Material Designers

Boosting talent towards circular economies

Ma De

MaDe (Material Designers) is a project, co-funded by Creative Europe Programme of The European Union, which aims at boosting talents towards circular economies across Europe. MaDe is a platform, a training program, an award and an event series showcasing and demonstrating the positive impact Material Designers can have across all industry and on the generation of an alternative creative industry aiming at circular economies.

Material Designers are agents of change. They can design, redesign, reform, reuse and redefine materials giving them an entirely new purpose. Increasing the potential of materials, they can go on to research, advise, educate and communicate what materials are and can be in the immediate, near and far future, implementing positive social, economic, political and environmental change across all sectors towards a responsibly designed future.

→ Editors

Laura Clèries, PhD
Elisava Barcelona School of Design and Engineering

Valentina Rognoli, PhD
Design Department, Politecnico di Milano

Seetal Solanki
Ma-tt-er London

Pere Llorach, PhD
Elisava Barcelona School of Design and Engineering

→ MaDe Book Scientific Board

Marta González, PhD
Lucio Magri, PhD
Javier Peña, PhD
Aart van Bezooijen

→ Information

MaDe Website
materialdesigners.org

Designed by All Purpose
allpurpose.studio

ISBN 978-84-09-24439-3
Digital edition

ISBN 978-84-09-24438-6
Printed edition

Co-funded by the Creative Europe Programme of the European Union

Circular Material Fundamentals

Material Designers Toolkit

Circular Material Fundamentals

1.0

Industry and Sociocultural Impact

1.4

1.4 INDUSTRY AND SOCIOCULTURAL IMPACT CIRCULAR MATERIAL FUNDAMENTALS 51

Circular Material for Creative Industries: The Emerging Bioplastics

Words by Marinella Ferrara

Creative Industries (CIs) make up the most important sector of European economies and are among the fastest-growing (KEA 2006, Power and Nielsén 2010). According to the European Commission (2010), CIs are "those industries which use culture as an input and have a cultural dimension, although their outputs are mainly functional." They produce tangible goods or intangible services and can support innovation in other industries through typical creative inputs of art, design, and architecture. Culture and creative labour are applying to new concepts of material, products, services or strategic communication ensuring continuous innovation based on high values products (product innovation) and new technologies, procedures, and routines to raise efficiency or quality (process innovation). Speaking about CIs innovation, we recall that "Material research plays an important role in the creative industries because the key success of a new product is increasingly linked to the materials used." (Rosso 2012) CIs can be important appliers of new materials products and manufacturing processes or contribute themselves to material innovation. It is on this very topic that we focus our contribution to MaDe. We display the potentiality of new biobased plastics for CIs. At the same time, we highlight the role of the design-driven material innovation approach and the advisable implementation in CIs.

From 2012, European Commission, jointly with the EASME endorsed actions to promote new collaborative innovation strategies for the integration of design creativity into material research and development. Projects such as 'Damadei', dedicated to increasing the collaboration between creative and material community, and the 'Design for Enterprises', a series of courses to increase the innovative capability of European small and medium-sized enterprises (Ferrara & Lecce 2019) - with a dedicated module of 'Design for Materials' (Ferrara 2017 p.179-181) – contribute to spreading among scholar, SMEs and incubators an approach of design-driven material innovation (also named creative-driven material innovation approach), relative methodologies and knowledge about what design creativity could do for materials development (EC 2013). EU actions have been contributing moving beyond the consolidated design guidelines, such as the selection and application of given materials, and pushed design culture toward an expanded and more complex materials innovation process to capture new value and drive production as well as consumption towards sustainability.

02 CIRCULAR ECONOMY TRANSITION AND MATERIAL INNOVATION IN CIS

In the topical and expected transition phase to Circular Economy (CE) paradigm, CIs are the first to start to reorganize their product manufacturing on sustainability principles to reduce environmental footprint (Prendeville, et al 2014, Loiseau et al 2016, Geissdoerfer et al 2017). Within a company the transition mattes a way to reduce conflicts between the competitivity in terms of improved efficiency, ecological responsibility, ethical values and customer satisfaction (EIO 2013; Martos-Pedrero et al 2019). Reducing the impact on the environment have also a positive financial impact: less raw material they use more they can recycle, and less they have to spend on those materials. But the transition requires investments because of materials research and an intensive process of "recirculation of resources in loops of reuse", recycling and renewal (using clean energy and eliminating waste) are needed (Clark et al 2016). Moreover, besides its academic penetration, CE seems to be a rather unclear or poorly understood concept that deficit of well-defined methodology (de Jesus & Mendonça 2018). It lacks clear information and effective legislation (Rizos et al 2015).

