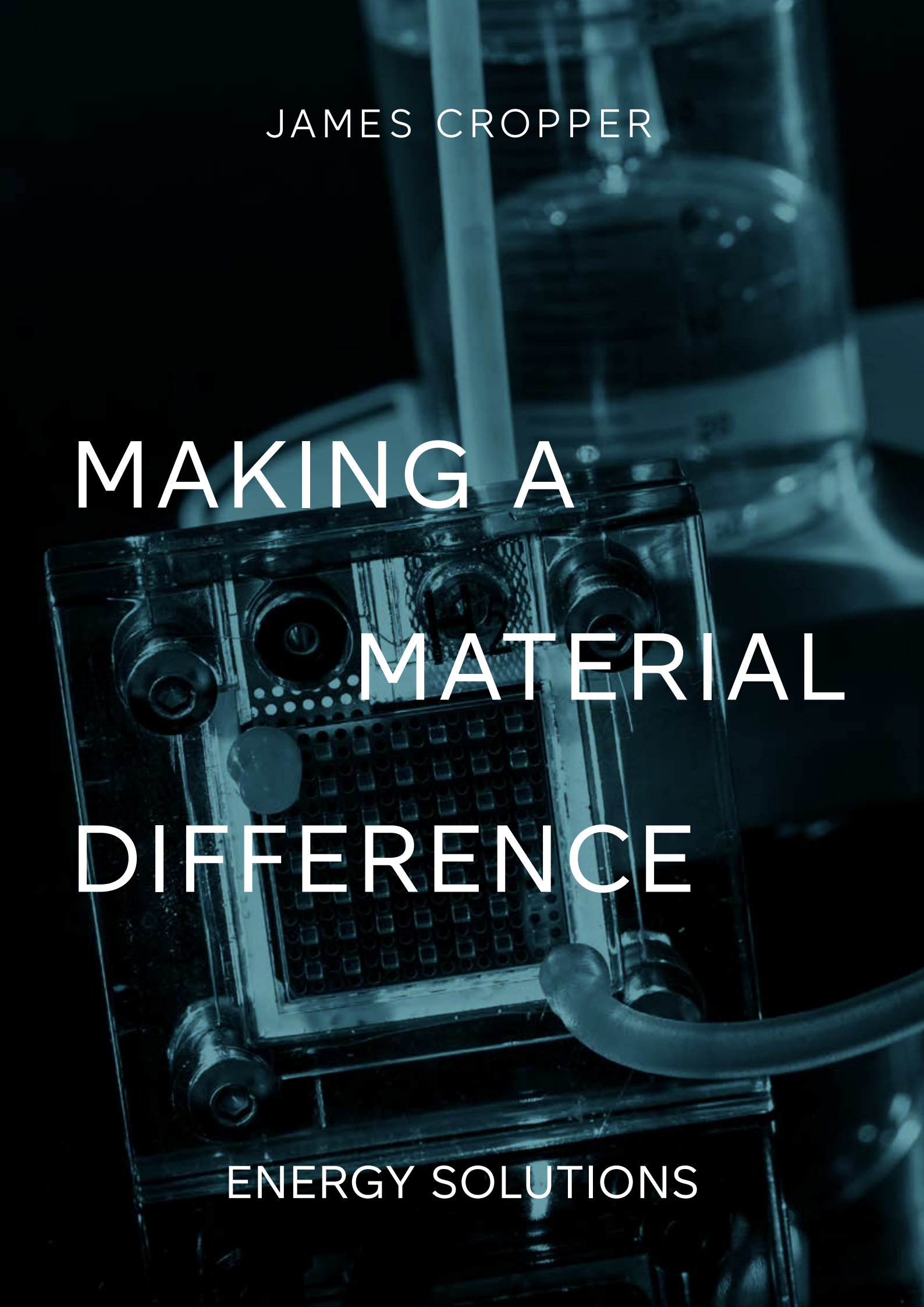




JAMES CROPPER

MAKING A MATERIAL DIFFERENCE

ENERGY SOLUTIONS

ELECTROCHEMICAL MATERIALS

James Cropper works at the edge of material science, creating future focused solutions across a broad portfolio of products.



