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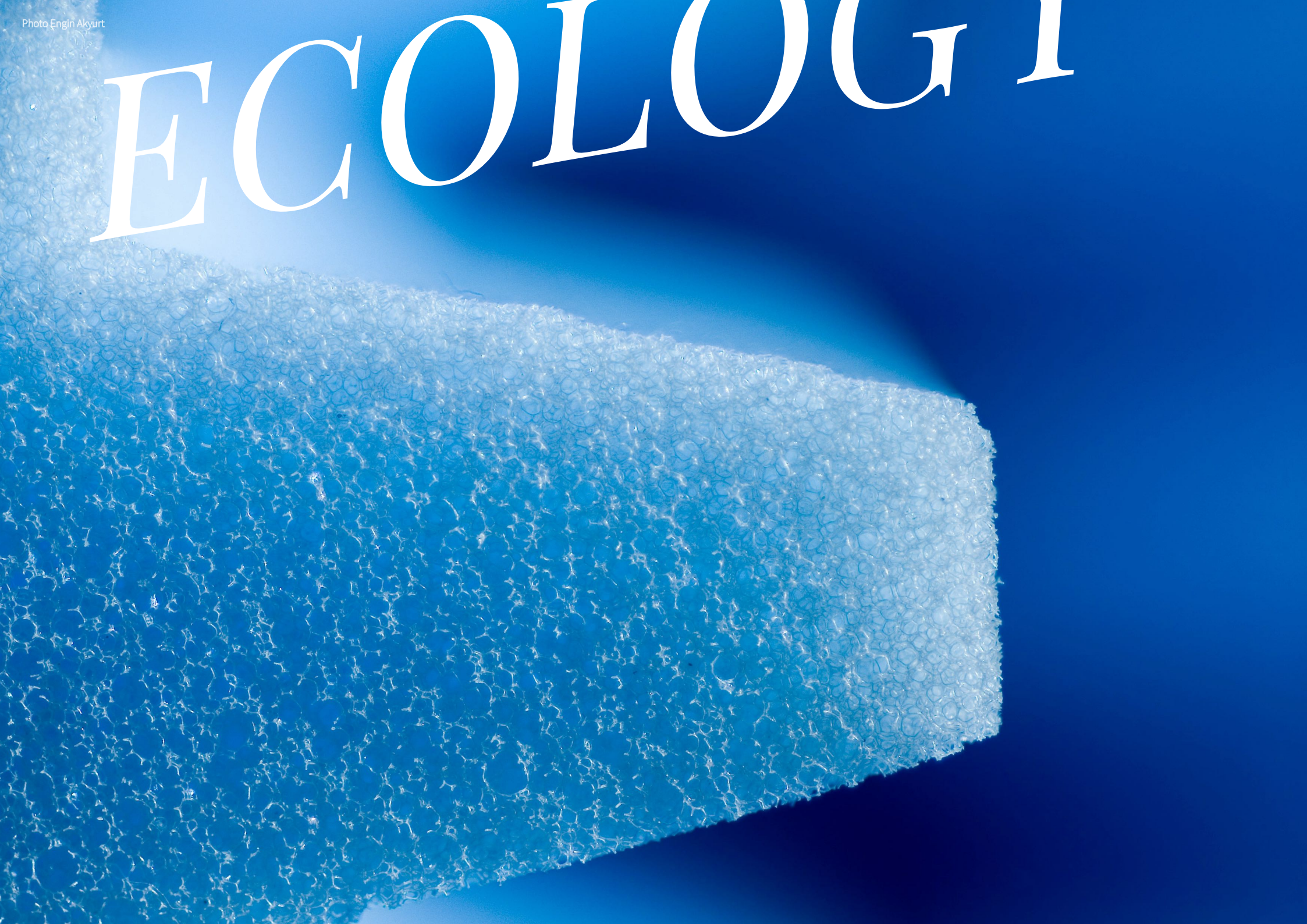

Photo Engin Akyurt

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"EUROPE'S CULTURAL HERITAGE DESERVES METICULOUS PRESERVATION"

Italian chemist Letizia Verdolotti is developing sustainable foams for the cultural heritage sector at the Italian National Research Council, a partner of the European GREENART project.

Her journey as a chemist began with a PhD thesis centred on sustainable polyurethane cement foams, conducted under the expert guidance of Marino Lavorgna. This endeavour culminated in the formulation of a groundbreaking material, subsequently licensed to Hypucem, a CNR spinoff that has since blossomed into an independent entity.

