

Project title	Lead organisation	Public description
Bio-based chemicals from pulping and agricultural waste	NOVA BIOCHEM LTD	Nova Biochem is on a mission to revolutionise the chemicals industry with their groundbreaking platform that uses waste from the agriculture and paper industries to produce bio-based molecules. Lignin, a plant-derived polymer, is the only renewable source of valuable aromatic chemicals that are currently only obtainable from crude oil. Currently lignin is being burned and land-filled releasing >20 giga-tons/year of CO2. Nova's innovative technology has the potential to significantly reduce CO2 emissions and create a renewable source of important molecules for multiple industries. Led by cleantech/engineering entrepreneurs with a proven track record, Nova Biochem is poised to enter the market in 2027 with their Pilot Plant, annually processing 5,000 tons of lignin, substituting chemicals otherwise obtained from 110,000 barrels of crude, while saving 40,000 tons CO2 emissions moving closer to UK's target of Net-Zero by 2050. If proven successful within this project, Nova's technology can add 38% of profit to UK paper industry and create 2,500 jobs.
Developing Mixed Microbial Populations for Industrial Sidestream Conversion into Textile Dyes and Wider Bio-Products	EVOLUTOR LIMITED	Biomanufacturing using yeast/bacteria and precision fermentation processes is a powerful approach that can displace manufacturing processes that are currently extremely polluting and destructive such as fossil fuel extraction, non-degradable plastic production and intensive animal agriculture. But these harmful industries have decades of infrastructure, economies-of-scale and subsidisation behind them, making the commercial optimisation of biomanufacturing processes to achieve price parity on existing markets a huge challenge for biomanufacturers across all sectors. One way that commercial viability can be achieved is through using cheaper raw materials to feed into precision fermentation processes. Currently, the majority of biomanufacturers use virgin sugars as their feedstocks. These can make up almost 50% of overall biomanufacturing cost, and they also create competition with other markets where these sugars could arguably be better used, for example going directly into existing food manufacturing chains. In this project, Evolutor will use its proprietary microbe optimisation technology platform to develop entirely new microbial systems that can effectively utilise industrial side streams as fermentation feedstocks better than any existing microbial solutions. Side streams are challenging to capture as biomanufacturing feedstocks as they are generally complex, impure and inconsistent, making reliable fermentation difficult. But over 500M tonnes of waste goes to landfill or is incinerated every year (an estimated economic loss of \$720B). With Evolutor's new microbe developments, we will unlock side stream valorisation for biomanufacturing on a global scale, pushing our economies closer to a much needed Bio-Industrial Revolution. To demonstrate the power of our new microbes in the first instance, we are partnering with Faber Futures. Faber are developing their "Project Coelicolor" to produce bacterial textile dyes and decentralise the production of high-quality, sustainable garments. By allowing them to use currently wasted or under-valorised side streams as raw materials for this dye production, this project will push Faber Futures' fabrics to market in late 2023 and fulfil their mission of building textile biomanufacturing supply chains that are entirely ethical, equitable and sustainable from end-to-end.
World's First On-site Integration of BioConcrete Manufacturing	BIOZEROC LTD	Modern society relies upon concrete for our built environment - it is the second most used material on Earth after water. However, concrete accounts for 8% of our annual carbon emissions. This is due to the energy intensive, carbon emitting manufacture of cement, the glue that binds aggregate and sand together in

		conventional concrete. BioZeroC is a biomaterials company that produces low-carbon concrete using bacteria. Our patented process uses this bacteria to bind aggregates and sand together into a material that performs as well as conventional concrete. This BioConcrete production process emits at least 85% less carbon, and has the potential to be carbon-negative once we incorporate waste materials into our bacterial feedstocks. We are here to decarbonise concrete. This is a key step on our route to scale.
