of professionals trained in digital technologies applied to the rubber sector).

- **Cybersecurity and ethics** are important concerns in the digital transition for the rubber industry, emerging as important drivers of change in this sector.

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AMBITION

The main ambition in the rubber sector is to **develop rubber materials with tailored properties, while ensuring durability, recyclability and minimal environmental impact still achieving the performance required for their applications with economic feasibility.** This global motivation can be divided into more precise objectives:

- The rubber sector aims to continuously improve the environmental, health, safety, and security performance of rubber companies. To reach its goal of becoming carbon neutral, the sector should improve the traceability of raw materials, develop more efficient logistics and implement advanced manufacturing processes that maximize material and energy efficiency. The ultimate objective is to create closed-loop systems and zero-waste production processes. Standardized life-cycle assessments could provide reliable quantification of environmental impacts from cradle to grave. Additionally, the adoption of green chemistry principles, **replacement and elimination of the most harmful and hazardous chemicals and substances**, and the **design and development of energy-saving and more durable products** are key objectives to improve safety and minimize the microplastic pollution and environmental impact of the rubber sector.

- The Safe and Sustainable-by-Design (SSbD) concept in the rubber sector promotes the (re)design of chemicals, materials, and products, while comprehensively accounting for their manufacturing, use, and end-of-life management so that these innovations do not adversely affect human and environmental health at any point in their lifecycles. At the same time, SSbD promotes circularity, aims to meet societal needs and standards, and contribute to social and economic resilience. In addition, the design of rubber materials and products that are inherently easier to recycle could further enhance the circularity of this sector. In this context, efforts to **develop more sustainable rubber materials based on renewable and recycled feedstocks and ingredients** are focused on maintaining the performance of their fossil-based counterparts at a competitive cost to expand their potential applications. Novel materials and designs are applied to increase of lifetime of rubber products and also to promote the reuse and repair of rubber products in order to prevent the waste generation according to the EU waste framework directive. Finally, the ambition in rubber recycling is twofold: the expansion of ground tyre rubber markets obtained by mechanical recycling methods and the development of large-scale, energy efficient and cost-effective recycling methods based on pyrolysis and devulcanization processes to enhance the end-products quality, enabling the upcycling of these recycled raw materials towards novel applications and therefore push toward a circular economy in a safe, health and sustainable way.

- Regulation plays a critical enabling role, acting as a forcing mechanism that translates positive consumer attitudes into market scale to incentivize the production and consumption of sustainable products by positive motivation, including tax breaks and subsidies for companies that adopt circular economy principles and reach the desired outcomes, targets and objectives. **Faster adoption of regulation and harmonized regulatory frameworks** are essential to facilitate the market entry of new sustainable materials. This would streamline regulation and alleviate regulatory pressures to strengthen resilience of the sector and support global competitiveness. Finally, the development of robust standards for life cycle assessment and recyclability are essential to ensure transparency, build consumer trust, and create a level playing field.

- **Digitalization** is essential to orchestrate the path towards a sustainable, carbon-neutral, circular economy, which include new digitally enabled supply chain-structures. Leveraging AI, machine learning, and predictive modelling accelerate the discovery of more sustainable rubber materials and optimize their production and lifecycle management. Another key approach in this path is the implementation of digital twins, IoT sensors for real-time monitoring, AI-driven predictive maintenance, and generative design tools to optimize performance, reduce testing requirements and thus accelerate the innovation in the rubber sector. AI-assisted screening and composition–property mapping can shorten development cycles and help identify the best formulations for specific applications. Security and ethics in the digital transition emerge as important drivers of change in this sector.

- **Development of training programmes** adapted to the current and future needs of the rubber industry are required to provide upskilling and reskilling in sustainability and digitalization. These programmes must cover the skill sets needed for the new occupational profiles that are emerging as a result of the transition in the rubber sector.

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