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European Commission

CORDIS Results Pack on

safe and sustainable by design

A thematic collection of innovative EU-funded research results

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Responsible chemicals and materials development for Europe's green transition

Research and Innovation

Contents

Editorial

Responsible chemicals and materials development for Europe's green transition

Meeting Europe's environmental and sustainability goals requires transitioning industry toward a circular economy, centred on the production and use of innovative chemicals and materials that are safe, non-toxic, sustainable and easily recyclable while maintaining or improving performance. This CORDIS Results Pack on safe and sustainable by design highlights the work of 11 Horizon-funded projects leading this change in the chemicals and materials sector.

The European Commission's 'safe and sustainable by design' (SSbD) framework is a voluntary approach to guide the innovation process for chemicals and materials. It aims to minimise the impact of chemicals, materials and products on health, climate and the environment during sourcing, production, use and end-of-life.

The approach is especially relevant in the development of chemicals and advanced materials, the latter being intentionally designed and engineered substances and materials with innovative properties and functionalities.

The objective of SSbD materials research and innovation is to cement EU leadership in the green transition industrial policy. Doing so will secure a strong position on the respective high-growth global markets by stimulating scientific and technological advancements, investment using the SSbD framework when developing new chemicals and materials, as well as their uptake in high added-value, competitive products and services across a range of applications and sectors.

This Pack showcases the results of 10 Research and Innovation (RIA) and one Coordination and Support Action (CSA) Horizon-funded projects, centred on high-performance chemicals and materials designed and developed using the SSbD framework as an innovation guide. The collection demonstrates the potential of the chemicals and materials to ensure safe and sustainable industrial production, securing resilience and innovation potential in a number of industrial sectors critical for European autonomy, including medicine, advanced manufacturing (automotive and machinery), textile and energy.

The selected projects reflect efforts undertaken at EU level to ensure the elaboration of tools and advanced knowledge for SSbD approaches, particularly the development of multi-component advanced materials-enabled products, such as functional nanocoatings.

Europe's aim is to secure and increase its position in the global market by promoting widescale cooperation in and across many different value chains alongside different industrial sectors. Doing so will realise the scale-up of these technologies into viable commercial products.

To support this change, the IRISS project – highlighted in this Pack – aims to foster a SSbD community in Europe and globally. Already, more than 350 representatives from industries such as textiles, electronics and automotive have joined to promote the development of the SSbD ecosystem.

These and more flagship projects within Horizon 2020 and Horizon Europe are spearheading the global developments in SSbD, ensuring the long-term resilience of the European industrial and manufacturing value chains, and furthering the ambitious objectives of the EU green transition strategy.

A one-stop shop to ensure nanomaterials are safe and sustainable

The EU-funded DIAGONAL's work to make industrial nanomaterials safer and more sustainable is key to building consumer trust in this fledgling and wide-ranging technology.

Despite often being cited as a key enabling technology with the potential to revolutionise a variety of industries, nanotechnology still raises concerns.

Tiny nanoparticles used in a wide range of products from sunscreen to drug delivery, can cross the protective internal barriers of living organisms, such as mucus-secreting membranes for instance. Once inhaled or ingested, they may affect tissues in the brain, lungs or heart. They can also leach into soil or water, creating a potential threat to aquatic and terrestrial organisms.

We calculated that redesigning zinc oxide nanoparticles resulted in a 68 % mitigation of environmental risks.

"Before we can manage the risk from nanoparticles, we must first better understand their physicochemical properties and impact during exposure. Then we can suggest appropriate mitigation measures," says Carlos Rumbo Lorenzo, co-coordinator of the DIAGONAL project.

Alongside this aim, Rumbo and his colleagues at the University of Burgos in Spain set out to better quantify the sustainability implications of nanomaterials. "It's important to accurately account for the global benefits of any future widespread use," says Rumbo.

Having already produced 28 peer-reviewed journal articles, with more in preparation, the project has also generated tools to help industry decision makers apply safe and sustainable by design (SSbD) principles to nanomaterials.

Characterising nanoparticles

Most nanoparticle research focuses on pristine or simple nanoforms. DIAGONAL concentrated on the more complex multicomponent nanomaterials (MCNMs) and high aspect ratio nanomaterials (HARNs). They were studied within seven industrial demonstrators, covering cosmetics, health, automotive, aerospace, oil and gas, textiles, and printed electronics.

The demonstrators provided nanoparticle samples, so that Rumbo's team could study their physicochemical properties, such as composition, size and surface chemistry. Meanwhile, realistic in vitro cellular models – including of lung, gastrointestinal tract, skin and immune cells – were developed to explore the impact of human exposure. On-site monitoring was also carried out at the demonstrators' industrial facilities to gather detailed workplace data.

To assess the ecological implications, the team studied the impacts of nanoparticles on model species selected from various habitats: worms (soil), '*Pseudomonas putida*' biofilm (sediment), and daphnids and algae (freshwater).

The combined data, augmented by molecular modelling and machine learning techniques, then informed DIAGONAL's insights. Rumbo explains: "Our models characterise the structure of nanoparticles and simulate their behaviour in real environments. Thanks to AI we can now create models to predict the toxicity of a given MCNM or HARN."

Trust in nanotechnology

DIAGONAL's experimental and modelling work has inspired the development of SSbD strategies, validated by the project's industrial partners and implemented by the demonstrators.

These can be accessed through the DIAGONAL decision support tool which evaluates the relative safety of nanoparticles in particular scenarios, before proposing specific SSbD strategies alongside scores of anticipated impact. Crucially, these scores reflect concerns going beyond safety alone, encompassing wider environmental, economic and social impacts.

"Assessing the impact of the tool's SSbD strategies on sustainability issues in three case studies, we found significant improvements across the board. In one case study, we calculated that redesigning zinc oxide nanoparticles resulted in a 68 % mitigation of environmental risks and 87 % of social risks, as well as a 25 % cost reduction," adds project co-coordinator Sonia Martel Martin.

The decision support tool is hosted by DIAGONAL's cloud-based platform, alongside other risk management webtools.

"Our one-stop shop offers open access to the most up-to-date information for sector-specific risk management recommendations. Open databases and ongoing collaborations will ensure this continues," adds Rumbo.

Towards this end, while the team continues developing the support tools, it is already participating in joint activities with like-minded SSbD projects, such as SUNRISE and DESIDERATA.

PROJECT
DIAGONAL – Development and scaled Implementation of sAfe by design tools and Guidelines for multicOmponent aNd hArn nanomateriaLs

COORDINATED BY
University of Burgos in Spain

FUNDED UNDER
Horizon 2020-LEIT-NANO and Horizon 2020-LEIT-ADVMAT

CORDIS FACTSHEET
cordis.europa.eu/project/id/953152

PROJECT WEBSITE
diagonalproject.eu

The heavy-duty composite bioplastics designed to be dismantled

Lightweight and durable, reinforced plastics are critical to modern industry but difficult to recycle. The EU-funded ESTELLA project offers an environmentally friendly solution.