Sustainable Bioproduction of Lactobionic Acid from Whey-Based Bioprocess and Expansion of Accessible Markets through Biotech Active Ingredients ("BIONICE")	ACTIVATEC LTD	The project is focused on the use of true industrial waste streams, or the bio valorisation of low-value products derived from them. One example would be bio valorisation of whey, whey permeate, or whey derived lactose, which although produced in 180 to 190 million tonnes per annum from the manufacture of cheese and other dairy products, are still poorly exploited natural resources. The focus of this project is an accelerated development of a whey-based, sustainable bioprocess for the manufacture of lactobionic acid, a key, highly efficacious and desirable anti-ageing and moisturising cosmetic ingredient which also has applications in a range of other diverse markets such as Food/Pharma and the chemical industry. The project outcome will be a commercially relevant end-to end process ready for first tech transfer and initial manufacturing trials at a selected Toll manufacturing company. Targeting the environmentally sensitive manufacture of ingredients primarily for use in cosmetics and personal care and in particular for use in skincare permits Activatec to fully exploit the changing face of the cosmetics industry driven by the rapidly changing consumer trends towards 'organic'; 'natural' 'green' and 'environmentally sensitive' product labelling and the trending interest in 'fermented cosmetics' The manufacturing approach is simplistic, in line with reported non-commercial methods, but innovative in design which will permit successful commercial exploitation. The whole approach is designed for sustainability utilising environmentally benign manufacturing methods including those required for the downstream recovery and purification of the product. The technology is also expected to be flexible with the potential for cross-application for the manufacture of other related specific target products and derivatives.
Peptide Raw Materials for High Performance and Biodegradable Personal Care Products	ZENTRAXA LIMITED	Of the many environmental challenges we face in the UK, water pollution has been at the forefront in recent times. The DEFRA outcome delivery plan for 2021/22 lists the improvement of the environment through cleaner air and water, minimised waste, and thriving plants and terrestrial and marine wildlife first in its priority outcomes. Part of the solution will be to develop a 'circular bioeconomy' in which our dependence on fossil fuels for environmental growth is removed, and resources are extracted and recovered from waste products and used as ingredients in new products or as a source of energy. However, personal care products like make-up and shampoo will inevitably introduce a break in this circular economy as they end up in landfill or wastewater at the end of their use. In addition to there being no way of recovering and re-using their chemical ingredients, many of these products contain chemicals that are non-biodegradable and persist in the environment. European regulations prevent the use of certain toxic chemicals in personal care products, due to their impact on the environment from contaminated

		wastewater. But there are many ingredients for which the effect is unknown or not studied, resulting in a lack of technical innovations that address this challenge. Cosmetics have been used in human societies for over 7000 years and they continue to provide many people with a much-needed opportunity for self-care. Unfortunately, many of the chemicals in cosmetics cannot simply be removed as they give performance properties like ease of application or comfort to wear which are important to users. Consumers are then faced with a difficult choice between environmentally friendly products with poor performance or high-performance products with unknown environmental impact. Our innovative solution is to replace non-biodegradable chemical ingredients with biodegradable alternatives like peptides. We have developed novel, proprietary peptides that perform better than industrial chemical standards, providing the user with the optimal balance of ease of application, long wear time and comfort without compromising sustainability. Peptides can be challenging to produce, but we have developed methods that allow for bioproduction by fermentation and efficient isolation of the product in a pure form. We now need funding to scale our processes to make enough peptide for a launch product with a commercial partner. This will not only demonstrate the potential for replacing environmentally persistent chemicals with biodegradable alternatives, but hopefully encourage greater innovation in this sector.
Fermentation optimisation for a palm oil alternative	SUN BEAR BIOWORKS LTD	Palm oil is everywhere. It is in food, cosmetics and biofuels. It is in 50% of our supermarket products. Palm oil is unique in the vegetable oil market; it melts in your mouth, is great for cooking and is a high-yielding crop. However, palm oil is one of the biggest carbon emitters due to loss of tropical rainforest and peatland to make way for plantations - it contributes over 500 million tonnes of CO₂e, over 1% global emissions, from 19 million hectares of tropical land. It has caused significant habitat loss, including for the Orangutan and Sun Bear, and all too often smallholder farmers do not receive a fair price for their produce. The UK Government has committed to reaching Net Zero by 2050; 20% of UK emissions stem from agriculture and the food supply chain. These emissions must be tackled if we are to reach net zero. Sun Bear Bioworks is a UK-based company using synthetic biology and precision fermentation to make an alternative to palm oil. We are optimising a naturally oil-producing yeast strain to produce our oil from food waste quickly and efficiently. Our process saves 4kg CO₂ and 2000m² of land for every kg of palm oil - a saving in both cases of 80%. We are working with the LeoRiosLab at University College London and the RLALab at Imperial College London on this project to radically optimise our strains and fermentation process to produce fats quickly and efficiently. Feedstock costs are prohibitively expensive for scaling fermentation processes in fats - maximising lipid productivity is vital if we are to have the greatest environmental impact. This project will enable a sustainable palm oil alternative to be produced domestically at scale in the UK, creating jobs in biotechnology and food production and reversing a substantial trade deficit. This builds on the work we carried out as part of our Fast Start award, project 10045430 "Alternative feedstock for precision fermentation of oil", which has allowed us to develop our yeast modification capabilities and work with non-sugar feedstocks.