MAKING A MATERIAL DIFFERENCE

From lightweight glass nonwovens found on most commercial aircraft, to electrochemical coatings creating green hydrogen at the heart of PEM Electrolysers. We specialise in providing innovative solutions for current and next generation technologies.

We operate globally, with sites in the UK and USA and a worldwide sales and support network. Our materials solve technical challenges across a wide range of markets such as aerospace, defence, automotive and construction, as well as in renewable energy, where there is a strong focus on enabling green technologies such as hydrogen fuel cells, carbon capture, batteries and PEM Electrolysers.

FOR MORE INFORMATION VISIT: www.am.cropper.com
OR EMAIL: enquiries@cropper.com

BONDED BY A VISION FOR A BETTER FUTURE

Our team of materials scientists and electrochemists are leaders in their field, working with partners to deliver innovative solutions to today's challenges. We regularly collaborate with academics, companies, governments, and others to develop cutting-edge, customer-specific, or market-specific needs. By introducing new materials and improving system efficiency, durability, and performance, we add significant value to electrochemical applications.

Our customers are innovators, using James Cropper to activate new technologies. That's why it's important that our R&D team constantly pushes the boundaries of what is achievable, developing new technologies, products, and solutions that transform industries.



INTRODUCING RESILLION™

POWERING EFFICIENCY,
LONGEVITY AND PERFORMANCE

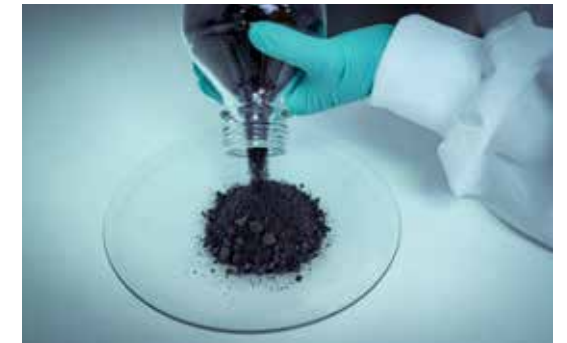
Resillion™ is a revolutionary new coating technology which provides enhanced conductivity, reduced contact resistance and protection against corrosion and oxidation to electrolyser components such as Titanium bi-polar plates, PTLs, sinters and meshes. It extends the lifetime of these stack components to maximise system efficiency, durability and profitability.

Our proprietary coating offers a number benefits including excellent adhesion, potential to rapidly scale production and the flexibility to coat a wide range of component sizes and shapes. A further advantage to Resillion™ is the capability to maximize platinum efficiency for complex shapes, distributing platinum across the entire metal surface, including places not visible to the naked eye, to ensure an optimum performance benefit.

1

SPECIALISTS IN ELECTROCHEMICAL MATERIALS

James Cropper is built on decades of knowledge and expertise in both electrochemical and nano materials; developing market leading coatings and catalysts for hydrogen technologies.



MATERIAL INNOVATION

Our dedicated Innovation Team is constantly challenging the boundaries of what is possible, developing the next generation of coating, catalyst and nonwoven materials to accelerate hydrogen adoption.

2

ADVANCED MATERIALS

ENABLING THE FUTURE OF GREEN ENERGY

With ISO9001 accreditation and proven real-world products, our electrochemical expertise delivers advanced materials for PEM water electrolyzers, hydrogen fuel cells, batteries, carbon capture and medical devices. We advance technologies by customising and optimizing coatings, electrodes, platinum group metal catalysts and nonwovens to increase system performance, efficiency and durability.

3

QUALITY

James Cropper is accredited to the ISO9001 Quality Management Standard and this, coupled with stringent in-house XRD and ICR quality testing of parts, provides our customers with the assurance of the highest quality materials and coatings.



4

CUSTOM MATERIALS

We pride ourselves on being the experts in our field and have coated over 250,000 parts to date. This knowledge and experience aids an in depth understanding of our customers' specific application requirements and enables us to develop the optimum material formulation to meet these.

5

SCALEABLE TECHNOLOGY

Our coating technology optimizes mass production and cost-efficiency. With a 3.2 GW coating capacity and facilities in the USA and UK, we are prepared to meet global demand and implement future expansions to support industry needs.