Thermoset composites are widely used in applications that must stand up to significant mechanical and thermal pressures, such as structural components of aircraft and wind turbines.

These materials owe their robustness to their unique structure, which combines a thermosetting polymer matrix and reinforcing fibres, typically glass or carbon. Once irreversibly 'cured', this three-dimensional crosslinked structure confers strength and rigidity on products, allowing them to maintain shape and prevent melting.

However, production relies on fossil-based raw materials, which can be toxic. They are also hard to recycle, with annual carbon and glass fibre composite waste from the aircraft and wind turbine industries alone, projected to be 840 300 tonnes by 2050.

"The available recycling techniques are typically either energy-intensive, so costly and unsustainable; or significantly degrade quality, limiting applications. Moreover, these techniques frequently focus on the recovery of the valuable fibres, while discarding the polymer matrix, limiting their reuse," explains ESTELLA project coordinator Laura Matesanz, from the Cidaut Foundation in Spain.

To offer a more sustainable alternative, ESTELLA adopted bio-based recyclable covalent adaptive networks (CANs) to redesign the crosslinked structure of traditional thermosetting materials.

The CAN-do approach

Comprising 13 research institutions and companies from eight European countries, ESTELLA's first challenge was to incorporate the CANs into epoxy resins to form the thermosetting three-dimensional matrices.

CANs are ideal, as these polymer structures are made up of chemical bonds which can break and reform under specific stimuli, such as heat, UV light or changes in acidity – meaning they can be more easily manipulated for both production and recycling.

Diels-Alder chemistry was first used to 'unlock' the chemical bonds of the CANs and integrate them into the epoxy resins. The next task was to find the most compatible bio-based fibres for the matrices. After exploring a range of options, hemp and nanocellulose fibres were chosen.

To ensure the right configuration of materials, the resulting composites have been manufactured into a series of plates and subjected to a range of tests to ensure relevant properties such as tensile strength and flexibility.

To explore how the materials would withstand real use cases, the teams are now working on the production of prototypes, initially for mobility and construction applications. A footrest for scooters using a composite of hemp fibres, and a window profile with a composite based on nanocellulose fibres, are currently being manufactured.

To identify optimum recycling options, the team is also adapting various pre-existing techniques. Primarily focused on chemical approaches to modifying the molecular structure of composites, mechanical recycling is also being explored.

"Keeping the original mechanical and thermal properties of recycled materials makes them more reusable, so we are fine-tuning our recycling techniques to retain fibres and the polymer matrix," adds Matesanz.

Ensuring sustainability and competitiveness

Recyclable bio-based thermosetting composites will help reduce European dependence on virgin fossil resources while minimising waste, supporting prominent EU initiatives such as the European Green Deal and circular economy action plan.

To help quantify ESTELLA's environmental contribution, the team will conduct life cycle analyses of their solution's impact on climate change, fossil depletion and terrestrial acidification, compared to conventional processes.

Economic feasibility studies, including on the scalability of the manufacturing and recycling processes required, will also be undertaken.

"Making more sustainable materials available to European sectors such as transport and construction will lead to more responsible industrial practices. This will not only create products that benefit people and planet but help position European companies at the global front line of the green transition," says Matesanz.

This will not only create products that benefit people and planet but help position European companies at the global front line of the green transition.

PROJECT
ESTELLA – DESign of bio-based Thermoset polymer with rEcycLing capabiLity by dynAmic bonds for bio-composite manufacturing

COORDINATED BY
Cidaut Foundation in Spain

FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101058371

PROJECT WEBSITE
estellaproject.eu

Putting safety at centre of complex nanotech materials

Robust safety assessments developed by the EU-funded HARMLESS project are helping to ensure that citizens are protected while the European nanotech industry can prosper.

Advances in nanotechnology have led to the development of innovative nanomaterials with applications across a range of sectors. These advanced materials (AdMa), engineered with improved properties compared to conventional materials, have the potential to revolutionise industries ranging from construction to agriculture.

The complexity of these products presents a significant challenge to both innovators and regulators. As they are composed of intricate mixtures of multiple components, traditional safety assessment approaches can fall short.

"The benefits of these materials must be weighed against their potential risks to human health and the environment," says Tobias Stoeger from Helmholtz Munich in Germany, who together with his colleague Otmar Schmid coordinates the HARMLESS project. "Ensuring that these materials are safe for ecosystems, humans and natural resources is key."

Human health and environmental safety

Addressing this deficit was the central goal of HARMLESS. The project set out to develop a safe and sustainable innovation approach to AdMa, to consider both safe and sustainable by design (SSbD) principles as well as regulatory preparedness.

"We set out to develop novel methods and tools to accurately evaluate potential risks and ensure regulatory compliance," explains Stoeger. "We need mechanisms in place that support the design of safer AdMa, to convince society of their overall benefit."

To this end, the project has developed a series of integrated tools and guidance, along with an online decision support system. The idea is that these can be used by innovators to ensure the functionality, safety and sustainability of materials across their life cycle.

"Our user-friendly decision support system embeds safety considerations into the design process," adds Stoeger. "It provides industries with tools to make informed decisions during the development of materials for different consumer products."

Assessing life cycle safety of AdMa

The project's tools and support system have been trialled through several case studies. One critical area of focus has been the use of nanostructures and matrix-embedded small particles incorporated into products such as paints and agricultural products.

"When paints are exposed to harsh weather conditions, they degrade over time and potentially release tiny particles – some less than 100 nanometres in size, or about 100 times smaller than a strand of hair – into the environment," says Stoeger.

"Similarly, small particles can be released from plant protection products during handling or spraying onto fields. When inhaled, these small particles may harm human health and the environment."

Other case studies used the project's guidance and tools to assess the safety of colloidal silica used in the paper industry, as well as advanced nanomaterials used for thermal insulation in houses. Catalysts containing nanomaterials for various chemical processes were also assessed.

Promoting safe and sustainable materials

These trials have successfully demonstrated the potential of HARMLESS tools and guidance to help industries, from construction to manufacturing and agriculture, to innovate responsibly.

Users were able to refine product components, such as their shape and composition, to achieve the optimal balance between safety and functionality, from the very earliest stages of innovation.

Ensuring that these materials are safe for ecosystems, humans and natural resources is key.

"By promoting the use of sustainable and harmless materials, HARMLESS has helped to pave the way for a future where innovation through AdMa can flourish," notes Stoeger. "Assessing the safety of AdMa throughout their entire life cycle will help industry to produce next-generation AdMa that are safe to both humans and the environment."