Development of recyclable, sustainable and functionalised	CELLUCOMP LIMITED	The UoE has discovered a unique enzyme which enables new functionalities to be introduced into cellulosic materials and patented its use for industrial applications. CelluComp produces microfibrillated cellulose from vegetable plant waste. This project will combine these technologies to offer enhanced materials

packaging materials using plant-based technology to replace plastic		for applications in paper-based packaging to replace single use plastic packaging. The materials developed will enable the replacement of the additives used in paper based packaging that help to provide strengthening (in wet and dry state) and barrier properties. These additives can include Per/poly-fluoro substances (PFAS or forever chemicals), polyimides, epichlorohydrins etc. some of these chemicals are in the process of coming under legislative restrictions in many countries. In addition, the materials/processes developed in this project will enable 3D-moulded paper package to be moulded with higher quality surface finishes. A high quality surface finish is critical for application of water based barrier coatings at levels, which do not impede recyclability/repulpability and biodegradability of the paper-based packaging yet still give the high levels of barrier for water/grease and oxygen resistance required for food contact packaging. The project will carry out an independent Life Cycle Analysis (LCA) to assess the environmental impact of these new materials and processes. The opportunity to develop this plant enzyme based method to produce sustainable packaging and replace PFAS and oil based chemicals has considerable potential for economic and societal impact.
CO2 to biochar: harnessing the potential of a fast-growing cyanobacterium for cost-efficient carbon capture utilisation and storage	CYANOCAPTURE LTD	Industries producing over 25,000 T CO2/year represent ~40% of the total emissions of stationary installations in Europe and are currently subject to a carbon tax at ~€100/T CO2 under the EU Emission Trading Scheme (ETS). These industries are desperately looking for affordable carbon capture technologies to reduce emissions, however, current prominently used direct air capture (DAC) is not commercially feasible at scale. CyanoCapture Ltd., the project lead, is an innovative SME aiming to develop a sustainable and cost-effective solution for point source carbon capture by combining novel photobioreactor processes and a fast-growing cyanobacterium, <i>Synechococcus</i> sp. UTEX 3154 (Syn3154). Photosynthetic cyanobacteria are ubiquitous and account for 30-50% of environmental CO2 fixation. Cyanobacteria are naturally far more efficient than plants at capturing CO2 and hence are excellent candidates for scalable carbon capture. The cyanobacterium Syn3154 is a fast-growing, high biomass accumulating strain with a doubling time of less than 3 hours, with no need for external supplementation of vitamins for its growth -- meaning that it carries the potential to be an excellent candidate to enable mass-scale CO2 removal. The project partner UKBRC at the University of Edinburgh will develop a sustainable method for conversion of cyanobacteria biomass into stable biochar and evaluate applications such as agriculture, construction, sanitation, environmental management etc. that offer not only long-term carbon sequestration, but also additional economic and societal benefits. The proposed breakthrough solution enables affordable CO2 capture and has a strong potential to elevate the UK's position at the forefront of the global Net-Zero transition.
Biocatalytic nitro-reductions in scalable continuous flow reactors: paracetamol case study	HYDREGEN LIMITED	HydRegen vision: The HydRegen technologies offer the potential for cleaner, safer, faster and cheaper chemical manufacture. Deep understanding of biology and chemistry allow the HydRegen team to select the best components from biology and use them to develop robust biotechnologies that solve real problems in the chemicals sectors. We expect our technologies to play a part in the UK chemicals sector meeting ambitious Net Zero emissions targets (by 2050) and increasing adoption of enabling technologies such as Industrial Biocatalysis and continuous flow process.

