Innovate UK

Sustainable Medicines Manufacturing Innovation Programme

Grand Challenges

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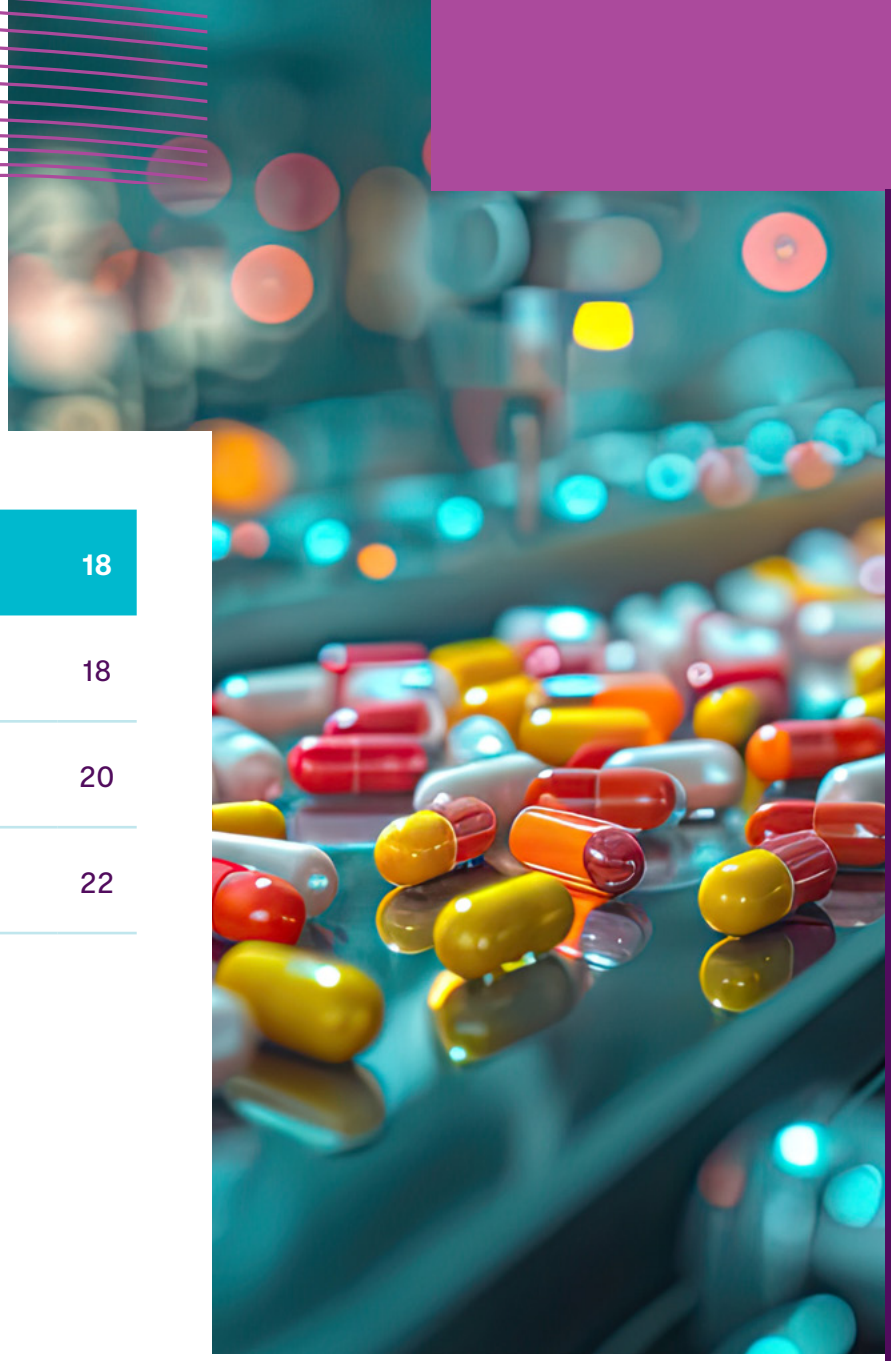