PROJECT
HARMLESS – Advanced High Aspect Ratio and Multicomponent materials: towards comprehensive intelLigent tEsting and Safe by design Strategies

COORDINATED BY
Helmholtz Munich in Germany

FUNDED UNDER
Horizon 2020-LEIT-NANO and Horizon 2020-LEIT-ADVMAT

CORDIS FACTSHEET
cordis.europa.eu/project/id/953183

PROJECT WEBSITE
harmless-project.eu

Community-building boosts safe and sustainable design

Industries such as textiles, electronics and automotive manufacturing are looking to increase safety and reduce the environmental impact. The EU-funded IRISS project fostered a network of stakeholders to implement safe and sustainable by design.

The future of European industry lies in a circular economy built on chemicals and materials that have reduced impact on human health and the environment. The concept of safe and sustainable by design (SSbD) has been developed to help identify such materials as early in the innovation process as possible.

"It is the combination of safety and sustainability that makes SSbD such a novel concept," explains IRISS project coordinator Emma Strömberg from the IVL Swedish Environmental Research Institute in Sweden. "This ensures that when designing chemicals and materials you don't just focus on one issue or the other, you address both at the same time."

Applying SSbD to circular economies

The IRISS project was launched in June 2022 to promote this concept among a wide range of industry partners. The starting point for this was the European Commission's SSbD framework, announced in December that year. "Before this framework, there really wasn't a common understanding of SSbD," adds Strömberg.

The project brought together experts from academia, industry and policy, with the aim of raising awareness and finding a common language for discussing SSbD. "We wanted to be able to explain what we actually mean when we talk about an SSbD assessment," says Strömberg.

The second major aim of the project was to build an SSbD community around this concept. The goal of this is to provide a platform where experiences can be exchanged, and discussions of complex issues can take place.

"One issue for example might be how to tackle contamination from recycling materials," notes Strömberg. "By applying the concept of SSbD, industrial partners can ensure that any health issues are addressed early in the design stage, while promoting circularity."

SSbD in industrial settings

To assess the applicability of the SSbD framework in industrial settings, the project focused on seven value chains for chemicals and products used in textiles, construction, electronics, energy, automotive, packaging and fragrance.

"We wanted to look at real case studies to find solutions," adds Strömberg. "Many of these case studies were very specific. In the automative sector for example, we looked at the polyurethane used in car seats."

Before this framework, there really wasn't a common understanding of SSbD.

The automotive industry is likely to play a significant role in the transition to a more safe and sustainable society. At the same time, it is a major contributor to greenhouse gas emissions and air pollution. Taking account of both safety and sustainability throughout the design and development phase is therefore likely to have strong societal benefits.

"Each value chain identified a product, material or chemical that they wished to focus on," explains Strömberg. "We were also interested in seeing if we could identify any knowledge or skills gaps that needed to be addressed."

Growing the SSbD community

The IRISS SSbD community was launched in May 2024 and already has over 350 members. The platform provides a space where information can be shared, working groups formed and sector-specific problems addressed.

"We will continue to build this community after the project ends," remarks Strömberg. "We are also planning training sessions on how to apply SSbD in specific sectors and are planning an SSbD conference in November 2025."

Strömberg believes that the project has already helped to raise awareness of SSbD, and kick-started a number of interesting discussions about the critical role of chemicals and materials in society.

"Community is the key factor here, and we are not just thinking about Europe," she says. "We are spreading the word through international arenas, with the aim of making SSbD a global initiative."

PROJECT
IRISS – The InteRnatIonal ecosystem for accelerating the transition to Safe-and-Sustainable-by-design materials, products and processes

COORDINATED BY
IVL Swedish Environmental Research Institute in Sweden

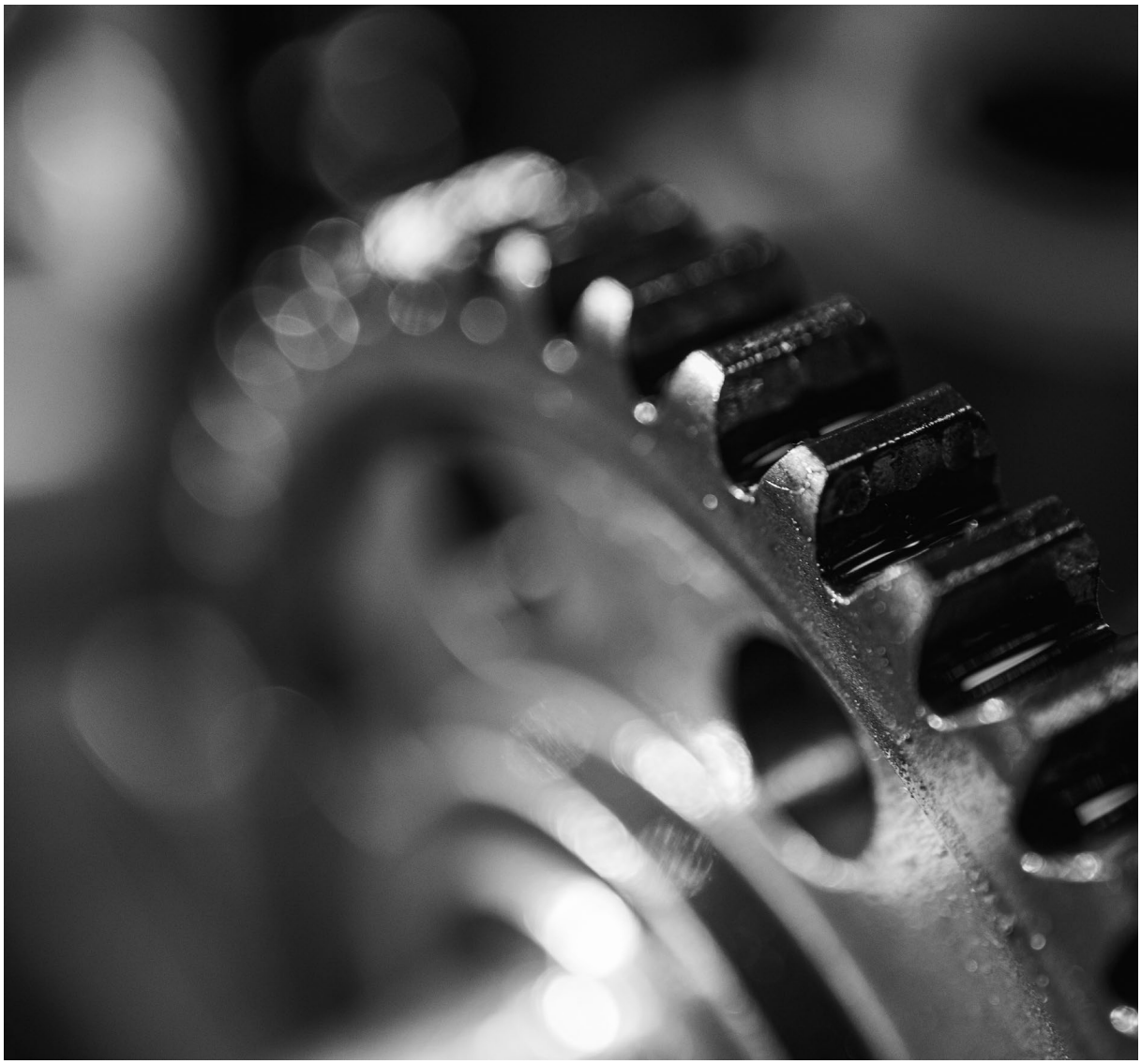
FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101058245

PROJECT WEBSITE
iriss-ssbd.eu

From hard chromium to safe and sustainable by design coatings

Nanocomposite coatings developed by the EU-funded MOZART project are poised to transform the surface treatment industry by showing equivalent performance to hard chromium, with improved safety and sustainability.