Recently, Marino Lavorgna presented her with an intriguing opportunity to delve into the realm of sustainable foams for the Cultural Heritage sector. "This venture resonated deeply with me as it seamlessly integrates my passion for designing environmentally conscious materials with the nuanced demands of preserving and transporting precious artworks," she says. "I eagerly anticipate the challenges and discoveries that lie ahead in this captivating field." Today, she participates to GREENART, a project launched by the European Union in October 2022, bringing scientists, conservators, and cultural institutions involved in the conservation and restoration of artworks. Together, they collaborate to develop new restoration products that are green and sustainable, such as cleaners, protective varnishes, consolidants, and monitoring technologies.

What is your actual role at Consiglio Nazionale delle Ricerche (CNR)?

Since 2009, I've been engaged in groundbreaking research at the Institute of Polymers, Composites, and Biomaterials within the National Research Council of Italy. This esteemed institution is renowned for its pioneering work in the development of sustainable, multifunctional polymer-based materials. My focus lies in the creation of innovative foams tailored for diverse applications, particularly within the realms of building construction, thermal insulation and automotive industries.

What is IPCB-CNR and your actual role in the GREENART project?

The IPCB-CNR is actively engaged in the GREENART project, contributing to three distinct research activities. First, the development of novel active and passive coatings aimed to protect the artworks. This involves the exploitation of potential of nanostructures and nanoparticles to serve as effective fillers for the controlled release of active compounds as well as to avoid the pollutants can get to the surface. Secondly, the development of sustainable packaging materials tailored for the storage and transportation of artworks. And then, undertaking the production of sustainable substrates to facilitate the production of graphene-based sensors. Under the coordination of Marino Lavorgna, who has been cooperating with CSGI project coordinator team across numerous European projects, the IPCB team,

— Antonio Mirabile

comprising researchers from two operational sites in Pozzuoli and Napoli/Portici, is diligently working on these initiatives.
In my capacity as the lead researcher, I am primarily responsible for developing sustainable packaging solutions based on polyurethane foams. Our aim is to engineer innovative foams capable of not only providing structural protection for artworks by acting as energy absorbers but also possessing the ability to absorb volatile organic compounds (VOCs) and regulate humidity levels within the storage containers. This multifaceted approach underscores our commitment to advancing the preservation and transportation of cultural treasures.

Can you tell us more about the packaging materials and foams for the preventive conservation of cultural properties?

Europe's cultural heritage is a priceless treasure, deserving of meticulous preservation and safe transportation to mitigate potential degradation risks. Traditionally, packaging materials such as petroleum-based polymeric foams (mainly polystyrene and polyurethane), paper tissue, and nylon fabric have been the go-to choices, albeit at environmental costs. However, CNR-IPCB has pioneered a groundbreaking solution: an environmentally friendly packaging material specifically engineered for the secure storage and transportation of cultural artefacts.
This innovative material is a sustainable polyurethane foam crafted from monomers derived from biomass biorefinery, strategically infused with a natural powder, Zeolite 4A, along with additional fillers to adsorb volatile organic compounds (VOCs). In comparison to conventional options, this composite polyurethane foam offers an array of unparalleled benefits.
It boasts enhanced compressive strength, exceptional energy absorption capabilities, and superior barrier properties against aggressive agents such as VOCs and acetic acid. Additionally, its adsorptive characteristics effectively regulate humidity levels, ensuring artefact preservation even in high-humidity or aggressive environments.
The conceptual basis of this endeavour was to develop a customised green packaging solution in compliance with current Europe's cultural legacy. This involved creating a multifunctional, bio-based packaging foam tailored to the specific requirements of the artwork using additive manufacturing techniques. This tailored approach ensures optimal protection while adhering to legal standards, marking a significant advancement in artefact packaging and preservation practices.

Which other GREENART research institutes are working with you?

We collaborate with Specific Polymers, one of GREENART partner because they provide us with bio-based precursor used for the polyurethane production, and CSGI because they provide us some functional fillers as VOCs adsorbers.

What is the origin of those materials?