		Currently we are addressing challenges in the manufacture of pharmaceuticals and speciality chemicals (e.g. flavours and fragrances) and exploring the potential of our technologies for larger-scale, lower-value chemical production. AMT: The patented active mixing technology opens up continuous manufacturing for a wide range of processes, mitigating challenges associated with the presence of solid particles, such as in heterogenous catalytic hydrogenation reactions. The range of Coflore continuous flow reactors offer a scalable manufacturing solution from grams to kilotonnes production per annum, de-risking tech transfer from R&D to pilot to commercial scale. According to a 2021 report by PwC, continuous manufacturing can increase energy efficiency up to 50% and reduce waste by 33% compared to existing batch methods of production. Global pressures such as the energy crisis and covid, have led EU and USA based companies to look to "re-shore" production away from India and China to strengthen supply chains. Project outcomes: Showcase de-risked, bio-manufacturing route for two generic active pharmaceutical ingredients and package for licensing to UK and global chemical producers. Improved competitiveness and commercial-reputation in delivering bio-manufacturing capabilities providing a disruptive sustainable bio-manufacturing strategy by 2050. Evaluation of bio-based route to 'nitration' chemistry and consequently bio-cascades for nitration-reduction in specialty chemical manufacturing.
Material, process and development of a novel composite, layered, plastic-free leather alternative derived from waste brewery grain	ARDA BIOMATERIALS LTD	This application is focused on the development of a sustainably produced leather alternative. The leather we consume today is the net result of a long chain of carbon intensive steps associated with animal agriculture, including animal rearing, leather harvesting, tanning, and processing. A sustainable leather alternative that removes the need for animal agriculture would make a significant contribution to climate change in addition to having a clear impact on animal welfare. The applicants are a recently formed company that is commercialising exciting research that has shown that it is possible to produce synthetic leather from the waste grain produced from beer brewing --- a by-product that is typically used as low value animal feed. This in effect takes a waste material from an existing and ubiquitous industrial process (i.e., the brewer's spent grain), omits the 'growing of the animal stage' and produces a synthetic leather. By omitting the animal growth phase this synthetic leather is estimated to have only 0.3% of the carbon footprint than conventional leathers have. The Arda team has conducted the first stage of proof of concept research and they've been able to produce small samples of synthetic leather from the waste brewing grain. The material looks like normal leather but it's not sufficiently strong enough to be made into functional clothing or products. Crucially the material lacks the tensile or fibrous strength of natural leathers. Arda aim is to expand the scope of our research and develop a process that introduces very fine sustainability produced protein fibres into a layer within this synthetic leather. This will have the substantial benefit of enhancing the strength of the leather while not diminishing the sustainable origins of the material. If the business is able to strengthen the synthetic leather in this way and scale for

		greater material production, Arda already has brewery suppliers and fashion customers waiting to be part of the supply chain for this new material. The enclosed funding application is focused on a programme of Industrial Research needed to develop, scale and evaluate the performance of this "composite" synthetic leather.
Bio-based urine fertiliser and circular economy business model	VANDENBERGHUK LTD	This project is a collaboration between VANDENBERGHUK (VDB), Agri-EPI Centre, PEEQUAL Ltd, Royal Agricultural University, Green Square Agro Consulting and Pilio. The focus of our innovation is to convert urine into a viable fertiliser.
Microbial Manufacturing of Metals from Mineral Mining Waste (5Ms)	University of Nottingham	As the global population and economies continue to grow at alarming rates, this places ever-increasing demands for metals needed to manufacture everyday electronics, life-saving medical equipment and for the future of clean energy technologies (i.e., solar panels, wind turbines, batteries for electric vehicles etc). The amounts required for the five key metals (i.e., lithium, Nickel, cobalt, copper, and rare earth elements-REEs) will grow exponentially over the next few decades. Conventional mining practices use high consumption of energy and chemicals for metal mobilisation, and to ensure profitability, industries tend to use high-grade metal ores as raw material, which is leading to rapid depletion. These mining practices result in millions of tons of waste produced as mine-tailings, which reside as dams scarring the landscapes of the world. This volume of waste material is also increasing due to declining ore grades (as low ore grades produce significantly more tailings waste). However, mine-tailings still contain valuable metals, reprocessing of which can turn this perceived waste into alternate valuable resource. Transformational change is now possible in the field of metal extraction from mine-waste tailings by establishing novel Biomanufacturing processes. Intersecting the field of waste mineral processing (i.e., amorphisation of waste mineral ores) with microbial bioreactor systems holds enormous potential to address the future of clean metal manufacturing, which also focus on the circular economy from the outset. This project consortium will establish sustainable microbial biomanufacturing processes to extract key important metals from mine-waste tailings. This 5Ms project will deliver an optimised microbial bioreactor demonstrator model and will show how the biomass produced and processed (spherical) particles will be utilised for secondary market applications to complete the circular economy loop, complete with Life Cycle and technoeconomic analysis.