Introduction

Innovate UK, in partnership with the **Department of Health and Social Care** (DHSC), has invested over £61m in nine Grand Challenge projects as part of the **Sustainable Medicines Manufacturing Innovation Programme** (SMMIP).* Sustainable medicines manufacturing is the process of producing medicines in a manner that minimises environmental impact, conserves natural resources, and ensures economic and social sustainability. This approach focuses on reducing waste, energy consumption and emissions, while enhancing efficiency, safety and cost-effectiveness throughout the manufacturing lifecycle. It also includes the adoption of innovative technologies and practices that promote the long-term viability of the medicines manufacturing industry. The SMMIP will drive innovation by giving organisations the capacity to collaborate in developing new innovations, technologies, tools, data sets and approaches that can ultimately contribute to a sustainable medicines manufacturing sector. The goal is to promote environmentally conscious production processes, reduce waste and energy consumption, and enhance the efficiency and long-term sustainability of the medicines manufacturing industry through innovative technologies and practices.

Grand Challenges are large-scale collaborative research and development (CR&D) awards of up to £10m per project. This brochure provides an overview of the successful projects, detailing the lead and partner organisations involved, the proposed Grand Challenge, and expected long-term benefits of these innovations.

* SMMIP is funded as part of the wider VPAG Investment Programme agreed as part of the **2024 Voluntary Scheme for Branded Medicines Pricing, Access and Growth** (VPAG).

How to get involved

If you are keen to speak to a project in this brochure about collaboration opportunities, please contact **Future.Medicines@iuk.ukri.org**

£61m+

Amount of grant funding committed

£16m+

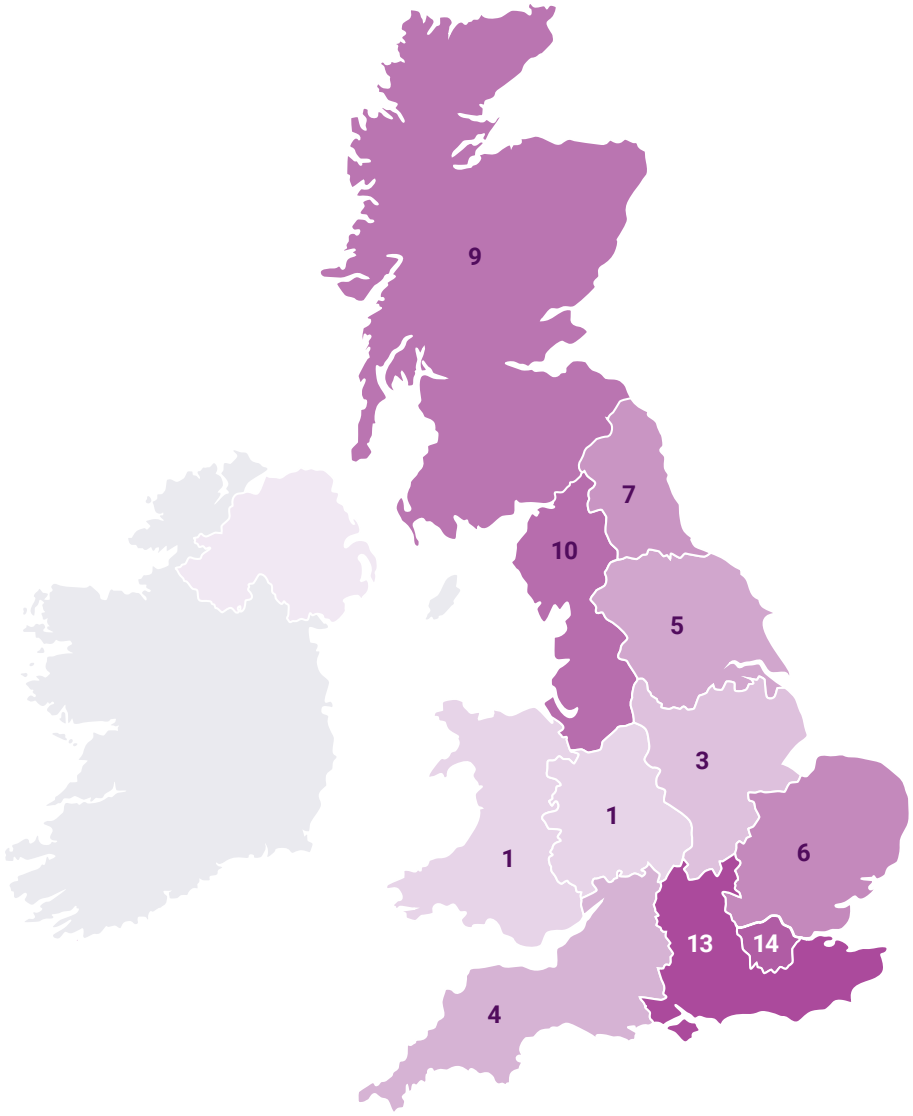
Industry co-investment

74

Organisations supported

Geographic locations of project participants

East Midlands	3
East of England	6
London	14
North East	7
North West	10
Scotland	9
South East	13
South West	4
Wales	1
West Midlands	1
Yorkshire and The Humber	5
Outside the UK	1
Grand Total	**74**