By virtue of their excellent hardness and resistance to wear and corrosion, hard chromium coatings have long been the preferred choice for a range of industrial applications. However, production of hard chromium requires the use of toxic hexavalent chromium (Cr6+) substances, presenting significant environmental and occupational health issues.

Because of their toxicity, Cr6+ substances are subject to authorisation under the EU's REACH regulation on harmful chemical substances. The European Commission has also approved a proposal that requires companies producing hard chromium coatings to implement strict risk management procedures, reassess the availability of safer alternatives, and implement a substitute material as soon as possible.

We are setting a new benchmark for environmentally friendly surface treatments.

Helping to orchestrate this transition is the EU-funded MOZART project.

"Using safe and sustainable by design principles, we've developed REACH-compliant nanocomposite coatings that can replace hard chromium coatings in targeted applications," says Myrto Pelopida, a business analyst at AXIA Innovation and the project's dissemination and exploitation manager.

Durable nanocomposite alternatives

One of the project's most important achievements is the development of nanocomposite coatings via the incorporation of nanoparticles in the metallic coating. "These nanoparticles can enhance the properties of the MOZART coatings to match or exceed the performance of hard chromium coatings," explains Pelopida.

Using REACH-compliant electrolytes, a series of nickel/silicon carbide nanocomposite coatings were produced at pilot scale, showing hardness comparable to hard chromium.

"Developing REACH-compliant electrolytes and incorporating nanoparticles into existing plating lines required us to overcome several technical hurdles," notes Pelopida. To address these challenges, the project used artificial intelligence-driven simulations, chemical functionalisation of nanoparticles, and advanced electroplating techniques. "Thanks to the hard work of our project partners, we were ultimately able to achieve high-quality, durable coatings while ensuring environmental safety," adds Pelopida.

Driving industrial innovation

By following safe and sustainable by design guidelines, MOZART ensured that its solutions can be used within current workflows. It is also developing a hybrid training dataset to help companies make the transition to the new nanocomposite coatings.

"Not only do our solutions offer equivalent levels of hardness and resistance to corrosion and wear to hard chromium-based coatings, but they are also compatible with existing manufacturing processes, meaning companies can essentially start using it today," explains Pelopida.

The team is currently working to further scale up its technology for commercial applications while also monitoring its sustainability. Furthermore, as artificial intelligence advances, the project is expanding its use of the technology to conduct more precise simulations and to refine its electrolyte formulations for broader industry uptake.

"We are setting a new benchmark for environmentally friendly surface treatments while demonstrating how advanced technologies like AI, nanotechnology, and safe and sustainable by design principles can drive industrial innovation without compromising environmental and worker safety," concludes Pelopida.

PROJECT
MOZART – Metal matrix nano-composite coatings utilization as alternative to hard chromium

COORDINATED BY
Polytechnic University of Milan in Italy

FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101058450

PROJECT WEBSITE
mozart-project.eu

Ensuring renewable energy stays green from source to socket

By reducing the use of rare earth materials and increasing recyclability, the EU-funded NOUVEAU project designed a more sustainable solution for converting and storing wind and solar energy.

Transitioning away from fossil fuels is critical to creating a sustainable energy supply. But this requires more than harnessing renewable energy sources – it also requires the energy to be converted and stored in an environmentally friendly manner.

"Because the wind doesn't always blow and the sun doesn't always shine, renewable energy can't always be produced," says Marijke Jacobs, a scientist at the Flemish Institute for Technological Research (VITO). "Instead, we must find ways to be able to convert and store that energy for later use."

Because the wind doesn't always blow and the sun doesn't always shine, renewable energy can't always be produced.

Currently, the most promising way of doing so is with what is called solid oxide electrolysis technology (SOEC). While SOEC is an efficient method for converting electricity into hydrogen fuel, the device is comprised of cells made from rare earth elements such as lanthanum.

"The cost of these elements is heavily influenced by the industrial and economic policies of rare earth-producing countries," adds Jacobs. "Any increase in the cost of rare earths may endanger the commercialisation of SOEC-based technologies." The EU-funded NOUVEAU project is helping to mitigate these risks.

Sustainable energy conversion

Coordinated by VITO, the NOUVEAU project created a sustainable, cost-effective solution for converting renewable energy. At the heart of that solution is an innovative solid oxide cell designed as a potential alternative to traditional cells. "This innovative electrode material, when used in combination with advanced coating methods, has the potential to significantly reduce the use of rare earth elements in SOEC technologies," explains Jacobs.

To better understand the potential of this development, researchers created a comprehensive virtual modelling database to calculate and predict the material properties of SOEC electrodes. This database, together with the project's experimental work, allowed researchers to identify the most promising composition for alternative electrodes.

A circular solution

While the main goal of the project was to reduce the use of rare earth elements in the manufacturing of solid oxide cells, researchers also saw an opportunity to go one step further. "To design a truly sustainable solution, we also looked at the manufacturing and end-of-life processes," notes Jacobs.

In terms of what happens to the cells once they can no longer be used, researchers developed innovative strategies to ensure that such critical elements as yttrium could be recycled and reused, reducing the need to mine new rare earth elements.

"Not only does NOUVEAU offer a sustainable and cost-effective alternative to the current SOEC technologies used for generating hydrogen, it also helps enable a circular economy," concludes Jacobs.

The project team continues to advance its research on SOEC technology, with a particular focus on integrating safe and sustainable by design principles into their processes.