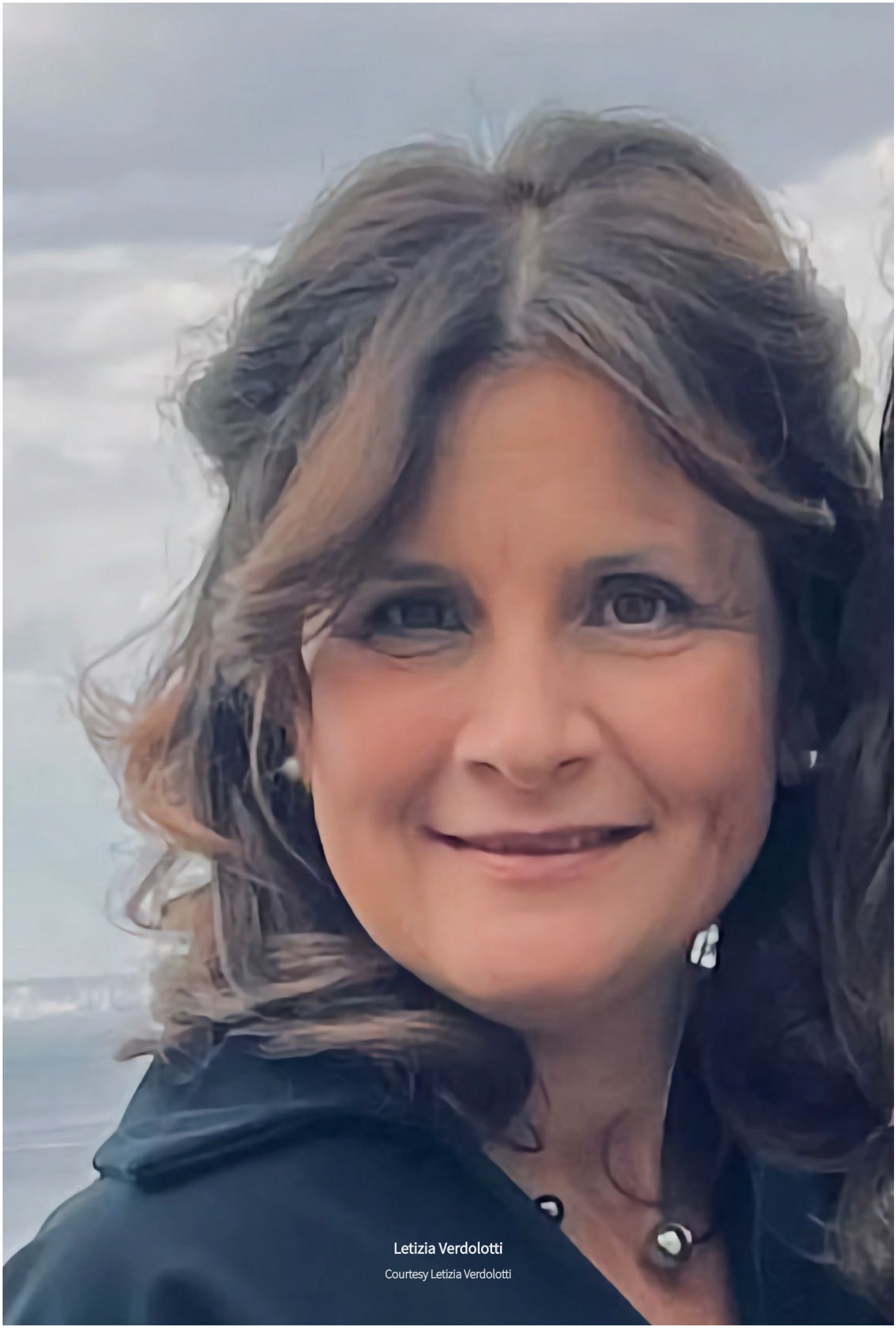
Polyurethane foams are commonly manufactured through a polyaddition reaction involving a polyol and a diisocyanate, accompanied by an exothermic foaming reaction that releases expanding gases.
The emergence of sustainable polyurethane foams for packaging stems from a heightened awareness of environmental concerns and the imperative for eco-conscious alternatives to traditional packaging materials. Various strategies have been explored to render polyurethane foams more sustainable: utilising polymeric precursors sourced from biomass; Eliminating isocyanates and substituting them with eco-friendlier molecules like cyclocarbonates and biobased amines; Developing materials that can be thermoplasticised for easy recycling, a particularly challenging endeavour.
Furthermore, the incorporation of micro- or nanofillers derived from natural sources, biomass, or waste materials into polyurethane foams not only improves their environmental credentials but also enhances their functional properties. These enhancements encompass increased compressive and impact strength, enhanced thermal or acoustic insulation, improved thermal stability, enhanced flame retardancy, and heightened pollutant adsorption capabilities. Such modifications allow for tailoring polyurethane foams to meet diverse packaging requirements while aligning with sustainability objectives.