Beyond single-use plastics: Processing innovation driving sustainable pharmaceutical packaging (SusPack)

Each year, the pharmaceutical packaging industry and the NHS respectively require around 100,000 and 133,000 tonnes of plastic, most of which is single use. Concerns around contamination and health risks have hindered the transition to more sustainable packaging, with factors such as material processing, manufacturing, and end-of-life management posing significant challenges. The lack of viable alternatives, alongside complex regulatory requirements, makes the adoption of greener packaging a multifaceted problem.

To improve the overall sustainability of medicines manufacturing and to support the NHS commitment to “Delivering a Net Zero NHS” by 2040, this project aims to accelerate the uptake and scale up of sustainable pharmaceutical packaging through the use of green chemistry and sustainable manufacturing practices.

Through three interconnected circular supply chains, the consortium will take a holistic approach to enhance the sustainability profile of:

a) Primary packaging (e.g., healthcare sharps and pharmaceutical blister packs) by developing state-of-the-art recycling technologies

b) Secondary packaging (e.g., expanded polystyrene passive cooling packs) by replacing them with biodegradable alternatives

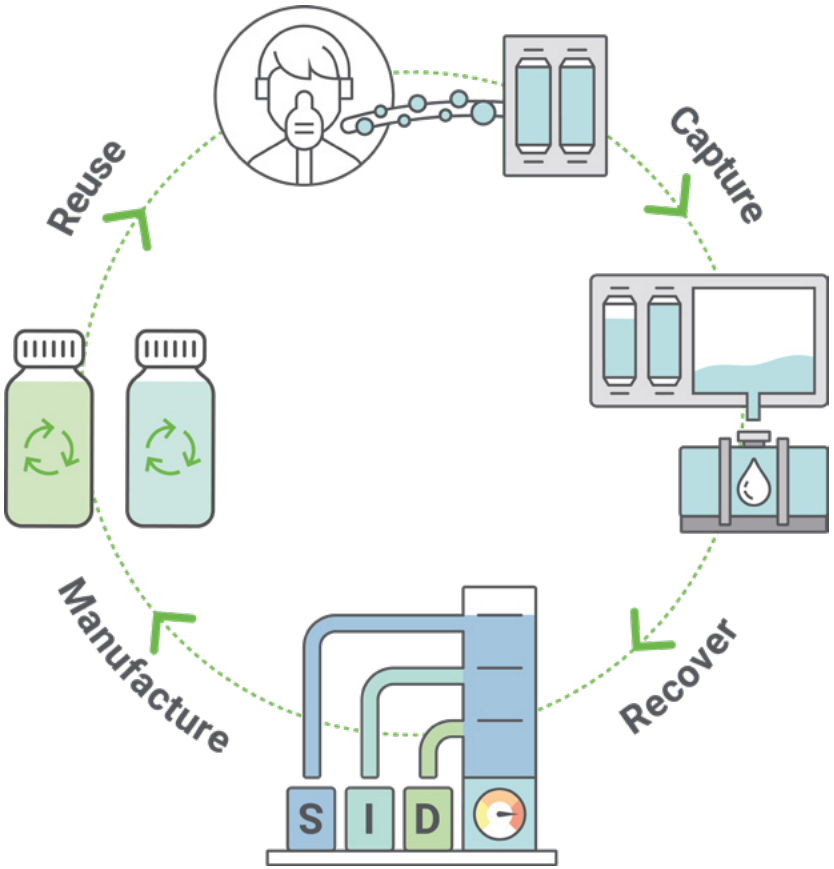
By tackling this critical industry challenge, the project will help shape the next generation of sustainable pharmaceutical packaging and processes, delivering solutions that meet environmental goals without compromising product safety, performance, or integrity.