PROJECT
NOUVEAU – Novel electrode coatings and interconnect for sustainable and reusable SOEC

COORDINATED BY
Flemish Institute for Technological Research in Belgium

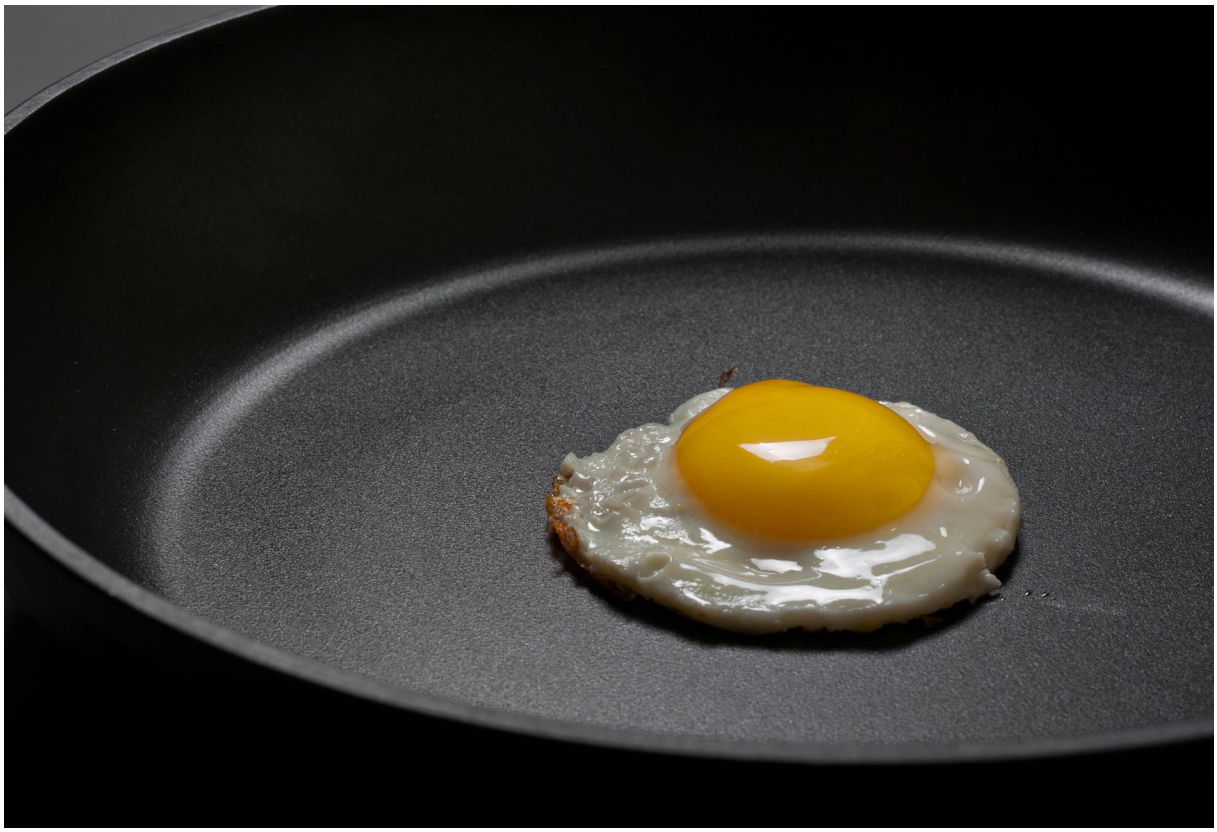
FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101058784

PROJECT WEBSITE
nouveau-project.eu

Creating sustainable coatings that protect products and the environment

Researchers for the EU-funded PROPLANET project developed a new range of coatings for the textile, food packaging and glass industries that avoid common environmental, ecological and health concerns.



The global coatings market is expanding, while regulations are becoming increasingly strict in order to protect consumer and environmental safety. Many commonly used and conventional coatings contain hazardous substances, including per- and polyfluoroalkyl substances (PFAS), volatile organic compounds (VOCs) and heavy metals.

"Additionally, coatings used in industrial applications may contain microplastics, which end up in waterways, harming aquatic life and biodiversity," notes Johannes Seif, coordinator of the PROPLANET project.

PROPLANET developed safe and sustainable by design (SSbD) coatings that eliminate these environmental concerns while maintaining high performance. The project focused on creating coatings in three key industries: textiles, food packaging machinery and glass.

"Our bio-based hybrid coatings are designed to reduce environmental pollution, minimise toxic chemical exposure, and promote a circular economy by incorporating biodegradable and recyclable materials," explains Seif.

New sustainable alternatives

The team developed various water-based coatings for the textile industry, using natural compounds such as polysaccharides. This also led to improved technical know-how, including formulations and properties derived from biomaterials.

The developed coatings were applied on textile substrates and tested for properties such as water repellence, with performance measured against commercially available benchmark coatings. "With the proper fine-tuning of viscosity and other parameters, they could be applied on textiles by impregnation or knife coating techniques," adds Fabiola Brusciotti, technical coordinator of PROPLANET. The material used 50 % less fluorine than other water-repellent fabrics.

All PROPLANET coatings have been designed and optimised following a safe and sustainable by design approach.

Components used in food preparation machinery require coatings with non-stick properties and high resistance to temperature and corrosion. The team used a chemical process known as the sol-gel technique to develop a PFAS-free alternative. This new coating is an organic and inorganic hybrid, consisting of a corrosion and temperature-resistant basecoat and a scratch-resistant top layer, with low surface energy for non-stick properties.

The researchers also sought to design very thin, highly transparent glass coatings that are water-repellent and easy to clean. Using the sol-gel technique again, the team created environmentally friendly alternatives with equivalent properties to commonly used materials.

"All PROPLANET coatings have been designed and optimised following a safe and sustainable by design approach," says Brusciotti.

Interactive tool for industry stakeholders

PROPLANET's glass and food-packaging machine coatings formulations are 100 % PFAS-free, with hydrophobic behaviour comparable to the current benchmarks. The team also started development on an interactive tool, which will provide valuable information to stakeholders and facilitate the replication of PROPLANET results and application of the developed materials.

Several trials are now under way with industry stakeholders to evaluate the coatings in real-world applications and deliver feedback. By expanding to target industries such as construction, automotive and food packaging, PROPLANET will help lower carbon footprints and prevent the release of persistent pollutants into soil and water systems.

"Through these innovations, PROPLANET supports EU sustainability goals, aligning with the Green Deal, zero pollution strategy and REACH regulations, ensuring that Europe leads the way in green technology and responsible manufacturing," adds Ioanna Katsavou, communication and dissemination manager of the PROPLANET project.