In this scenario, the objective of this essay is to give insight into the role of design in the enterprises' transition toward the CE. Pursuing this intent, after having briefly highlighted the connection between CIs and design, we want to clarify the relationship CE-sustainability-material innovation, giving evidence to the potentiality of new bio-based plastics. Many of them have been already developed and placed on the market thanks to the contribution of designers in connection with CIs, giving voice to innovator sensibility and design research awareness according to EU plastics Strategy. Design is called from the process beginning to establish a new relationship between resources and production (Korhonen et al 2018).

03 CIRCULAR ECONOMY AND SUSTAINABLE INNOVATION

According to the Ellen MacArthur Foundation (2016a), CE is a concept "based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems". By designing products with materials that come from, and safely flow, into their respective nutrient cycles, they can be part of creating an optimized materials economy that eliminates the concept of waste (2016b). A useful sustainable business conceptualization by Scott (2010) is based on "a zero-waste industrial economy that profits from two types of material inputs: (i) biological materials which are those that can be reintroduced back into the biosphere in a restorative manner without harm or waste, by breakdown naturally and, (ii) technical materials, which can be continuously re-used without harm or waste". Even, McDonough and Braungart (2002) recognized two cycles in which resource loops flow, the 'technical cycle' and the 'biological cycle'. The first refers to closed loops within which inorganic materials or synthetics ones can stay in continued use without losing their properties or value. The biological cycle refers to organic nutrients or materials that can return to the system or decompose without causing harm to the environment and provide a source of food for the wider system. Finally, a sustainable circular material can be defined as something whose production is supported indefinitely by nature, which means, a resource is used up at the same speed that it is renewed. From the moment in which the raw materials are extracted to the moment in which the final product is disposed of, there must be no permanent damage to the environment. What is needed to embrace a circular model is the capability to limit the use of materials and energy at the top of the process and minimise their exit during the process, reducing negative environmental externalities.

In line with sustainability theories, a strong environmental sensitivity has stimulated researcher and innovators towards a deep exploration around materiality (Ferrara, 2017). Production cycles, material and energy flows through industrial systems have been questioned for understanding how these systems interact with the environment. Researchers deal with reducing the ecological footprint even if it needed to redesign processes and materials shifting from a linear system to a closed one where wastes can become new inputs to production. They trayed to turn industrial waste and disused objects into new materials, developing techniques and also machines for the recycling of thermoplastics, such as the Precious Plastic machines by the Dutch designer Dave Hakkens - that originated a movement to promote plastic-recycling organizations - or the candyfloss inspired machine by Polyfloss Factory allowing for the recycling of thermoplastics into fibres. Similarly, in Germany 3DEVO, developed a machine capable of transforming the plastic waste into 3D printable granules, which can be then turned into filaments. Instead, Refil that produced 100% recycled filaments of many thermoplastics from plastic waste, now is changing its focus on the operations of Better Future Factory to help brands & business moving to sustainable plastics. Technical cycles like these could be considered a partial solution to the environmental problems but can open new economic of ecological potentialities for manufacturing companies as well as for craftspeople and local communities in many contexts. In a time when plastics are ubiquitous with a profound negative impact on animal welfare and the environment, plastic waste is a crucial issue.

There are plenty of CE transition cases through materials' innovation among design-oriented industries. Speaking of technical material cycles, for instance, Magis, one of the most popular Italian design furniture brands developed a polypropylene recycling sourced from its production waste and that of the local car industry. new originated patented material, that excludes almost all virgin or new materials, can be 100% recycled again after use. This material was applied by the designer Konstantin Grcic in the monobloc Bell chair, which uses the minimum quantities of material and causes less energy consumption during production thanks to the structurally strong egg-shaped shell geometry, that is comfortable and welcoming. Once the product has reached the end of life, it can fully recycle creating an almost closed material cycle. Grcic's ecological aspiration behind the project drive to rethink the entire production and distribution process in order to keep the weight, the time of production and the price of the chair as low as possible. Distribution costs have been reduced by shipping the chair on a specially designed pallet, a vertical stack of 12 units, using the same recycled plastic (Grcic 2020, Magis 2020).

Even companies that do not operate in the products design sector have an interest in promoting their circular economy approach. For instance, in 2019 the multinational Heineken brewery awarded the Spanish architect Omayra Maymó for her idea to create a new material with barley waste from the beer-brewing process. She applied the draft of this new material to Malta I, a conceptual piece that embodies "a statement on the use of resources" (Maymó, 2020). This is made by taking the beer process residue and binding it with cement, forming a hybrid inorganic-organic composite structure lighter of cement, and capable of higher thermal insulation and strength. Used as concrete in architecture, this new formula could help to reduce the large carbon emission produced by traditional cement manufacturing.