Project lead: National Physical Laboratory (NPL)

Partners: Alga (Seaweed), Bridge Farm Bioscience, CPI, Impact Solutions, Impact Recycling, Nextek, ReVentas, Sealeo, The Naked Pharmacy, University of Kent, University of Nottingham

Funded amount: £8,055,428

Circularity and sustainability in volatile anaesthetics



This project will address the problem of the high carbon footprint associated with the use and disposal of volatile anaesthetics used in healthcare settings around the world. Currently, the anaesthetics are vented directly to atmosphere or bound to filters destined for landfill or incineration. Emissions from the disposal of volatile anaesthetics contribute approximately 4 million tonnes of carbon dioxide equivalents each year. There is an estimated further 3.75 million tonnes of carbon dioxide equivalents associated with their manufacture, and existing disposal systems. Disposal via landfill will eventually lead to atmospheric emissions as filter media degrade. Incineration is inefficient and has the potential for generating toxic degradation chemicals. Both methods ignore the inherent value in the used volatile anaesthetics, <5% is metabolised; they are stable molecules so make excellent targets for capture and reuse.

There are several innovative aspects to the project. There is innovation in the capture technology, and the recovery and remanufacture processes. Regulatory innovation for recycled medicines is also

an important deliverable in the project. The solution is most sustainable when deployed at large scale.

The solution will establish the UK as the leading provider of the technology and will generate skilled jobs in development, engineering, and manufacturing.

Project lead: SageTech Medical Equipment

Partners: CPI, Manufacturing Technology Centre, Royal Devon University Healthcare NHS Foundation Trust, University of Plymouth

Funded amount: £2,892,714

Project Alpha 10.6

Project Alpha 10.6 transforms the UK's recycled uranium into novel cancer treatments by extracting and using lead-212, a powerful radioisotope that enables highly targeted alpha-radiation therapies. This groundbreaking approach solves two critical challenges: repurposing nuclear material whilst creating a sovereign supply of essential medical isotopes.

Currently, cancer treatments using alpha-emitting isotopes like lead-212 are severely limited by costly production methods and unreliable international supply chains. This project's innovative 'waste-to-resource' process converts nuclear liabilities into high-value medical assets, positioning the UK as a global leader in radiopharmaceutical supply.

Project Alpha 10.6 brings together world-class expertise to develop a complete ecosystem, from material processing to final pharmaceutical manufacturing. This project is creating pathways for new cancer treatments to precisely target tumours whilst minimising damage to healthy tissue, offering hope for patients with previously untreatable cancers.

By partnering with regulators from the outset, Project Alpha 10.6 will ensure safety and compliance whilst accelerating

innovation. This aligns with government priorities for economic growth and improved health outcomes, supporting the life sciences sector as a key industry for the UK.

The fully operational system will supply medical-grade lead-212 to pharmaceutical companies and hospitals, generating revenue whilst establishing the UK's independence in critical medical isotope production and creating export potential to global markets.

Project lead: United Kingdom National Nuclear Laboratory

Partners: Aquila Nuclear Engineering, entX, Iksuda Therapeutics, Medicines Discovery Catapult, Pentabind, Seda Pharma Development Services

Funded amount: £9,890,105

Biocat copilot – Digital biocatalysis for sustainable medicines manufacturing

Biocatalysis offers a powerful option for sustainable medicines manufacturing, yet its adoption is hindered by two critical barriers: insufficient information for confident decision-making, and slow, resource-intensive implementation timelines that cannot meet drug development demands.

This project will deliver an integrated digital ecosystem that transforms biocatalysis from a niche specialty into a readily accessible, predictable, and rapidly implementable strategy for sustainable active pharmaceutical ingredients (API) manufacturing.

The project combines:

- **Artificial intelligence (AI)-powered synthesis planning** that seamlessly integrates chemistry and biocatalysis, with expert-encoded reaction rules and machine learning (ML)-driven feasibility predictions to de-risk biocatalytic steps
- **A comprehensive biocatalysis knowledge base** created through automated literature data curation and systematic high-throughput screening
- **Intelligent enzyme selection** using cutting-edge enzyme-substrate interaction (ESI) models that predict the best off-the-shelf enzymes for any reaction, purchasable directly from UK manufacturers
- **Industrially ready enzyme platforms** through mining natural functional diversity and targeted enzyme engineering for enhanced promiscuity and stability, including breakthrough new-to-nature chemistry

- **Streamlined route evaluation and process understanding tools** with automated calculation of sustainability metrics enabling green-by-design planning and exploring regulatory considerations and process development challenges

This project will make biocatalysis substantially more accessible and actionable for chemists, dramatically accelerating the design-to-validation cycle for new routes and establishing the UK as a global leader in digitally enabled sustainable medicines manufacturing.