PROJECT
PROPLANET – Enhanced Safe and Sustainable coatings for supporting the Planet

COORDINATED BY
Idener Research and Development in Spain

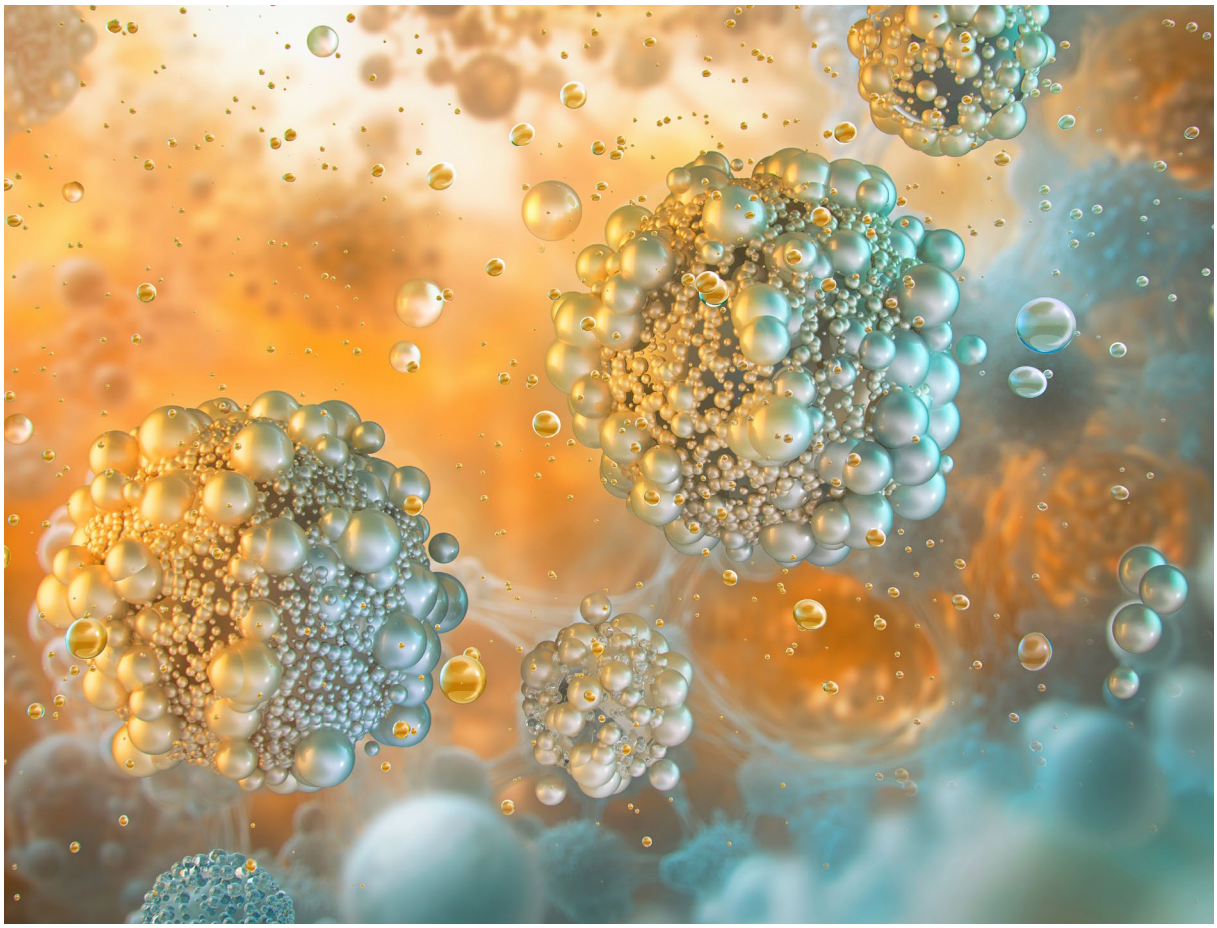
FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101091842

PROJECT WEBSITE
proplanet-project.eu

Designing sustainable advanced multi-component nanomaterials

State-of-the-art hybrid nanomaterials carry potential benefits – and risks. The EU-funded SUNSHINE project created new strategies to overcome concerns about the technology.



Multi-component nanomaterials (MCNMs) are advanced hybrid materials formed by two or more functional components, such as nanocrystals and nanoparticles, or by a nanomaterial with a unique chemical composition modified by hard or soft coatings.

Major industrial sectors such as construction, food, healthcare, energy, cosmetics and electronics are all investing in the research, design and technological development of these promising new materials, which offer unprecedented technological benefits.

Yet MCNMs pose considerable design challenges. Furthermore, due to the varied toxicities of separate components, and complex interactions with biological and ecological systems, these hybrid products also bring a range of environmental, health and safety concerns.

"These concerns are magnified by the lack of fundamental research and regulatory guidance addressing the unique properties of these advanced materials," explains Danail Hristozov, coordinator of the SUNSHINE project.

Hristozov's team worked to develop safe and sustainable by design (SSbD) strategies for the creation of products that incorporate multi-component nanomaterials.

Getting to know MCNMs

The project worked on several specific case studies of MCNM products including materials to replace halogenated flame retardants, nanohybrid materials that improve the mechanical resistance of building materials, applications to remove toxic gases from building facades, nanoclays for anti-pest cereal grain packaging, and non-stick coatings to replace polytetrafluoroethylene in baking.

"The project generated a solid understanding of the hazard and exposure characteristics of these advanced materials, and of the impact of their complex interactions on manufacturing processes and product performance," says Hristozov.

Part of the SUNSHINE project involved the development and testing of a digital e-infrastructure to facilitate collaboration and information exchange between various actors in the supply chain.

This offers a platform for gathering all the essential knowledge, tools and data needed to develop and validate SSbD strategies for MCNM-based materials and products. Through SUNSHINE, the e-infrastructure was applied in the various project case studies at different stages in an iterative process, which enabled its continuous refinement according to stakeholder needs.

A more sustainable Europe

SUNSHINE will significantly contribute to enhancing the capacity of the nanotechnology sector to deliver innovative products to the market. "The SSbD strategies will ensure safety without compromising the successful scale-up of nanotechnologies, which will speed up innovation," notes Hristozov.

The project generated a solid understanding of the hazard and exposure characteristics of these advanced materials.

Some MCNMs can reveal unexpected safety risks only several years after their market introduction, which could result in future heavy-handed regulations that might harm consumer confidence. By addressing regulatory concerns in the early stages of innovation, the SUNSHINE approach will bring safer MCNM-based technologies to the market, while reducing life cycle R&D and regulatory compliance costs.

"This will directly increase industrial competitiveness and economic growth," adds Hristozov. "The project will have a significant impact on society by delivering safer value-added products that contribute directly to the well-being of citizens."

From SUNSHINE to SUNRISE

The promising work of SUNSHINE will continue in a new project, SUNRISE, which will run until the end of 2027. "SUNRISE will build upon our achievements to deliver an approach for integrated assessment of health, environmental, social and economic impacts, and we will test it through case studies representing industrially relevant advanced materials of high societal relevance," says Hristozov.

PROJECT
SUNSHINE – Safe and sUstainable by desigN Strategies for HIgh performance multi-component NanomatErials

COORDINATED BY
University of Venice in Italy

FUNDED UNDER
Horizon 2020-LEIT-ADVMAT and Horizon 2020-LEIT-NANO

CORDIS FACTSHEET
cordis.europa.eu/project/id/952924

PROJECT WEBSITE
h2020sunshine.eu

Tackling plastic waste with next-gen materials

The EU-funded SURPASS project is on a mission to revolutionise the plastics industry by producing safe, sustainable and recyclable materials by design.