04 BIOBASED PLASTICS: A RENEWED GENERATION OF GREEN PLASTIC

Nowadays, for a more long-standing challenge new sustainable and renewable substances entered the productive scene and new ones are promising to soon enter thanks plaint of material researches. We refer to biobased plastics, i.e. industrial polymeric materials which are wholly or partly derived or composed of natural sources, including plants (such as corn, sugarcane, tapioca, or other forms of cellulose), animal and marine materials (for example prawn shells) and its protein and chitin, bacteria and also fossil-fuel-based (Vert et al 2012). Bio-based sources or waste-based material solutions are compatible with a bio-economy, like materials derived from agriculture or food waste. If combined with bio-resin, these bring effective sustainable alternatives to conventional plastics for a new generation of green products.

As regards to the expected biological cycle, it is important to consider that biobased plastics are not necessarily environmentally friendly. This could be not biocompatible, nor biodegradable (Vert et al 2012). It must make attention to the needed biodegradation conditions and to the eventual presence of compounded polymer or a copolymer that can include bio-resistant additives or moieties, respectively (Vert et al 2012).

The macro-category of biobased plastics includes various materials that differ in properties and applications depending on their base materials, compounded polymers and manufacture. Biobased plastics can be distinguished as full or partially natural, renewable or not. It can also be or not be biodegradable and compostable. Biodegradable refers to a substance able to entirely degrade naturally by biological activity without leaving behind any residue (Ceresana 2009). Effective biodegradation requires micro-organisms action that metabolises the material leading to a significant change in their chemical structure, converting it into other natural substances such as compost water, and carbon dioxide. In the case of compostable materials, biotransformation happens in specific environmental conditions including location, temperature, level of aeration, and timeframe, allowing microorganisms (especially by enzymatic action) metabolise the material. According to European Bioplastics (2018), a bio-based material "is defined as a bioplastic if it is either bio-based biodegradable, or features both properties."

One of the first bioplastics, both biobased and biodegradable, is the Polylactic Acid (PLA) produced by bacterial fermentation under controlled conditions of a carbohydrate source like corn starch. It was discovered in the 1930s, but only recently became the most popular and promising green plastic alternatives for commercialization on a large scale. It happens thanks also its properties, comparable to other plastics in the industry, such as PET, and to the ability to be processed in different forms (from film to moulded shapes and even filaments for 3D print) on existing production equipment. PLA does not release toxic fumes when oxygenated. Recognized as safe, it is mostly used in food packaging and also in medical applications because can be absorbed biologically. Its production allows the reuse of products for a considerable number of times, by remelting the recycled material, lowering plastic pollution. But the 2nd generation PLA is less efficient in term of production than the first. Moreover, even if it is made from renewable resources, its renewable materials absorb carbon to grow, although in fewer quantities if compared to fossil-based plastics.

The fastest growing bio-based plastics group worldwide are the so-called bio-based *drop-in chemicals,* which are partially made from renewable sources

and are recyclable but non-biodegradable. The renewable (or partly renewable) basis of these products reduces their carbon footprint while also lowering production costs. They are a kind of bio-similar copy of petrochemical plastics but are made from biomass instead of fossil oil. There are types of PE, PP, PVC, and PET. This last is widely known thanks to the launch of the Plantbottle™ by Coca-Cola company. This specific PET is manufactured using 30% plant-based materials while retaining the same characteristics as the traditional bottle and being fully recyclable.

Another group of bio-based plastics are the biopolymers that are produced from bacteria such us the polyhydroxalkanoates (PHAs). Each type of PHA is produced by a specific strain of bacteria. These are exposed to a specific supply of essential nutrients (such as oxygen and nitrogen), which promotes the growth of PHA in granules of plastic inside their cells as food and energy reserves. Industrial production prefers certain bacteria capable of producing PHA from a range of carbon sources including waste effluents, plant oils, fatty acids, alkane, and simple carbohydrates. In this case, PHA has the dual benefit of reducing cost and the cost of waste disposal. PHA is non-toxic, fully biodegradable under the right conditions, and can be used in a wide range of applications, from food packaging to medical implants.

Last, but not least there is a group of biodegradable biopolymers fossil-fuel-based such as the polybutyrate (PBAT) – a random copolymer made up of butylene adipate and terephthalate - and the polycaprolactone (PCL). Used primarily in hybrid conjunction with starch or other bioplastic materials, they improve the application-specific performance of the final product due to their biodegradability and mechanical properties. They have emerged as promising biopolymers finding numerous applications as thermoplastics, elastomers, adhesives, packaging materials, dining utensils, disposable razors, diapers, cosmetic containers - shampoo bottles and cups.