Project lead: Disyn Biotec

Partners: BRIDGE CMC, Bristol-Myers Squibb Pharmaceuticals, Britest, Dayhoff Labs UK, GlaxoSmithKline, Imperagen, Prozomix, Sterling Pharma Solutions, The Biorenewables Development Centre, The University of Manchester

Funded amount: £3,987,255

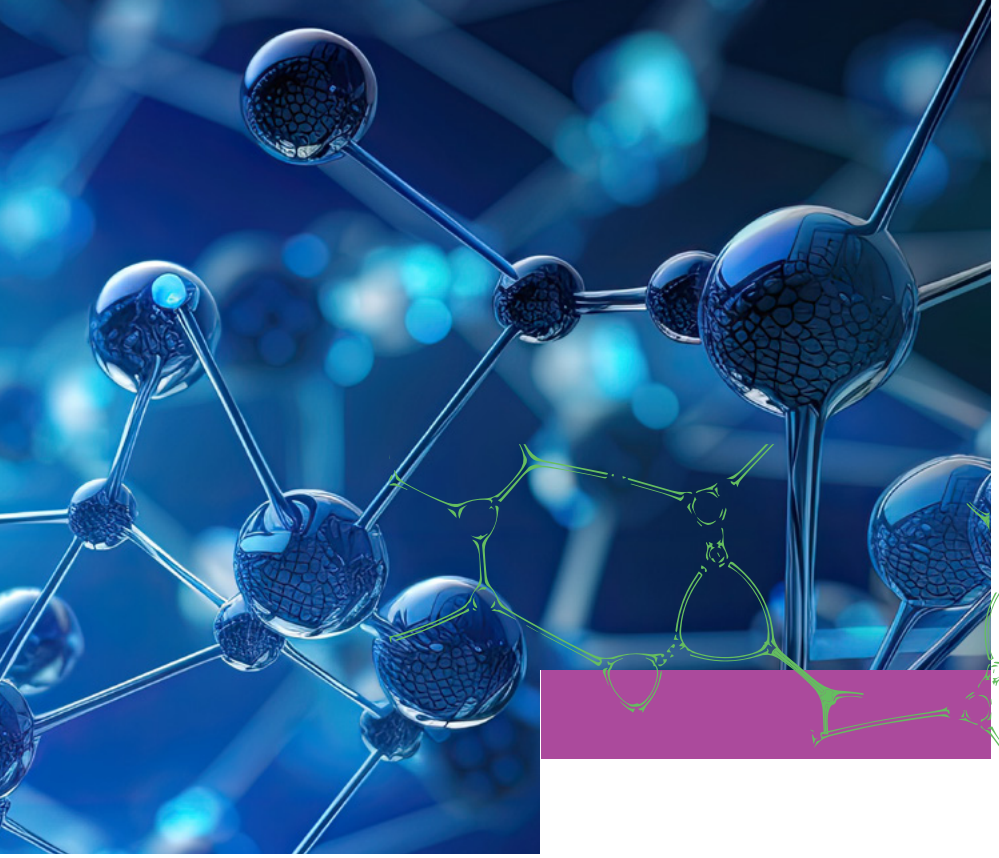
Environmental peptide production

Peptides are naturally occurring molecules that play a significant role in cell signalling and function. They are also artificially synthesised due to their important properties in research and in medicines, such as insulin. However, peptide medicines are difficult and expensive to make. The current manufacturing processes are extremely wasteful, requiring environmentally hazardous chemicals.

The Origin Peptides project will develop a novel peptide synthesis technology, in combination with industry-leading product sampling technologies, to create a commercially ready peptide manufacturing system to make life-saving medicines with the smallest environmental footprint and at the lowest cost.

This technology has been demonstrated in the laboratory at small scale. The next step is to expand that process at larger scales which pharmaceutical companies can utilise to make medicines for those in need.