Are they already used in other fields?

Polyurethane foams are renowned for their versatility, with exceptional mechanical, chemical and physical properties that make them indispensable in a wide range of industries. Their applications span a wide spectrum, encompassing sectors such as building and construction, thermal insulation, textiles, furniture, automotive, refrigeration, wood substitutes, and, notably, packaging — a realm we've explored through several projects, involving also several companies.
Across these diverse applications, there's a palpable surge in interest surrounding sustainable polyurethane foams. This burgeoning enthusiasm reflects a collective commitment to environmental stewardship and the pursuit of eco-friendly solutions across industries.
As we navigate toward a more sustainable future, the utilisation of sustainable polyurethane foams stands as a key pillar to our dedication to innovation and responsible resource management.

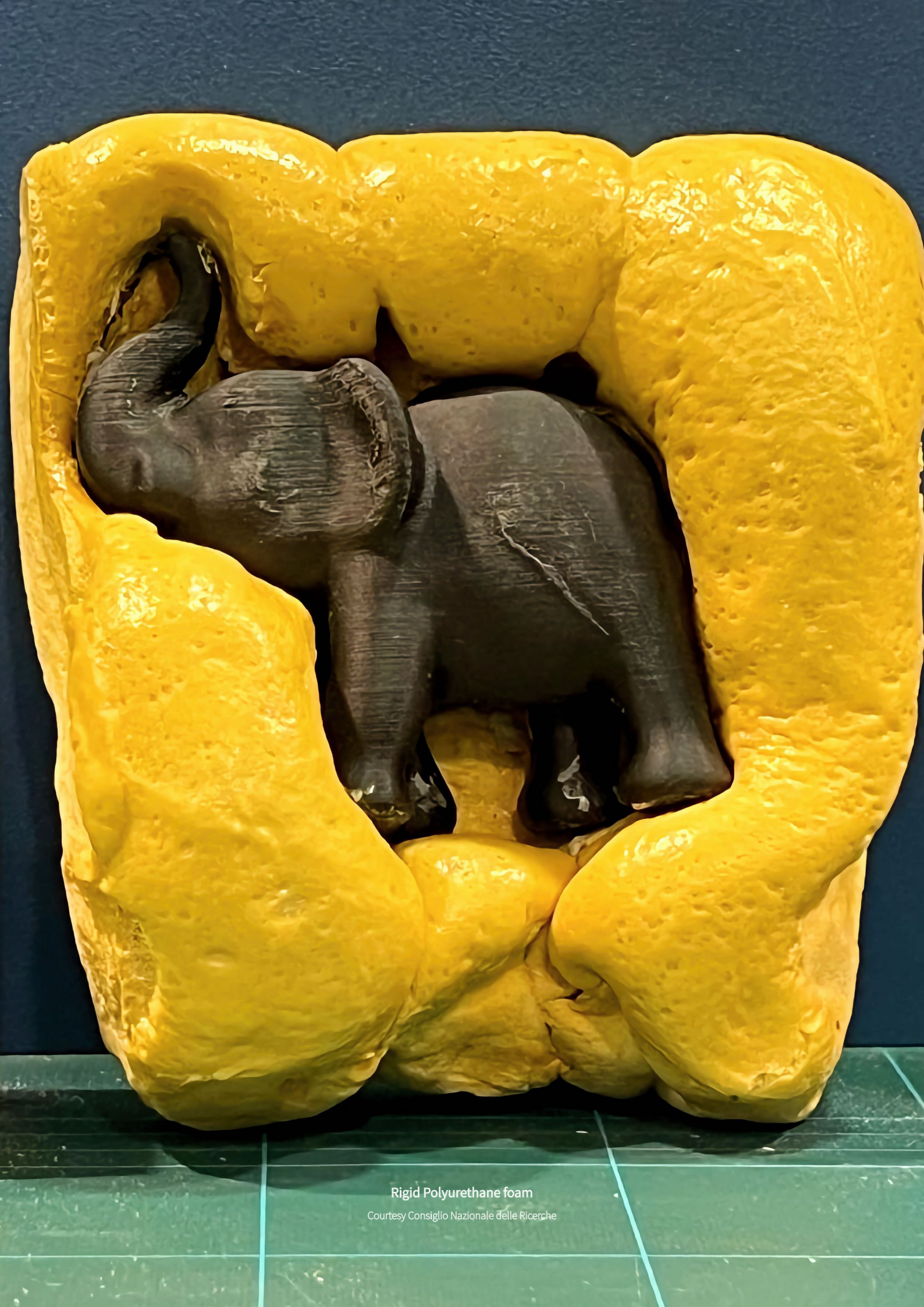
Are those materials suitable for all sort of cultural property material?