Bioelectrocatalysis Ethylene Synthesis	TRANSFORMATIONAL ENERGY LIMITED	The goal of the project is development of a direct carbon utilisation technology to convert biogas and flue gases into bioethylene and techno-commercial assessment of building manufacturing capability in the UK. The project will deliver a biosynthesis technology which will convert carbon dioxide in flue gases and wastewater into chemicals such as bioethylene, without the need of carbon capture and Hydrogen, which are the two biggest cost contributors to the cost of e-fuels. The project will also deliver adoption of technical, automation and manufacturing advancements to reduce the cost of manufacturing and develop a techno-commercial assessment of building a competitive manufacturing facility in the UK. The project will be delivered in collaboration between Transformational Energy Limited and MTC (Manufacturing Technology Centre). The project will accelerate the adoption of engineering biology technology to enhance the energy efficiency of carbon dioxide reduction processes, which

		would accelerate decarbonisation of industries as well as develop biomanufacturing capability in the UK. The project will also lead to development of highly skilled services in engineering biology sector, and export opportunity of bioreactors and associated services to countries such as EU, USA, Japan and South Korea. The cost of bioethylene produced from the engineering biology process is expected to be highly cost competitive as compared to traditional thermochemical technologies for production of e-fuels. The innovation will advance the leadership position of United Kingdom in the area of engineering biology and develop a large scale and high margin sector with significant export potential.
The use of seaweed spent biomass to catalyse Industrial up-scaling of PHA and PGGA, a circular biorefinery approach.	FLEXSEA LTD	FlexSea has teamed up with the UK Centre for Process Innovation (CPI) to optimise and up-scale the biosynthesis of two innovative biomaterials. Poly-gamma glutamic acid and Poly(hydroxyalkanoates) are two classes of biologically derived biopolymers that could significantly displace synthetic alternatives. With FlexSea striving to meet the demand for home compostable, bio-based alternative products to conventional plastics, this project aims to tackle this significant industrial challenge. Thanks to FlexSea's innovative fermentation technology we can now use spent algal fractions (by-product of FlexSea's transparent film casting technology - uses 20_40% of the seaweed fraction) to synthesise these materials reproducibly. During the project we aim to further optimise the yields and characteristics of the biopolymers as well as liaise with industrial partners to assess their properties for a number of applications. During the project the biosynthesis of these materials will be up-scaled from 250 mL to 4-L to 1500L. By the end of the 20-month project FlexSea aims to patent the technology and employ the material synthesised to undertake commercial pilots with several industry partners. In addition, the consortium will deliver a full technoeconomic and life-cycle assessment for further commercialization of the technology. By producing three single use plastic- alternatives (hydrocolloid films; PHAs, PGGA) in a biorefinery approach, we aim to scale and commercialise the sustainable (no waste) and economic advantage (reduced raw material costs; additional revenue stream) of using seaweed as a sustainable bio-based feedstock.