PEM WATER ELECTROLYSERS

Our coatings and electrocatalysts enhance the performance and lifetime of PEM electrolyser systems. Specialist coatings protect titanium components such as bipolar plates and PTLs from corrosion, reducing hydriding and embrittlement, as well as decreasing ohmic resistance and preventing mechanical failure. This results in improved long-term component performance and extended cell lifetime.

BATTERIES

We offer a multitude of solutions for battery technologies ranging from flow batteries to lithium ion, lead acid and lithium thionyl chloride. Our product portfolio includes high C-rate capability electrode materials, durable, high performance electrocatalysts and chemically resistant cell separators, all specifically engineered to optimize cell operation and output.

BEHIND THE SCENES BUT EVER PRESENT

ADVANCING CURRENT AND NEXT GENERATION ENERGY TECHNOLOGIES



CARBON CAPTURE

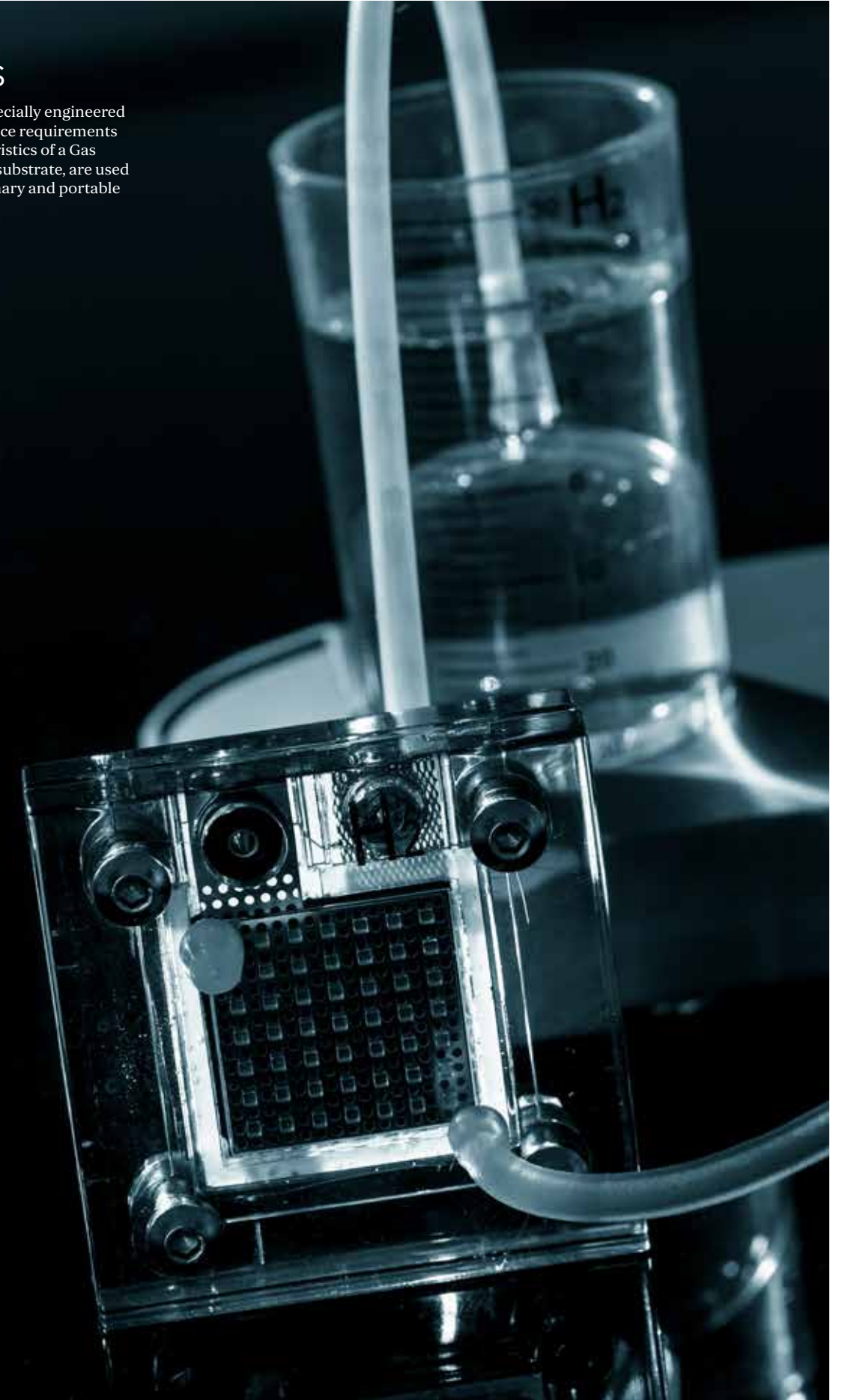
We are working with some of the leading carbon capture companies around the world to develop proprietary functional veils for the industry. Our nonwovens offer the necessary material characteristics to provide an ideal support architecture for solid sorbent carbon capture technology.