Our expertise extends to finely tuning the mechanical properties of polyurethane foam, allowing for precise adjustments in terms of softness or stiffness/hardness. This flexibility enables us to tailor



Letizia Verdolotti

Courtesy Letizia Verdolotti



Rigid Polyurethane foam

Courtesy Consiglio Nazionale delle Ricerche

the foam to suit the specific requirements of the object being transported, ensuring optimal protection. Simultaneously, through the incorporation of specialised functional fillers, independent of the mechanical characteristics, we can functionalise the foam with targeted properties. This multifaceted approach underscores our commitment to delivering tailored solutions that not only protect the transported artworks but also address broader environmental and functional considerations such as reduction of petroleum-based resources, improvement of carbon footprint of the materials, improve the recyclability.

How is innovative compared with existing materials?

A conventional packaging system for artefacts typically includes three layers: a direct wrapping layer — this initial layer directly envelops and protects the object, prioritising the avoidance of harm to any delicate or protruding parts; an intermediate cushioning layer — following the direct wrapping, an intermediate cushioning layer is employed to provide further protection; an outer protective box — finally, the artwork is encased in an outer hard box, often made of materials such as cardboard, plastics, or wood. This approach aims to control the microclimate conditions and ensure thermal comfort to preserve the artefacts' integrity. Unfortunately, this results in significant energy consumption during both production and transportation phases.
Most of these materials, integral to the preservation process, are predominantly derived from petroleum-based sources. This reliance on non-renewable resources underscores the need for innovation and sustainable alternatives in the packaging and conservation practices of cultural heritage.
Conversely, we have conveniently designed and developed a sustainable composite multifunctional foam in which all of the required functions are adequately integrated, and which can also be customised (by using 3D printing technique) for specific artefact.

It's a temporary or long-term protection and against which deterioration agents?

Foam is designed for the storage or transport of objects and, provided that the packaging can be adapted to the object in terms of properties and shape, it can be used for a long time and, when customised on the artwork, it can be used many times with the same object. However, it should be noted that we are currently investigating the reversibility of foam, making it easily recyclable through thermal processes, as is currently the case with plastics such as PET.

What about the sustainability, how can you say that the novel materials are greener?