Developing innovative green packaging materials	JAMES HUTTON LIMITED	Food and drink packaging (>\$300Bn/year global market) relies on plastics and a variety of chemicals now considered hazardous to health and dangerous to the environment. These chemicals usually impart barrier properties, non-stick surfaces, flame retardancy and antimicrobial activities which are required for food/drink packaging. New regulations are being introduced globally to limit/restrict use of these chemicals, meaning that new biosafe barriers for food/drink packaging need to be found, which will also support consumer demand for safe and environmentally friendly materials. This project will develop new biodegradable and biosafe materials with oil/water resistant surfaces, and flame retardant and antimicrobial properties which can be deployed to the food/drink packaging sector. Our industry partners will develop low energy environmentally friendly enzymatic processes to break down waste potato and sugar beet to extract nanocelluloses. Nanocelluloses have remarkable tensile strength, flexibility and absorbancy/barrier properties and small quantities added to paper mixes greatly improves strength and robustness. These characterised nanocelluloses produced by industry partners will have functional

		groups attached to them using non-hazardous chemicals and proteins, which will impart oil/water resistance, antimicrobial activities and fire retardant properties. ISO accredited analytical approaches will confirm that these functional groups have been suitably integrated into the nanocelluloses. The oil/water resistance and flame retardancy of the novel materials will be assessed, as will their antiviral and antibacterial activities. Nanocelluloses with suitable functionality will be provided to partners for incorporation into paper fibres in different ratios and dried down or applied as a coating to paper. These will be physically and chemically characterised by partners to confirm the presence of functional groups. Partners will assess the composite materials tensile strength, oil/water resistance, water vapour transmission rate, gas barrier properties, flammability, antimicrobial activities and biodegradability in soil. Materials that are the most promising will be earmarked for scaled up production assessment and also for life cycle analysis which will indicate economic and environmental costs and energy burdens of producing these materials. All project partners will protect IP prior to discussing these products with their existing customers, who are global leaders in the food/packaging industry. Further market analysis will be carried out to potentially roll out the technologies to other market sectors.
Bio-methanol Manufacturing Using Farming Biogas By-Products	PURIFIRE LABS LIMITED	In 2022, PuriFire Labs were approached by a traditional anaerobic digestion (AD) biogas plant (JJ Power Ltd), and other industry representatives from the agritech market to design and develop a new, more effective, highly cost-efficient approach to separating CO2 emissions as a feedstock from AD biogas, this as part of the process to manufacture the bio-based material bio-methanol (green methanol). PuriFire will use by-products from an AD biogas plant trial site to create a cost-effective, low-carbon, circular ecosystem and upgrade the outputs to produce bio-methanol, providing an alternative to the traditional manufacture. The aim is to achieve this by integrating their proprietary carbon capture (to generate the carbon dioxide feedstock) and hydrothermal gasification (to generate the hydrogen feedstock) technologies for catalytic upgrading. Methanol is a clear liquid chemical used in thousands of everyday products, including plastics, paints, cosmetics, and fuels/energy in marine, automotive, and electricity sectors. Methanol is traditionally produced from coal or natural gas, however, with increasing interest in sustainability, more projects are utilising renewable feedstocks such as agricultural waste, sewage, renewable electricity, and captured CO2 to produce green methanol, which can be classified as either bio-methanol or e-methanol. Green Methanol is a clean-burning, biodegradable fuel, making it an attractive alternative fuel for powering vehicles and ships, cooking food, and heating homes. The design of this innovative manufacturing technology/process was influenced in the feasibility and industrial research stages of this project, including end user engagement with the biogas industry and other end users including agriculture and marine (downstream market). This to ensure key stakeholders are contributing to the design thinking, delivery of the build, ensuring the product meets the requirements of these key customer groups. This approach will be embedded in the experimental development design phases of the project going forward, including matching design and specifications to market and regulatory needs, and looking at the economic issues of potential users based in rural communities as well as in urban facilities, to ensure price-point does not exclude target markets.

		This project will demonstrate how all agricultural sites, anaerobic digestion biogas plants and carbon capture facilities globally can be converted into bio-methanol manufacturing facilities. As per our knowledge and research, there are no producers of biomethanol in the UK today. The Project will accelerate the commercialisation of low-carbon bio-methanol with PuriFire Labs as the technology provider in collaboration with leading industry partners on the upstream and downstream sides.