WIND ENERGY

Our nonwovens provide lightweight solutions to enhance surface finish and improve blade toughening as well as help protect the electronics and technical equipment in the nacelle from electromagnetic interference (EMI) and fire.

FUEL CELLS

Our carbon papers, specially engineered to meet the performance requirements and material characteristics of a Gas Diffusion Layer (GDL) substrate, are used globally in both stationary and portable fuel cell systems.



PRODUCT PORTFOLIO

COATINGS

James Cropper’s specialised coatings enhance the performance, efficiency, and durability of PEM electrolyzers, effectively reducing the long-term cost of green hydrogen production.

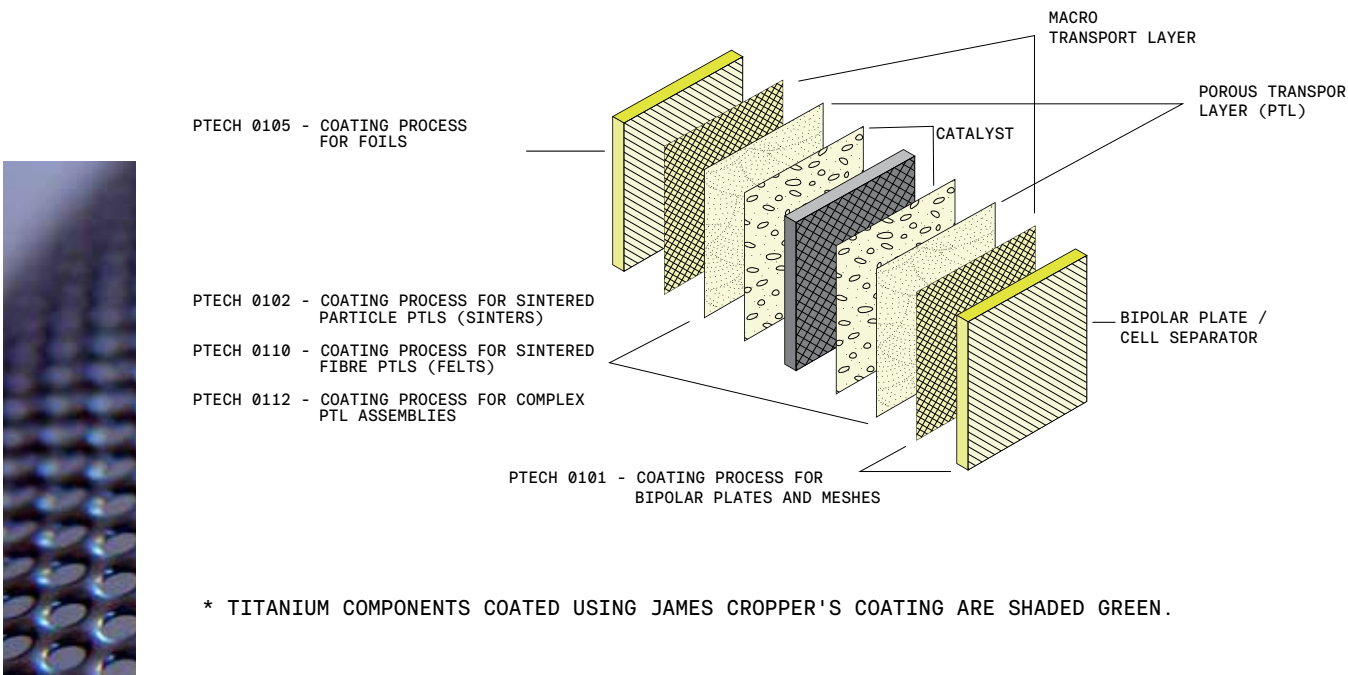
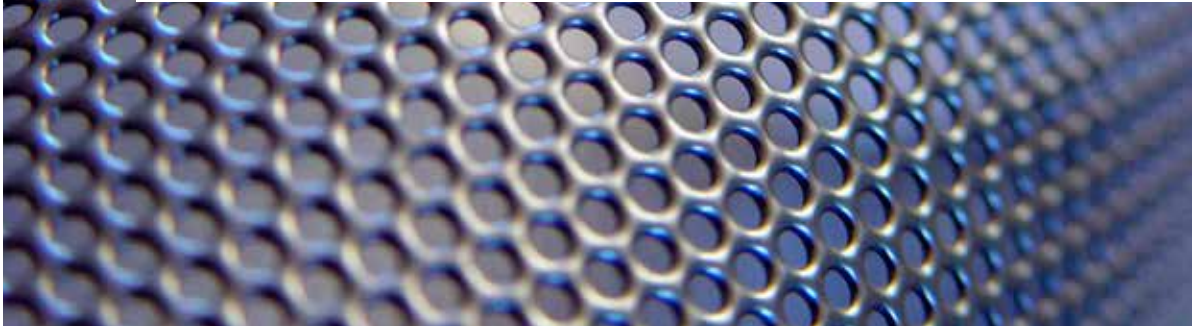
Green hydrogen is a crucial element in advancing the energy transition. For this to become a reality, technologies like PEM electrolyzers must combine high performance with affordability.