CONVENTIONAL/ MAINSTREAM PLASTICS	BIO-BASED PLASTICS OR BIOPLASTICS		
NOT BIODEGRADABLE PLASTICS BASED ON NOT RENEWABLE PETROCHEMICAL RAW MATERIAL	NOT BIODEGRADABLE BIO-BASED PLASTICS	NEW BIODEGRADABLE BIOPLASTICS	
		BIO-BASED PLASTICS	FOSSIL-BASED (NON RENEWABLE RESOURCES)
PA Plyamide PE Polyethylen PET Polyethylentherephthalat PP Polypropylen PS Polystyrene PVC Polyvinylchlorid ABS Acrylnitril-Butandien-Styrol-Copolymer HDPE High-Density Polyethylene LDPE low-Density Polyethylene + many others	Bio-PA Bio-PE Bio-PET (partially biobased) Bio-PP Bio-PEF Biobased polyethylene furanoate Bio-PTT	PLA PLA PHAs PHAs PHB PHB Starch-based polymers Cellulose-based polymers	PBS Polybutylensuccinat PBSA Polybuthylensuccinat-Adipat PCL Polycaprolactone Aliphatic (co)polyesters e.g. PBS Polybutylene Succinate, PES Polyethylene Succinate, PEA Polyethylene Adipate Aliphatic-aromatic (co)polyesters e.g. PBAT Polybutylene Adipate Terephthalate PBST Polybutylene Succinate Terephthalate PBAT Polybutylenadipatterephthalat

05 FASHIONABLE BIOPLASTICS

The fashion sector often includes niche materials and results of start-ups, as evidenced by the so-called *fashionable bioplastic,* i.e. a new generation of semi-finished products that, while being environmentally sustainable, also maintain adequate physical properties and aesthetic qualities to meet the performance requirements of fashion products, accessories and upholstery.

Among these, there are green alternatives to leather that, while contributing to reduce the use of animal-leather unique products, maintain the valuable properties of the natural material such as durability and flexibility, and also offers colour customisation options and a cost comparable to high-quality animal leather. These leathers can be divided into Vegan and Bacterial leathers. The Vegan ones are of vegetable origin. They contain neither fossil nor animal materials, so are mainly PETA-approved vegan. All are cellulose-based materials featuring a variety of textures, thicknesses and embossing options. They are easily cut, sewed and printed, making it suitable for uses across fashion, interiors and furniture. Among the options already in the market there are:

→ The Piñatex leather by the London-based start-up Ananas Anam, that is produced from pineapple harvest (leaf fibres) in the Philippines improving an ancient Filipino processing technique to obtain a non-woven material that is finished in Italy and Spain. This leather is tear and tensile resistant, soft, versatile, breathable and lightweight.

→ The Wineleather by the Italian startup Vegea obtained from the processing of grape skins, seeds and stalks during the production of Italian wine – in particular from the lignocellulose and the oils utilizing a sustainable process that uses the machinery already present in the tanning plants

→ The Apple Ten Lork leather by the Italian company Frumat produced from apple waste as the main ingredient. The apple waste of South Tyrol-based, a region well known for the apple production, is dried and ground into powder. This powder is mixed with pigments and a binder and spread out onto a canvas until it turns into a leather-like material. A similar 100% biodegradable Apple leather is produced in Denmark by Apple Girl, and in Canada by Samara.

The bio-fabricated leather-like bacteria cellulose by the Germany startup ScobyTec. Its production is location-independent and resource-efficient, thanks to its low consumption of energy and raw materials. The production process is based on the symbiosis between bacteria and natural sources. It contains neither fossil nor animal materials. The entire process is handled in and does not produce any chemical waste. The material is fully biodegradable. Potential fields of application are fashion, automotive, aerospace and electronic components.

Applying similar fashionable biopolymers, the German home Nat2 of sustainable luxury footwear, propose engineered high-end sneakers made of leather-look-alike from algae, cannabis, fungi, coffee, milk, roses, stone, and more natural substances.

Thanks to the storytelling about their areas of production and the material origin, like waste transformed into products, new biomaterials qualities enable companies to propose meanings directed to conscious consumers to make a statement buying sustainable innovation to express their value.