Sustainably sourced biopolymers for use in complex paper packaging	CAMBRIDGE SMART PLASTICS LIMITED	Plastic packaging and the waste associated with it is a well-known and painful part of modern life. However, it is the recycling, recovery, and end-of-life that we all hate, not the added convenience, hygiene, and shelf-life of products. Certain products just could not be sold without packaging, as oxygen and humidity would spoil and rot the food or let coffee beans lose all their aroma, but equally -- protect sensitive electronics or battery innards. These are precisely the packaging materials that can't be recycled and wind up in landfill or incinerators. The packaging materials, which you have likely handled today, are those with a lining of thin film of aluminium. This metal layer blocks all gas transmission, but equally, makes recycling and separating the metal from the plastic nearly impossible -- so actually plastic is not the only villain here... Our project aims to kick metals out of packaging films and turn to nature for a solution. Chitosan is an abundant natural polymer found in fungi and insect/crustaceans shells and itself evolved over billions of years to be stronger than steel and completely impervious to air and water. By making thin films of chitosan (and a little magical chemistry from our Smart Plastics library), we can create layers that serve the function of metal coatings but remain totally biodegradable and recyclable. Chitosan once crushed and mixed back into a recycled plastic will not degrade its properties, as metal would, but in fact strengthen the recycled materials. By using chitosan, we can aim for our packaging materials to be home compostable and totally sustainable. We propose a focused product development to move our technology into the market by piloting a new flexible film that can seal in flavour, extend shelf lives, and all of this without the need for mixing metals into our plastic. We hope the wait for bioplastics is over and the UK can be the champion of this revolution.
A.R.T.I.S.T.: Advanced Recycling Technology for Innovative Styrene Transformation	CROWN PAINTS LIMITED	Project A.R.T.I.S.T is a collaboration between Hempel, C-Source Renewables (CSR) Limited, the University of Edinburgh, and Impact Solutions with the aim of reducing the carbon footprint of the paints and coatings industry. The project focuses on using bio-based styrene material in the production of paints and coatings instead of the petrochemically produced equivalent. Bio-based styrene has the potential to significantly reduce the industry's carbon footprint, but there is still uncertainty about product yields, and the initial toxicity of bio-styrene generated inside the cell presents a barrier to achieving the required production values. To address these challenges, A.R.T.I.S.T will use bio-derived glucose rich bread waste that undergo enzymatic conversion to produce Bio-Styrene, which will be used to create polymers following Hempel's existing formulations as a guide. The resulting high-performance styrene-acrylic emulsion paint formulations will have significantly lower environmental impact, and the process supports a 20% reduction in GHG-emissions. The project will use synthetic biology capabilities at UoE to genetically optimize the entire pathway enabling the project to increase productivity and titres of bio-styrene from L-phenylalanine and ultimately D-glucose waste, delivering predictable/consistent processes suitable for manufacturing at scale and surpassing the state-of-the-art. The project outcomes include a bioprocess for styrene production from waste-feedstocks, an optimized, purpose-built protocol for creating bio-styrene-based

		polymers, a report detailing full characterization of the bio-styrene monomer/polymer, and a life-cycle/market analysis and route to commercialization report. Project A.R.T.I.S.T aligns with the UK government's aim to grow the bio-economy sector to £440b by 2030 and enables the paints and coatings industry to become more environmentally sustainable while better meeting the needs of customers who are increasingly concerned about the environmental impact of manufacturing. The potential impact of A.R.T.I.S.T is significant, as the project could significantly reduce the industry's carbon footprint while meeting the growing demand for environmentally sustainable products.
From seaweed farm to seaweed fork, from biomaterial to biomanufacturing - Development and manufacturing of Notpla Rigid material from whole biomass seaweed	NOTPLA LIMITED	Under this project, the consortium members aim to build a unique, world-class UK biotech-based production capacity for the manufacture of injection-moulded feedstock 'Notpla Rigid Pellets'. These are made from whole seaweed biomass including UK-grown seaweeds, to produce a truly circular and sustainable product (100% bio-based and home compostable) which minimises wastes, cuts input costs and significantly reduces climate and environmental impacts. We will advance the Notpla Rigid material and by project end have built out the capacity to produce tonnes of Notpla Rigid product, for conversion into a range of products. Existing and incoming legislation banning single-use, disposable plastic cutlery will create vast new market opportunities which we aim to fill with an advanced bioproduct (Rigid material single-use cutlery) made from a sustainable, bio-based feedstock (Seaweed) and manufactured entirely in the UK. Utilising brown seaweed grown in the UK allows us to support the growth of the UK seaweed sector, an industry with significant potential to supply the UK's future bio-based feedstocks to replace petrochemical feedstocks. Our consortium comprises partners representing every stage of the value chain; seaweed growers, processors, lab development and manufacturers. Over the 24 months of this project, the consortium members will embark on collaborative industrial research and development, building working relationships and partnerships and sharing specialist expertise in their respective areas needed for industrialisation. We will build long-term cooperation across UK sectors to grow manufacturing capacity. Finally, we will build the commercial relationships to ensure that by project end, we are positioned to commercialise the products (cutlery, secondary packaging and others), providing the business case for scaling up production and manufacturing and building out the UK's future green economy. In addition, rigorous assessment of the process from farm to factory gate to disposal will enable us to demonstrate the potential of our products to mitigate climate change and protect the environment when compared to traditional plastics and bioplastics, verifying their circular and sustainable properties.