Our coatings can be applied to a number of different titanium PEM electrolyzers components to help achieve this, reducing the voltage degradation rate of the electrolyzers to just 3 µV/h over 10,000s hours, effecting a 60% improvement over uncoated components and significantly reducing the lifetime cost of hydrogen production.

Cell Separators, Bipolar and Unipolar plates can all be coated using our unique Resillion™ coating technology, protecting them from corrosion and reducing hydriding & embrittlement which increases the ohmic resistance and can lead to mechanical failure.

The result is improved long term component performance and cell lifetime. Resillion™ coatings offer the same benefits for macro transport layer meshes and porous transport layers PTLs, such as titanium sinters and felts, as well as lowering the interfacial contact resistances of these components and maintaining this over 10,000s of hours. In PTLs the specially designed coatings also protect against oxidation and reduce overpotential, enabling operation at high energy efficiency over long time periods.

All these benefits mean that the electrolyzers system is able to operate at high energy efficiency over long time periods, which is necessary to make green hydrogen production more competitive.



PRODUCT RANGE – PTECH COATINGS FOR TITANIUM PEM ELECTROLYSER COMPONENTS

PTECH 0101

OUR OPTIMIZED COATING FOR BIPOLAR PLATES OR MESH

PTECH 0102

A ROBUST COATING FORMULATION WITH SUPERIOR PERFORMANCE AND LONGEVITY FOR THE SINTERED PTLs

PTECH 0105

A SPECIALISED COATING FORMULATION DESIGNED FOR FOIL COMPONENTS

PTECH 0110

COATING DESIGNED FOR MAXIMISING PERFORMANCE ON FELT PTL COMPONENTS

PTECH 0112

TAILORED TO MEET THE DEMANDS OF SINTERED PTL AND MESH ASSEMBLIES, ENSURING PEAK PERFORMANCE

SECTORS:
PEM WATER ELECTROLYSERS

KEY BENEFITS

- Reduces and maintains low interfacial contact resistance (ICR) to enable operation at high energy efficiencies and increase component durability.
- Delivers low contact resistance which is maintained over 10,000s of hours.
- Protects against corrosion and oxidation to minimize maintenance requirements.
- Provides a 60% improvement in voltage degradation rate compared to uncoated components to maximise stack longevity and profitability.
- Withstands and protects against oxidation and hydriding, increasing component lifetime.
- Tailored formulation to suit the system requirements for optimum performance.
- Excellent coating adhesion combined with consistent coating coverage (macro & micro scale) and quality.
- Rapidly scalable coating technology - streamline mass production and optimize cost structures.
- Protects components against hydrogen embrittlement and improves fluoride ion tolerance to extend stack lifetime.