In the eyewear sector and accessories, producers are always looking for the lightest, durable, resistant and, also eco-friendly material. Despite the already eco-friendliness of the acetate material, and a new type of cellulose acetate certified as eco-friendly, biodegradable and recyclable – such as the M49 by the Italian Mazzucchelli company – other bio-based materials appear to guaranty a less footprint, a big variety of sensor-aesthetical characteristics. In this sector new hemp cellulose, bio-composites and filaments have been introduced. The hemp filaments adoption in eyewear is not much common yet, but promising. Kanèsis is an Italian start-up that produces a hemp filament, recovering a history of production from the beginning of the last century, and give appropriate examples of potential applications with 3D printing additive manufacturing, that increase sustainability in the use of material. In bio-composites sheet materials, the renewable hemp is used in fibres as reinforcement in the blending. They are extremely strong and durable. The resin can include polyethene, polyester, and polypropylene, but it is possible to use a 100% bio-composite adding plant-based resins. Hemp and flax fibre composites sheet which are impregnated with an eco-friendly binder are handcraft by the Scottish Hemp Eyewear with natural-looking. For its acoustic and thermal insulation properties hemp bio-composites are used also in other consumer products including furniture and automotive interior substrates such us in the case of Acrodur® by BASF.

06 CIRCULAR MATERIAL SUCCESS STORIES

In this last paragraph, we offer empirical evidence of new CIs engaged in sustainable and circular materials. These show how innovators and entrepreneurs could apply a design-driven material innovation approach and manage their enterprise from *material drafts* stage to a bio-based business. These start-ups have been grown from low tech experimentations often carried out under autonomy and in the absence of any connection with the industry, contributing to the diffuse phenomenon of self-production in the design sector (Ferrara, 2011) and Material Activism (Ribul, 2013). For sure, their path from draft material to industrial production was not an easy one. As draft results, their applications are mainly hypothetical, i.e., not feasible to produce as consumer products in their current state of development and could find several difficulties for effective industrial application. This is especially true when the research is limited to the conception of a material omitting technical development for characterization and the design of applications. This can limit the successful penetration of the innovation in established companies' R&D processes. The path from design experimentation practices to industries is not an easy one but is more promising in terms of user preference and market penetration in comparison to traditional scientific research.

We have chosen the following two success stories of CIs among many others, not only for the obtained results and high qualities of materials but also for their exemplar journey. These two case studies, of which we interview the protagonists after a study of secondary sources, allow us to highlighted strain points of their start-up journey and also the principal barriers they are crossing. These case studies are a condensation of good suggestions for new entrepreneurs, designers or not, who want to undertake a design-driven material innovation start-up path.

07 SUCCESS STORY 1 – MOGU

MoGu is an industrial project and concrete proof of design-driven material innovation, based since the beginning of 2015 on the research by Maurizio Montalti, an Italian engineer and a designer working jointly with Officina Corpuscoli, the design studio which he founded in Amsterdam. The studio works through a rather experimental approach towards the identification of novel materials and processes, situated at the intersection between science and design. Their research brought to the generation of innovative processes and high-added value ecologically responsible resources, exploring the possibility of growing materials, making use of different waste and by-products of other industries and value-chains, and valorising them through the digestion using of fungal organisms (Montalti, 2017). In time, they have been discovering inherent properties that each fungal Mycelium strain can provide to a final material, and elaborating different methods, technics, conditions, different strains, and substrates to employ to create specific materials with specific properties. From long experimentation, a series of new 100% bio-based composites are born, some of these now are in production in the MoGu factory established in Lombardy, Italy.

Mogu's team is composed of mycologists, biotechnologists, engineers, and designers. They have identified effective protocols to monitor the growth of mycelium and to engineer the properties of the resulting materials for interior application. The basic material is made by applying a method that uses the structure of particular selected strains of mycelium, to implement the structural transformation and binding pre-engineered substrates made of agro-industrial and upcycled textiles residues into strong composites with new functionalities. At the end of the production process, mycelium materials are inertised by slow drying, for reduced energy consumption. The resulting products are completely stable, safe, durable and recyclable. Thanks to Mogu's design and engineering skills, the process alloy mycelium to convert the low-value input matter into a product for interior design with high added value, characterized by unique aesthetics.

The company development has been implemented though different stages: a first Pilot scale, the second phase of demo scale carry out in partnership with a player of the mushroom industry, and the third phase of commercial scale, now still in progress. The company milestones include: 1) the implementation of the Pilot plant in Varese, 2) two exclusive scientific collaboration agreement with the University of Padova and the University of Utrecht 3) the company incubation Program Alimanta2Talent 4) Company acceleration Program Unicredit Startlab, 5) Participation in BBI project (Agrimax & Grace), 6) A Partnership with Moffu Labs and SME instrument Phase 2 project approval.

At the same time, as there is not yet a market for this disruptive and completely new series of materials. They are to overcome this barrier creating the bases for a market and to favour the introduction of the first set of products so that the consumers can become acquainted with the related opportunities and limitations. For this to happen, the work implied the choice of a field of application, the design of detailed effective application of final products, as well as evaluating and demonstrating its economic feasibility at scale, participating in exhibitions and fares, and in promotion event by media.