Next-generation sustainable liquid packaging using only bio-based feedstock derived from non-food waste - Pulpex UK BioScience Initiative	PULPEX LIMITED	The 'Pulpex UK BioScience Initiative' will help Pulpex Ltd fully achieve its medium-term ambition by replacing its existing petrochemical-based barrier coatings with truly sustainable coatings as barriers to water and foods. The barrier coatings are applied on the interior of the Pulpex sustainable bottle. Sustainable materials are the future of food packaging; consumers, general public and corporates are demanding this product now. Pulpex has already demonstrated the manufacture of a paper bottle that will enable brands to switch from glass or plastic to a sustainable alternative that is readily recycled. Pulpex has developed an advanced manufacturing process that converts cellulose fibre into a bottle that can be easily recycled through the existing and well-established paper collection schemes that are available

		throughout the UK. Pulpex are partnering with two UK bio-manufacturing firms. CuanTec is a world leading firm based in the European Centre for Marine Biotechnology in Oban who produce chitosan from waste material from shellfish using a proprietary fermentation process. CelluComp is an established company based in Fife with deep expertise in the extraction of micro-fibrillated cellulose (MFC) from waste root vegetables using bioprocessing techniques. These are world-class companies based here the UK and seeking expanding markets for their products. This ambitious collaborative project draws on scientific expertise from across the UK to accelerate the adoption of bioprocessing-derived barrier coatings for Pulpex's breakthrough fibre bottles and other high barrier packaging applications. The incredible calibre of our partners is testament to the high standards we aspire to. The project offers deep industry and academic collaboration across the entire supply chain -- converting non-food waste (e.g. shells from crustaceans and discards from root vegetables) into high value high barrier packaging that is market ready and validated. We see properly bioprocessing as essential to the development of the next generation of sustainable products. The project aim is to deliver and accelerate commercial high barrier products -- derived from the bioprocessing / fermentation of chitosan and MFC from vegetal waste streams -- that can be effectively applied to Pulpex fibre bottles at scale and certified as suitable for liquid food use.
FermoChar: Fermentation residue into engineered char-based materials for sustainable industrial applications; A pathway to NetZero	Teesside University	Fermentation is a major upstream process in many food, feed, beverages, biopharmaceutical and biotechnological industries. It is a metabolic process where microorganisms are responsible for chemical reactions to convert certain carbohydrates into various products. The choice of the product is usually based on the type of the microorganism used and the fermentation method. Upon the completion of the process, the broth is centrifuged to form supernatant, where the targeted products are usually dissolved, and residual solid waste that is composed of the cells, remaining feedstock and other metabolites. These residual solids are usually incinerated/landfilled or utilised by some industries to produce fertilisers and animal feed (not considered as process revenue). The separated liquid supernatant is subjected to downstream processing to extract and purify the targeted product. The downstream process is considered immensely costly and energy incentive stage as it consists of several steps of purification and utilise various materials. Adsorbents, such as char, are commonly used in these downstream process steps for purification and/ clarification of the products. This project is designed to provide an innovative and sustainable solution for a variety of biopharmaceutical and biotechnological industries. The residual waste from the fermentation process will be valorised into engineered value-added adsorbents that could be utilised in the downstream process or considered as process revenue. The properties of the developed adsorbents will mainly depend on the feedstock used and the type of cells. The project consists of two industrial partners from different fields including pharmaceutical and bioplastics that are utilising different feedstock and microorganisms and hence the produced bio-solids and resulting adsorbent material will vary. Modification of the produced materials will be investigated for the development of novel tailored adsorbents to be used in different downstream processes based on the targeted application of the industrial partner.