This collaborative project will work with the world's biggest manufacturers of peptide medicines together with world-class experts in engineering, chemistry and manufacturing processes from the renowned CPI (UK) to build



a cutting-edge process and hardware suite for environmentally friendly peptide manufacture.

These will be produced locally, ethically, environmentally and using circular economy, in a way that is only possible with Origin Peptides' new technology – a world first in aqueous templated peptide synthesis.

Project lead: Origin Peptides

Partners: CPI, New Gradient, Queen Mary University of London

Funded amount: £6,411,241

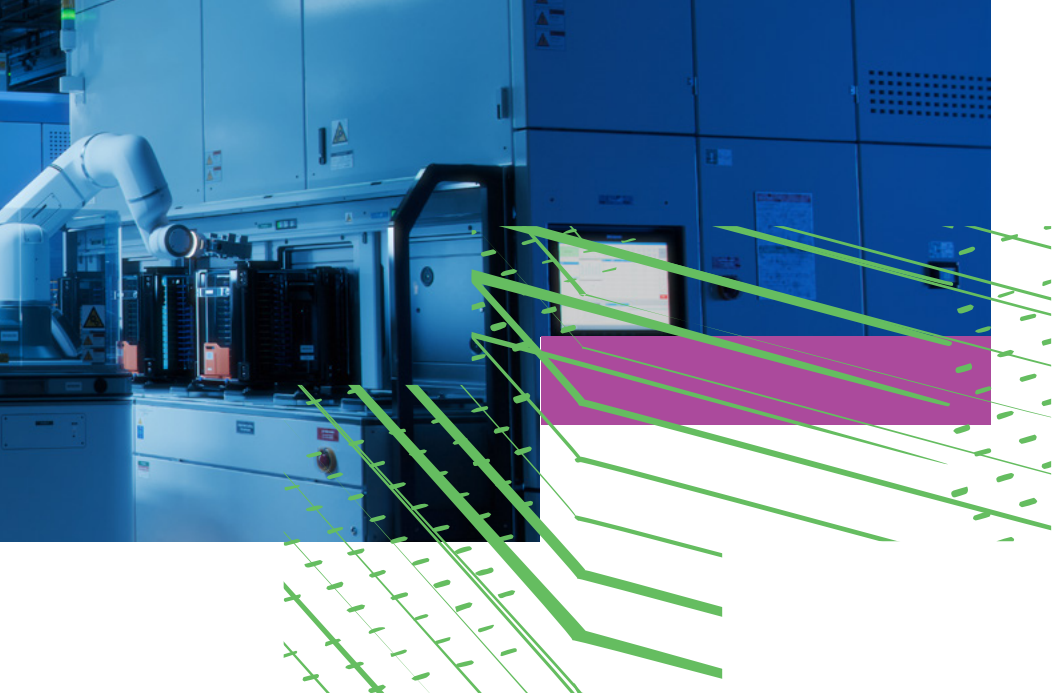
Industrialising UK bio-based solvents for global medicine manufacturing

Global medicines manufacturers use around two million tonnes of solvents each year across active pharmaceutical ingredients synthesis, purification, formulation and cleaning. While essential to pharmaceutical production, solvents are one of the largest contributors to Scope 3 greenhouse gas (GHG) emissions in medicines manufacturing. As the sector accelerates toward net zero targets, reducing emissions associated with conventional fossil solvent manufacture and disposal has become a critical challenge. Current bio-based alternatives remain constrained by cost, limited availability and difficulties in meeting pharmaceutical-grade specifications.

This 36-month project will industrialise low-GHG, bio-based 'drop-in' solvents for global medicines manufacturing, focusing on bio-acetonitrile, bio-acetone and bio-heptane/n-hexane. These solvents are chemically equivalent to fossil-derived materials, enabling adoption without changes to existing manufacturing processes or infrastructure. The project targets lifecycle GHG reductions of at least 60% compared with conventional solvents, supporting manufacturers in meeting growing regulatory, customer and procurement-driven decarbonisation requirements.

The consortium is led by Exactmer, with the strategic lead of GlaxoSmithKline (non-funded partner), the UK-headquartered global medicine and vaccines manufacturer, with support from major industry partners. The project will use advanced membrane purification technologies to address one of the most significant barriers to bio-based solvent adoption: the high energy and cost required to achieve pharmaceutical-grade purity and moisture specifications.