The first commercialized MoGu product is the Acoustic collection for interior design comfort, launched in June 2019. The production includes several models each combining acoustic functionality with the organic shape and a multisensorial touch of the soft foam beauty characterizing the space decoration. This foam with its beautiful natural white colour, with small captivating tone variations, makes the aesthetic of each module a single piece rather unique.

The second product is MoGu Floor a disruptive solution for commercial and residential resilient flooring, combining design, performance and sustainability. The product is no harmful VOCs, sustainable, faster to install & easy to repair with a natural look and a great 'foot feel' and last but not least, cheaper than luxury vinyl.

08 SUCCESS STORY 1 – SULAPAC

The Sulapac project, developed by Finn's passionate biochemists Suvi Haimi and Laura Kyllönen, aims to accelerate the plastic waste-free future with sustainable materials that are beautiful and functional. The already developed materials is a biobased compostable plastic for fully biodegradable packaging with an initial application for the cosmetic industry.

When the two biomaterial researchers, were combined with the wood composite expertise of Petro Lahtinen and Antti Pärssinen, Sulapac material innovation was born. The patent material consists of renewable natural wood chips from sustainably managed forests and bio plastic-like properties natural binders that replace the traditional fossil-based plastic material with a new more sustainable one (Sulapac Ltd, 2017). It biodegrades fully without leaving permanent microplastics behind. The material is resistant to oil and water and it doesn't penetrate oxygen. Sulapac® can be processed with existing plastic product machinery, making the switch from conventional plastic to an eco-friendly alternative easier than you might think.

The Sulapac start-up was founded in 2016 in Helsinki, Finland, and immediately started a strong collaboration with Make Helsinki. This is a team of designers and communication experts specialized in many design fields. Their collaboration has been the right hand of Sulapac when it comes to communication, marketing, and also package design needs. Visual communications guidelines and artifacts, from brochures to photoshoots, from the website to investment applications, have been pretty much planned together and designed and executed by Make Helsinki. Sulapac's material concept had to be told to investors, B2B customers as well as to the public in a friendly, effective, reliable, and ecological way as designers know to perfectly deal with. Marketing and communication had to be awakening, informative, and emotional at the same time. Thanks to its effective way to communicate, Sulapac has won multiple competitions and gained very good feedback on their brand communication and visual materials from their peers and customers. Winning competitions and investment applications have of course had a concrete monetary value for them.

The contribution of the design impact on material success thanks to a natural look (thanks to visible wood chips) and feel (thanks to haptic touch and a ceramic sound) that is combined with a luxurious appearance. Sulapac® premium eco-packages will reduce the accumulation of plastic packaging waste into nature without compromising any product features making it an extremely attractive packaging choice to any product brand (Sulapac Ltd, 2017).

It is interesting to note that the biomaterials standardization is still under development. The only tool available is Circulytics™, the circularity metrics by the Ellen MacArthur Foundation to assess a company's circularity performance holistically. Sulapac team had to create criteria and validation schemes based on other European regulation standards, recommendations from top scientists in the field and also through scientific literature and then get validation from accredited, third-party test laboratories for their own business.

09 CONCLUSION

In a time of transition to CE, the demand for sustainable strategy is growing and expand. Bio-based plastics are of prior importance for sustainable innovation of end-product and a plastic waste-free future. Today the bioplastics industry is a small but rapidly growing section of the plastics industry. At present, it makes up around 1% of the total plastics market, a tiny drop in the plastic ocean. However, analysts forecast strong growth within the sector. Advances in technology have improved product quality and versatility while lowering production costs. This, in conjunction with rising fossil-fuel costs, has resulted in more companies entering the bioplastic market, promoting further research and competition.

In the path toward the CE paradigm shift, a great contribution come from design research and practices into the CIs. The here cited or presented projects, materials, and success stories introduce disruptive innovation in the plastics industry.

Their stories of European CIs firstly demonstrate that the design-driven material innovation approach is effective in strengthening competitiveness. The holistic way of the design thinking of innovating materials since the initial steps of their loop-closing conception, through identifying global needs and local opportunities of resources recovery, connecting biology to industry for the safety of living systems adds value to the whole productive supply chain. This approach integrates hard (the R&D-driven products, and cost-cutting processes) and soft innovation (concerning changes meeting the perspectives of consumers) connected to social awareness, environmental literacy shifting consumer preferences in line with social needs.

Secondly, the proposed case-studies show some of the pioneers driving the current system in the direction more sustainable one, affording the challenge of CE. In fact, despite the lack of effective

legislation, standards, or commonly adopted criteria, certifications of new biomaterials features, or even of a specific market for the newly bioproducts, they continue to contribute to accelerates and inspires the needed shift. In making this, they define a new business model, which strengths are the cooperation with other enterprises, the commitment to continuous learning and improvement, to spreading information and educating partners, customers, and the wider audience about opportunities and challenges related to sustainable products.