The modern world relies on plastics, but the growing focus on household sorting and recycling efforts highlights the need to investigate more effective reprocessing and recycling methods once plastics reach the end of their useful life, as well as strategies to integrate recycling as early as possible in the innovation stage.

Hosted by the French Alternative Energies and Atomic Energy Commission (CEA), in collaboration with research and technology organisations and industry partners, the SURPASS project is integrating safety and sustainability into material development from the very earliest stages.

"Many plastics on the market are neither completely safe nor sustainable," explains project coordinator Simon Clavaguera, head of laboratory at CEA in Grenoble. "They were designed without considering their full life cycle, including environmental impact, recyclability or potential hazards. Our goal is to ensure new materials prioritise these aspects from the outset."

Eliminating plastic waste

Plastic waste remains a significant environmental issue, with much of it ending up in landfills. To address this, SURPASS targets three industrial sectors that together account for 70 % of European plastic demand.

In construction, SURPASS has created recyclable bio-sourced polyurethane resins for window frames, while improving performance by reducing thermal conductance by 70 % compared to PVC, the present industry standard. Free of hazardous substances, these resins are also being optimised for recyclability with minimal material loss.

SURPASS prioritises safety and sustainability from the outset.

For transport, the team has developed fire-resistant, recyclable composites material to replace metal in train bodies. Meeting strict fire safety standards, these lightweight materials enhance durability, reduce train weight and improve energy efficiency.

In food packaging, the project has met key targets with its recyclable multi-nanolayered films, improving reprocessing and oxygen barrier properties. Trials show promising results, though transparency remains a challenge. "We achieved a significant barrier to oxygen, crucial for preserving food," Clavaguera notes. "The team is now addressing the material's visual quality while assessing consumer acceptance."

Industry collaboration

A key goal has been advancing materials from technology readiness level (TRL) 3 to TRL 5 within 3.5 years, ensuring real-world application readiness. Several project partners have already patented key innovations, with licensing discussions under way to facilitate commercialisation.

Collaboration with industry partners has been vital to the project's success to date. Indresmat, a Spanish SME, is developing innovative formulations, while WIPAK, a flexible packaging company, ensures the materials meet market needs. BASF supports the consortium in developing sustainable innovative materials and assessing safety from an industrial perspective.

In the transport sector, the project has worked with research institutions such as Fraunhofer ICT and Cidetec, acting as a launching pad for industry actors such as the Spanish train manufacturer Talgo.

Standardisation and digital tools

With one year left, SURPASS is now turning its attention towards digital infrastructure. "We are developing a website to compile our findings, along with tools and methods to help SMEs both adopt our results, and participate in the development of safe and sustainable plastics, thereby strengthening European competitiveness," Clavaguera concludes.

Standardisation is another key element, with the team implementing changes to existing standards and launching new ones, particularly for plastic decontamination after use. This alignment is essential for maximising the project's impact and practical application.

SURPASS ends in November 2025, and its impact on the plastics industry could be profound, setting new precedents for sustainability, safety and recyclability across multiple sectors.

PROJECT
SURPASS – Safe-, sUstainable- and Recyclable-by design Polymeric systems - A guidance towardS next generation of plasticS

COORDINATED BY
French Alternative Energies and Atomic Energy Commission in France

FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101057901

PROJECT WEBSITE
surpass-project.eu

Towards safer plastic coatings for the circular economy

The EU-funded TORNADO project is creating bio-based coating alternatives for textile, packaging and kitchenware, without the environmental and health hazards linked to per- and polyfluoroalkyl substances.

Per- and polyfluoroalkyl substances (PFAS) are widely used for their durability and resistance to heat, stains and water. However, their potential toxicity has raised serious concerns. In response, TORNADO is developing water- and oil-repellent coatings that align with the European Green Deal and circular economy principles, ensuring safety without compromising performance.

The project brings together partners from France, Italy, Spain, Sweden and Türkiye, aiming to strengthen Europe's manufacturing sector. Project coordinator Raquel Rodríguez, senior researcher/project manager at the TECNALIA Research & Innovation Foundation in Spain, explains: "We need to develop new bio-based coatings to be in line with the circular economy. And to involve European

companies in developing their own coatings to improve industrial capacity."

Innovation and progress

At the centre of TORNADO is the development of biomonomers, the building blocks of new coatings. These will be used to create water-based acrylic polymer coatings and sol-gel (liquid to solid) hybrid coatings, targeting applications in packaging, textiles and kitchenware.

A key challenge has been achieving scalability and ensuring that these innovations move from the lab to industrial production. One major success has been overcoming difficulties in polymerisation, a crucial step in creating the coatings.

We need to develop new bio-based coatings to be in line with the circular economy.

"The most challenging step for us was to perform the copolymerisation of the biomonomers in a process that could be scaled up by a company," adds Rodríguez. "We have achieved that and we are now working on further scalability."

While the project is ongoing, significant progress has been made. Researchers have successfully created hydrophobic coatings with water contact angles exceeding 100 degrees, a strong indicator of water repellence. In real-world testing, these coatings have shown impressive resistance, particularly in packaging applications. "We have checked that this coating can avoid the penetration of ketchup and mayonnaise in paper," says Rodríguez, demonstrating its potential for food packaging solutions.

Dissemination and engagement

TORNADO has actively engaged with the scientific and industrial communities through key events. The project was presented at MeetingPack24 in Valencia, Spain in April 2024, where an in-depth presentation highlighted the latest findings in packaging. Smart & Technical Textiles 2024 also featured discussions on the project's contributions to sustainable textile solutions.

Beyond physical events, TORNADO has reached a wider audience through online dissemination, with webinars attracting participants from universities, research centres and industry, demonstrating a strong global interest in bio-based coating solutions.

Achievements to date

As TORNADO moves into its final phases, the focus will be on validating the coatings in operational environments. This will involve testing their performance against industry standards for durability, waterproofing and oxygen barrier properties. The project follows the safe and sustainable by design (SSbD) framework, ensuring that safety and environmental considerations are embedded from the start.

Rodríguez highlights the project's holistic approach: "We are following the safe and sustainable by design criteria in all the value chains from the development of the biomonomers, to the coatings, and the application of the coatings."

In other results, TORNADO has successfully developed polymers containing 25 % functionalised biomass, an important step towards sustainability. Another milestone includes the submission of a patent application for a novel polymerisation process in December 2024.

These successes demonstrate that SSbD and high performance can go hand in hand.

PROJECT
TORNADO – New routes of safe and sustainable by design water and oil repellent biobased coatings

COORDINATED BY
TECNALIA Research & Innovation Foundation in Spain

FUNDED UNDER
Horizon Europe – Digital, Industry and Space

CORDIS FACTSHEET
cordis.europa.eu/project/id/101091944

PROJECT WEBSITE
tornado-project.eu

Beyond PFAS: safer coatings for EU consumer products

Widely used in food packaging and textiles, fluorinated compounds can accumulate in our bodies and the environment, posing health risks. The EU-funded ZeroF project is leading the search for replacements.