The consortium brings together technology providers, manufacturers, global pharmaceutical companies and translational research and innovation organisations. Bio-based solvents will be produced from waste-derived biomass and captured biogenic carbon, and demonstrated in realistic medicines manufacturing environments, including both small molecule, liquid and solid phase oligonucleotide synthesis



processes. This project was initiated by Environmental Resources Management (ERM) and Ayming, who co-ordinated the consortium's successful funding application for the £9.29m project. ERM will support the delivery of the project and market adoption.

By project completion, pharmaceutical-grade bio-based solvents will have been demonstrated, regulatory pathways will be de-risked, and a UK-owned supply chain will be established. The project aims for rapid global adoption of low-GHG solvents in the early 2030s, helping to decarbonise medicine manufacturing.

Project lead: Exactmer

Partners: Atmospheric AI, Celtic Renewables, CPI, Croda, Cytiva, GlaxoSmithKline, OXCCU, Queen Mary University of London, Solve Chemistry, University of Leeds

Funded amount: £7,316,907

A sustainable future factory

This project's vision is to transform pharmaceutical manufacturing by integrating robotics, automation, AI, and data-driven approaches to create sustainable, future-ready factories. It will embed sustainability into manufacturing processes at the design stage, tackling medicine production and waste processing. This project is designed to drive substantial gains in productivity, efficiency, and circularity by integrating advanced technologies, considering regulatory issues and setting new industry standards.

It will integrate collaborative robots (cobots) and automation into both R&D and manufacturing, boosting precision and efficiency, while reducing energy consumption and waste. This project will also develop self-optimising reactors and employ high throughput experimentation to minimise material use and time, feeding data back into AI for further optimisation.

This project will explore next-generation pharmaceutical manufacturing and continuous processing including new reactor designs. It will improve downstream processing including using membrane-based technologies, to minimise waste, and ensure efficient extraction of both products and materials for reuse. Robust data

collection through process analytical technologies (PAT) and AI will underpin its future factory, reducing environmental impact, improving efficiency, and enabling automation.

This project is supported by a consortium of major pharmaceutical companies, smaller businesses, RTOs and academic partners, working together to ensure these solutions deliver lasting change for the industry.

Project lead: AstraZeneca UK

Partners: Asymchem, BRIDGE CMC, Bristol-Myers Squibb Pharmaceuticals, Britest, Coretech Sciences, CPI, Exactmer, GlaxoSmithKline, Indicatrix Crystallography, IS-Instruments, Labman Automation, Newcastle University, Pharmaron UK, Queen Mary University of London, University of Leeds, University of Liverpool, University of Nottingham

Funded amount: £9,781,258

ECOCAR

Sustainable CAR T-cell manufacture

CAR T-cell therapies are expanding into earlier treatment lines for lymphomas, leukaemia, and multiple myeloma, with emerging potential in autoimmune diseases – significantly increasing market demand. All approved CAR T-cell therapies are autologous, requiring patient-specific manufacture. Allogeneic 'off-the-shelf' CAR T-cell therapies have faced clinical setbacks due to allo-rejection.

Current manufacturing involves semi-automated macrofluidic systems with multiple discrete steps, T-cell isolation, activation, lentivector transduction, expansion, and cryopreservation, each requiring separate consumables and plasticware. This fragmented process limits scalability and contributes to a substantial environmental footprint.

EcoCAR aims to revolutionise sustainability in CAR T-cell manufacturing by engineering lentiviral vectors to incorporate T-cell capture, activation, and cytokine moieties directly into the viral envelope. Using a low-volume bioreactor, we propose a streamlined 'one-pot' process completing selection, activation, transduction, and expansion in a single vessel within 36–48 hours.

This unique approach will reduce plastic use, reagent complexity, and clean-room time. This project unites NHS and academic organisations, commercial and Catapult partners to deliver this novel concept. It will establish sustainable manufacturing and supply chain benchmarks, and regulatory standards, positioning the UK at the forefront of environmentally responsible CAR T-cell production.