Barriers aren't an excuse for not innovating. They are ready to go forwards. Are the national industrial systems and consolidate enterprises ready too?

Ceresana Research (2009), Market Study: Bioplastics. Costance: Ceresana.

Clark, J.H., Farmer, T.J., Herrero-Davila, L., Sherwood, J. (2016), Circular economy design considerations for research and process development in the chemical sciences. Green Chem., 18, 3914-3934. de Jesus A. & Mendonça, S., (2018),

Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. Ecological Economy, 18, 75-89.
EC- European Commission (2013) Creativity-driven (e.g. design-driven) materials innovation. Available at: https://ec.europa.eu/research/industrial_technologies/pdf/creativity-driven-material-innovation_en.pdf

EIO (2013), A Systemic Perspective on Eco-innovation Eco-innovation Observatory. Funded by the European Commission, DG Environment, Brussels

Ellen MacArthut Foundation (2016 a) [Online]. Available at: https://www.ellenmacarthurfoundation.org/circular-economy.

Ellen MacArthur Foundation (2016 b), The Circular Design Guide.

EU- European Union (2010, April), Commission Green Paper "Unlocking the potential of cultural and creative industries". http://ec.europa.eu/culture/our-policy-development/doc/GreenPaper_creative_industries_en.pdf

European Bioplastics. What are Bioplastics) fact sheet. Available at: https://docs.european-bioplastics.org
Ferrara, M. (2017) Shifting to Design-Driven Material innovation. In Ferrara, M. & Ceppi, G., Ideas and the Matter, p.173-185. Trento: ListLab
Ferrara, M. Lecce, C., (2019). "Design for Enterprises": developing European SMEs capabilities for Design-driven Innovation. MARKETS, GLOBALIZATION & DEVELOPMENT REVIEW 4,2, article 7. https://digitalcommons.uri.edu/mgdr/vol4/iss2/7

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm? Journal of Cleaner Production, 143, 757–768.

Grcic K. (2020), Bell/Mono-bloc chair/ Magis/2020 [Online]. Available at: http://konstantin-grcic.com/.

KEA European Affairs (2006) The Economy of Culture in Europe (Study prepared for the European Commission by the Directorate-General for Education and Culture). Available at: https://ec.europa.eu/assets/eac/culture/library/studies/cultural-economy_en.pdf

Korhonen, J., Nuur, C., Feldmann, A., Birkie, S.E. (2018). Circular Economy as an Essentially Contested Concept. Journal of Cleaner Production, 175, 544-552.

Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., … Thomsen, M. (2016). Green economy and related concepts: An overview. Journal of Cleaner Production, 139, 361–371.

Magis (2020). Bell chair. Available at: https://bell-chair.com/

Martos-Pedrero, A., Cortés-García, F. J. & Jiménez-Castillo D. (2019) The Relationship between Social Responsibility and Business Performance: An Analysis of the Agri-Food Sector of Southeast Spain. Sustanaibility 11, 22, 6390 https://www.mdpi.com/2071-1050/11/22/6390?type=check_update&version=1

Maymó, O (2020), Malta I. Available at: http://www.omayramaymo.com/MALTA-I

McDonough, W. and Braungart, M. (2002). "Cradle to Cradle: Remaking the Way We Make Things". No Point Press

Montalti, M. (2017), The growing lab: Fungal futures. In Ferrara, M, & Ceppi, G. Ideas and the Matter, pp. 71-89. Trento: ListLab

Power, D., Nielsén, T. (2010), Priority Sector Report: Creative and Cultural Industries. Brussels: Europe Innova Initiative/European Commission.

Prendeville, S., Sanders, C., Sherry J., Costa F. (2014). Circular Economy. Is it Enough? UK, Cardiff: Ecodesign Centre (EDC) Cardiff Business.

Ribul, M. (2015), Material Activism [Online]. Available at: https://www.miriamribul.com/material-activism. [Accessed 8 March 2020].

Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M., Ioannou A. (2015), The Circular Economy: Barriers and Opportunities for SMEs (No. 412), CEPS Working Document. Centre for European Policy Studies (CEPS)

Rosso, L. (ed) (2012). Materials. Research and innovation in the creative industries. Report on the round table discussion, Brussels, 5 October 2012. https://ec.europa.eu/research/industrial_technologies/pdf/materials-in-creative-industries-report_en.pdf

Scott, J. T. (2010), The Sustainable Business: A Practitioner's Guide to Achieving Long-Term Profitability and Competitiveness. Routledge

Sulapac Ltd, "Sulapac," 2017. [Online]. Available: https://www.sulapac.com/sulapac-ltd-presenting-a-novel-premium-eco-packaging-at-luxe-pack-monaco-2017/. [Accessed 8 March 2018].