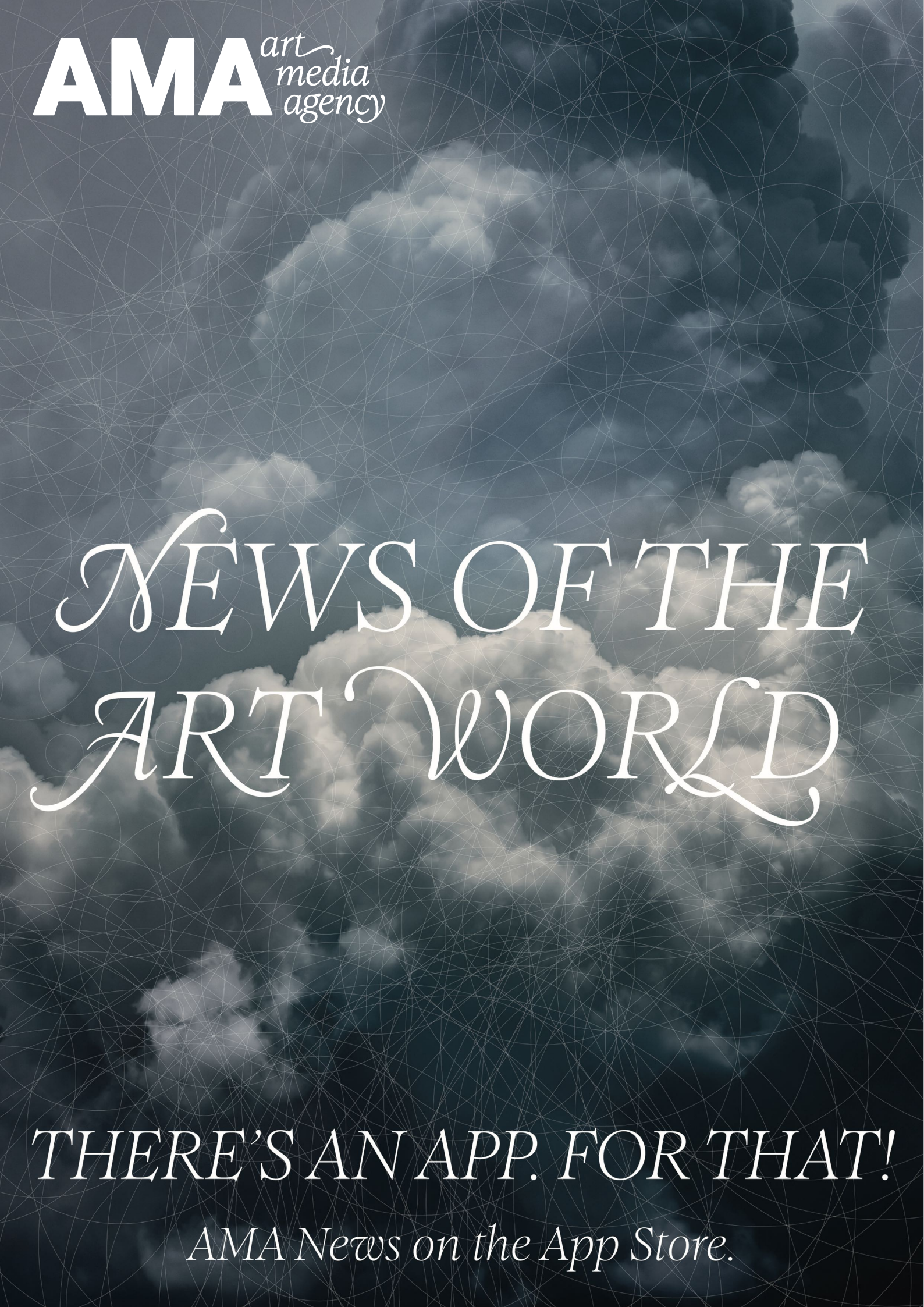
As previously mentioned, our composite polyurethane foam derives its eco-friendly credentials from green precursors and sustainable fillers. Moreover, our customisation approach enables us to minimise the amount of packaging required for each artefact, further reducing environmental impact.
In our ongoing pursuit of sustainability, we're also exploring the feasibility of rendering the foam reversible. This entails investigating methods to reprocess the foam at the end of its lifecycle, thereby facilitating its reuse. By embracing this circular approach to materials management, we not only enhance the eco-friendliness of our packaging solutions but also contribute to the broader goal of achieving a more sustainable and resource-efficient future.

Are you working with cultural heritage institution to assess and validate the novel materials?

Currently, our research efforts are primarily concentrated on the meticulous development of the foams, with a keen emphasis on crafting chemical structures that align with sustainability principles while meeting the requisite functionalities. Once we finalise the formulations, our aim is to transition from the laboratory to real-world applications. In this regard, I'm pleased to highlight the recent agreement forged between CNR-IPCB and the Peggy Guggenheim Collection in Venice. This collaboration marks an exciting opportunity to put our innovative materials to the test in safeguarding and conserving authentic works of art. A notable case study within this partnership involves the iconic *Box in a Valise* (1941) by Marcel Duchamp. By subjecting our materials to real-world scenarios and challenges, we aim to validate their efficacy and suitability for protecting invaluable cultural artefacts. This partnership underscores our commitment to bridging the gap between cutting-edge research and practical applications, with the ultimate goal of enhancing the preservation and longevity of our cultural heritage.

Do you think the innovative foams will be ready for production and sale at the end of the project?

As the project nears completion, the optimised formulation will be thoroughly validated and ready for deployment. It's noteworthy that our polyurethane foams offer versatile commercialisation opportunities. They can be marketed as laminates with fixed thicknesses or as raw materials, allowing for on-demand mixing prior to utilisation, whether for filling empty volumes or replicating specific forms.
At our institute, we have the capability to prepare laminates in-house, ensuring quality control and precise customisation. This means we can readily provide slabs of polyurethane to fill empty volumes as needed. While feasible, the preparation of bottles containing raw materials capable of reacting upon utilisation requires meticulous planning and execution. Nevertheless, we remain committed to exploring all avenues to make our innovative polyurethane foams accessible and available.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