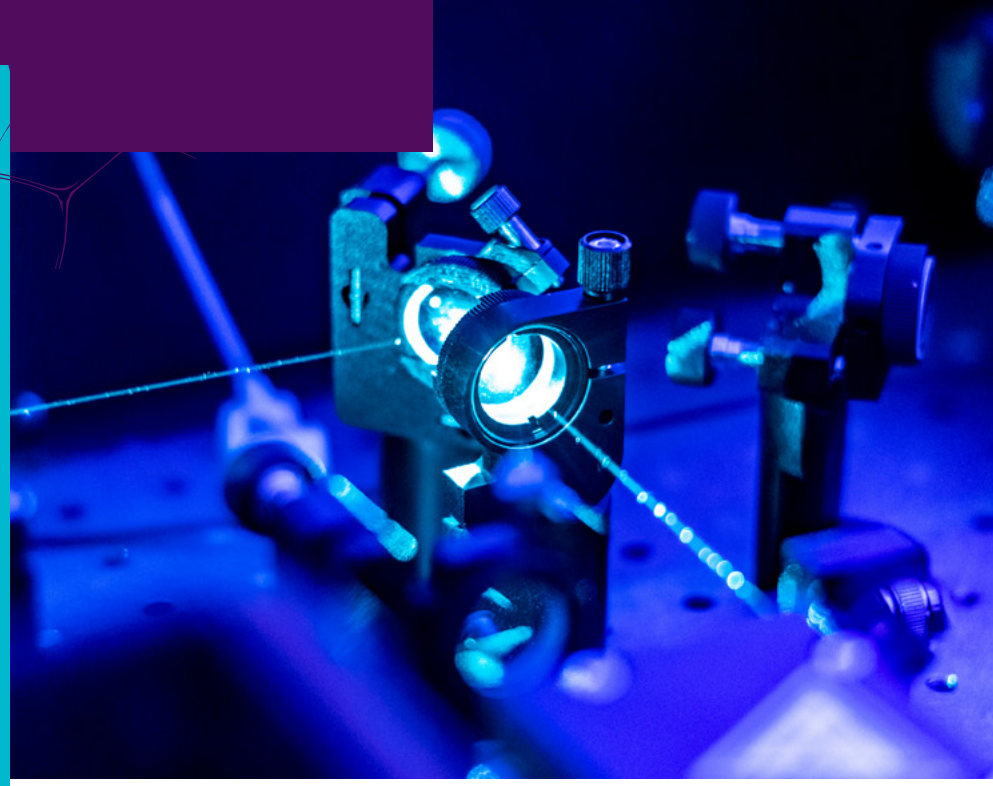
Project lead: Royal Free London NHS Foundation Trust

Partners: Autolus, Biopharm® Services, Cell and Gene Therapy Catapult, Imperial College London, MicrofluidX, University College London

Funded amount: £4,897,125

InSPIREmed

Integrated spectroscopy and photonics for increased productivity and resource efficiency in medicines manufacture



The InSPIREmed project will deliver and demonstrate advances in photonic sensing across medicines manufacturing to reduce waste and energy usage while increasing process yields. The project will address gaps in process analytical technologies (PAT) to enable real-time measurements of both batch and continuous processes that are currently not possible because they lack the required sensitivity, have overwhelming background signals or are too expensive, among other issues.

The proposed PAT innovations in Raman and mid infrared spectroscopy and particle analysis can be deployed widely in medicine, from small molecule to biologics, and process development through to full-scale manufacturing. Three exemplar applications will be used to demonstrate the sustainability benefits of enhanced sensing:

- Accelerated active pharmaceutical crystallisation screening
- Energy efficient freeze drying
- Process intensification in biotherapeutic manufacturing

New data architecture and digital tools will enable the rapid integration of these innovations into industry-accepted

software. Significant expertise in regulatory guidance and sustainability assessment are built into the consortium, with early engagement with regulatory and standards agencies. Wider engagement with the pharmaceutical industry will be facilitated through an end-user panel and a range of dissemination and training activities to promote exploitation and adoption of the technologies developed.

Project lead: Fraunhofer UK Research

Partners: CPI, Dyneval, GlaxoSmithKline, Global Life Sciences Solution Operations UK, Hellma UK, IS-Instruments, Martin Warman Consultancy, National Physical Laboratory, Optimal Industrial Technologies, Particology, SPARTA Biodiscovery, Spinnovate, The Secretary of State for Health and Social Care acting through the Medicines and Healthcare products Regulatory Agency (MHRA), University of Strathclyde, Visionmetric, Vortex Optical Coatings

Funded amount: £8,138,986

Innovate UK

Innovate UK
Polaris House
North Star Avenue
Swindon SN2 1ET

future.medicines@iuk.ukri.org

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