As the EU prepares to tighten regulations on per- and polyfluoroalkyl substances (PFAS) in 2026, the race is on for safer alternatives. ZeroF brings together 12 research and industry partners from nine countries, coordinated by Finland's leading research centre VTT.

Their aim is to develop safe and sustainable PFAS-free coatings for food packaging and upholstery textiles, maintaining the beneficial properties of traditional coatings.

"We need solutions that perform just as well as PFAS, without the risks," says Miika Nikinmaa, lead of biomaterial solutions at VTT. "The industry has to adapt quickly to upcoming regulations to ensure safety and performance remain uncompromised."

Frameworks and outcomes

ZeroF uses the safe and sustainable by design framework (SSbD) of the Joint Research Centre (JRC) to develop materials, optimise formulations and assess safety, performance and sustainability. This approach ensures that the developed coatings are effective, environmentally friendly, safe and compliant with regulatory standards.

The project focused on creating organic-inorganic hybrid coatings for textiles and advanced barrier solutions for moulded packaging. Researchers have improved the water resistance of PFAS-free textiles and are exploring innovative chemistry to enhance oil repellence.

So far, the team has made significant progress in developing PFAS-free coatings for textiles and packaging, including a product named ORMOCER®, and carbohydrate fatty acid ester-based coatings demonstrating excellent water and oil resistance. ZeroF has eliminated harmful solvents, replaced hazardous catalysts and optimised formulations with advanced additives and polymers to guarantee strong performance and safety.

Spray and powder coating techniques were refined to support industrial-scale production. Life cycle assessments and consumer surveys offer insights into sustainability and market potential, supporting real-world application of ZeroF's innovations.

Collaborative efforts

Replacing PFAS is not easy, and achieving strong water and grease repellence while keeping costs reasonable was a key challenge. ZeroF aims to reduce environmental impact by 25 % while keeping cost increases for consumers under 20 %.

Additionally, gaps in safety data for PFAS alternatives and the limited applicability of existing assessment tools complicated the research process. "The lack of comprehensive safety data made it difficult to fully assess PFAS alternatives," Nikinmaa notes. "We needed a stronger database to guide development and establish regulatory compliance."

ZeroF's success so far is also thanks to its collaboration with other EU-funded initiatives, such as BIO-SUSHY, PROPLANET and TORNADO.

Participation in ECOSYSTEX also provides a valuable network for sharing knowledge, while close cooperation with SSbD networks such as IRISS maintains alignment with safe and sustainable by design principles at every stage of development.

A safer future

The newly developed barrier coatings are on track for commercial production, particularly in the moulded packaging sector. In textiles, researchers are refining oil and chemical resistance to expand applications into areas such as protective clothing.

We need solutions that perform as well as PFAS, without the risks.

To further raise awareness, a dedicated campaign is being launched in 2025, highlighting the benefits of PFAS-free solutions. "It isn't just about regulations; we want consumers and businesses to understand why switching to safer alternatives matters," adds Nikinmaa. This will culminate in a final event in October 2025, showcasing the project's findings and paving the way for wider adoption.

As the project concludes in December 2025, the final phase will explore biodegradability for packaging applications and sustainable end-of-life solutions for textiles to prevent long-term environmental damage. This ensures that safer alternatives are accessible and practical for widespread adoption.

PROJECT
ZeroF – Development of verified safe and sustainable PFAS-free coatings for food packaging and upholstery textile applications

COORDINATED BY
VTT in Finland

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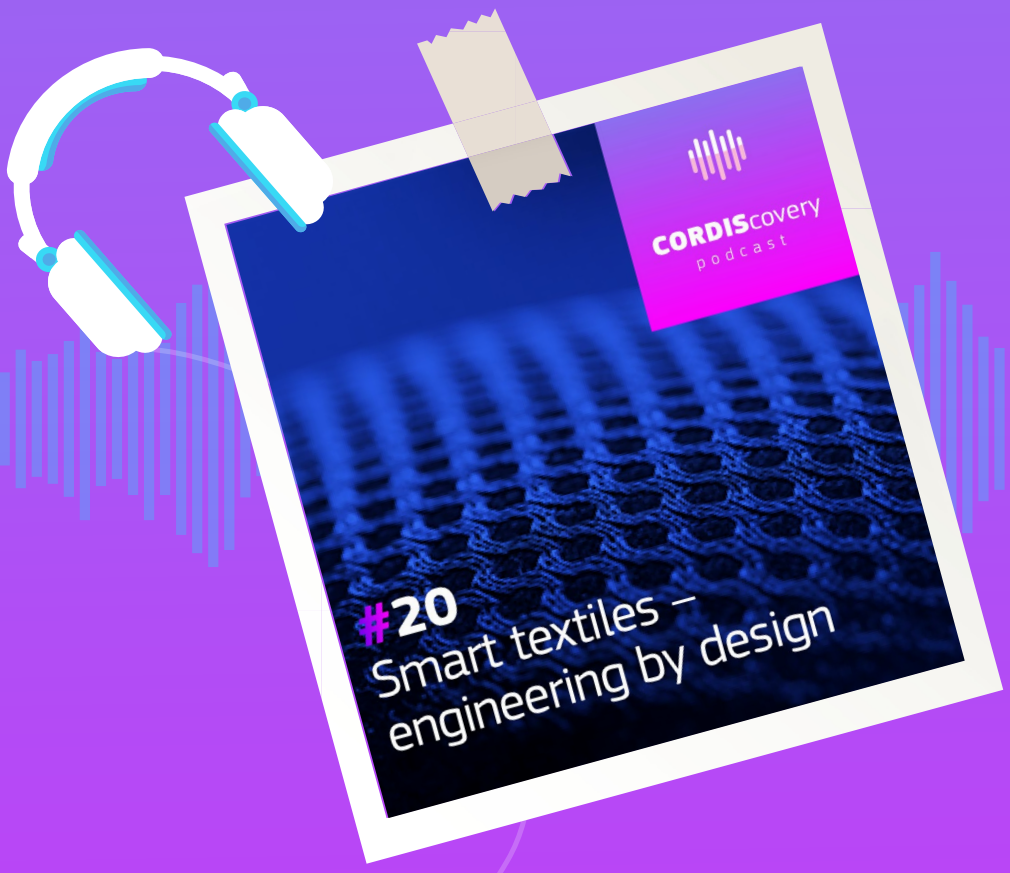
Smart textiles – engineering by design

Wearables have become 'must have' fashion – how can we make assistive technology as desirable? The most sophisticated device is useless if it is uncomfortable or unattractive. This episode, we are looking at the interface between design and engineering and how the next generation of smart textiles could make assistive tech, invisible.

Tune in and enjoy: cordis.europa.eu/article/id/442423



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