Vert M., Y. Doi, et al. (2012). Terminology for biorelated polymers and applications (IUPAC Recommendations 2012). Pure Appl. Chem., V. 84, N. 2, pp. 377–410.

2.5 ACKNOWLEDGEMENTS MATERIAL DESIGNERS

→ LEADING PROJECT PARTNERS

ELISAVA BARCELONA SCHOOL OF DESIGN AND ENGINEERING (PROJECT COORDINATOR)

LAURA CLÈRIES, PhD
Head of Elisava Research and expert in materials design innovation and forecasting

PERE LLORACH-MASSANA, PhD
Head of Sustainability Area

MARTA GONZÁLEZ, PhD
Head of Materials Narratives Platform

MARIA GRACIA
Marketing and Communications

ATTASSA CABRERA
Art Director of Graphic and Communication Department

DESIGN DEPARTMENT, POLITECNICO DI MILANO

VALENTINA ROGNOLI, PhD
Associate professor and Materials Experience Lab co-founder

HELGA AVERSA
Research grant

MARINELLA FERRARA, PhD
Associate professor. Founder of MADEC, the Material Design Culture Research Centre

MA-TT-ER DESIGN STUDIO

SEETAL SOLANKI
Creative Director and Materials Designer. Founder of Ma-tt-er and teaching at Royal College of Art
www.ma-tt-er.org

ALEX GROSS & TED HEFFERNAN
Graphic Designers.
www.allpurpose.studio

→ ASSOCIATED PARTNERS

BURG GIEBICHENSTEIN UNIVERSITY OF ART AND DESIGN HALLE
Aart van Bezooijen. Professor of material and technology transfer.
www.burg-halle.de/en

DESIGN SCHOOL KOLDING
Karen-Marie Hasling, PhD. Professor of materials, sustainability and design
www.designskolenkolding.dk/en.

ESAD ARTE + DESIGN MATOSINHOS
Lucio Magri. Associate professor and coordinator of the product design degree. www.esad.pt

ESTONIAN ACADEMY OF ARTS
Kristi Kuusk, PhD. Associate professor in Textile futures. www.artun.ee/en/home/

FORM DESIGN CENTER SWEDEN
Terese Alstin.
www.formdesigncenter.com/en

ICELAND ACADEMY OF ARTS
Rúna Thors. Programme Director of Product Design
www.lhi.is/en

→ SCIENTIFIC BOARD

MARTA GONZÁLEZ, PhD
Head of Materials Narratives Platform at Elisava Barcelona School of Design and Engineering

LUCIO MAGRI, PhD
Associate professor and coordinator of the product design degree at ESAD Arte + Design Matosinhos

JAVIER PEÑA, PhD
General Director of ELISAVA Barcelona School of Design and Engineering and materials believer

AART VAN BEZOOIJEN
Professor of material and technology transfer at Burg Giebichenstein University of Art and Design Halle

→ OTHER SUPPORTING OPINION LEADERS

ELLEN MACARTHUR FOUNDATION

→ DISSEMINATION NETWORKS/ MULTIPLIERS:

ADI ITALIA
Associazione per il disegno industriale. www.adi-design.org

CUMULUS
International Association of Universities and Colleges of Art, Design and Media.
www.cumulusassociation.org

Design for social innovation and sutainability.
www.desisnetwork.org

LENS.
The learning network on sustainability.
www.lens.polimi.it

→ HOSTING COMPANIES

MATREC, ANCONA (MARCO CAPELLINI)
www.matrec.com/news-trend/marco-capellini-ceo-matrec-re-think-2019

MA-TT-ER, LONDON (SEETAL SOLANKI)
www.ma-tt-er.org

MAM ORIGINALS, BARCELONA (LUIS ESLAVA) www.es.mamoriginals.com

→ GRAPHIC DESIGN

ALL PURPOSE STUDIO, LONDON
www.allpurpose.studio

→ PHOTOGRAPHY DIRECTION

ESTHER RICO
Spatial Designer and Economist.
www.estherrico.com

→ FILM DIRECTION

JORDI CUSSÓ
Professional filmmaker.
www.jordicusso.com

MATERIALS DESIGNERS
Boosting Talent towards Circular Economies (MaDe)

Ma De

CO-FUNDED BY THE CREATIVE EUROPE PROGRAMME OF THE EUROPEAN UNION

Co-funded by the Creative Europe Programme of the European Union

Co-funded by the
Creative Europe Programme
of the European Union