PRODUCT RANGE – ELECTROCATALYSTS

PTECH 0400 (IrO₂)

A DURABLE CATALYST DESIGNED FOR BOTH FUEL CELLS AND WATER ELECTROLYSERS TO ACCELERATE THE OXYGEN EVOLUTION REACTION (OER).

PTECH 0401 (IrRuO₂)

OUR IrRuO₂ CATALYST, PTECH 0401, FEATURES AN OPTIMIZED COMPOSITION AND HIGH SURFACE AREA. THIS DESIGN ENHANCES ENERGY EFFICIENCY IN OXYGEN EVOLUTION REACTION (OER) BY REDUCING OER OVERPOTENTIAL, WHILE ALSO ENSURING EXCELLENT DURABILITY.

PTECH 0600 (Pt/C)

THE CARBON SUPPORTED CATALYST PROVIDES A HIGH SURFACE AREA FOR THE HYDROGEN EVOLUTION REACTION (HER) WITH EXCELLENT STABILITY AND DURABILITY UNDER THE HIGH ACIDIC CONDITIONS.

SECTORS:
PEM WATER ELECTROLYSERS,
FUEL CELLS

KEY BENEFITS

- Operational at low voltages to ensure high efficiency.
- Proven performance over 10,000s hours makes them reliable for long-term use.
- Resistance to high oxidation environments, extending their lifespan.
- Excellent durability reduces maintenance needs and lowers operational costs.

- Cost effective due to enhanced efficiency and longevity, which makes green hydrogen production more economical.
- Highly dispersible into inks for ease of use.
- Rapid scalability possible to meet increasing demands in line with industry growth.



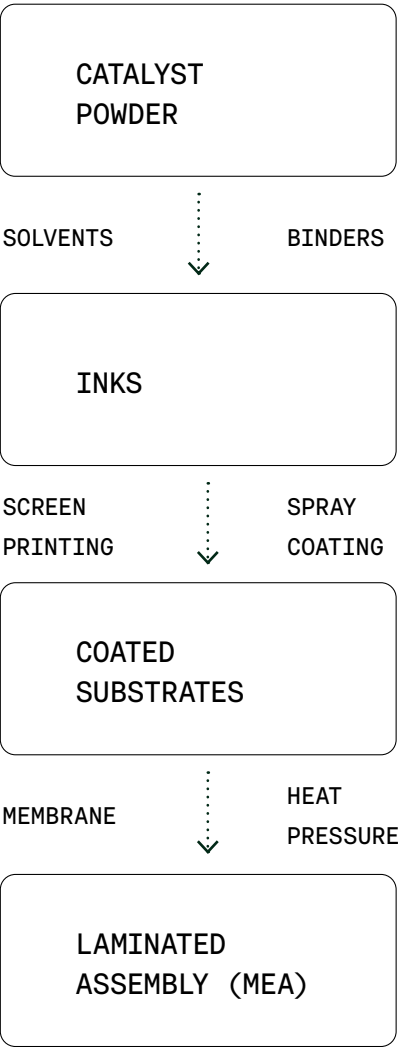
PRODUCT PORTFOLIO

CATALYSTS

James Cropper has developed a range of catalysts that are finely tuned to specific molecular ratios and electrochemical active surface areas (ECSA), ensuring outstanding durability without compromising catalytic performance production.

These catalysts are designed for various battery, electrolyser and fuel cell applications where resistance to corrosion and oxidation is crucial. By optimising the Pt ratio and other parameters, TFP's catalysts effectively enhance the longevity and efficiency of electrochemical systems, making them suitable for demanding environments.

Our range includes top-tier anode catalysts (IrO₂ and IrRuO₂) and cathode catalysts (Pt/C) for customers manufacturing Catalyst Coated Membranes (CCMs). These catalysts are designed for high dispersibility into inks and have consistently ranked highly in performance and durability evaluations.



PRODUCT PORTFOLIO

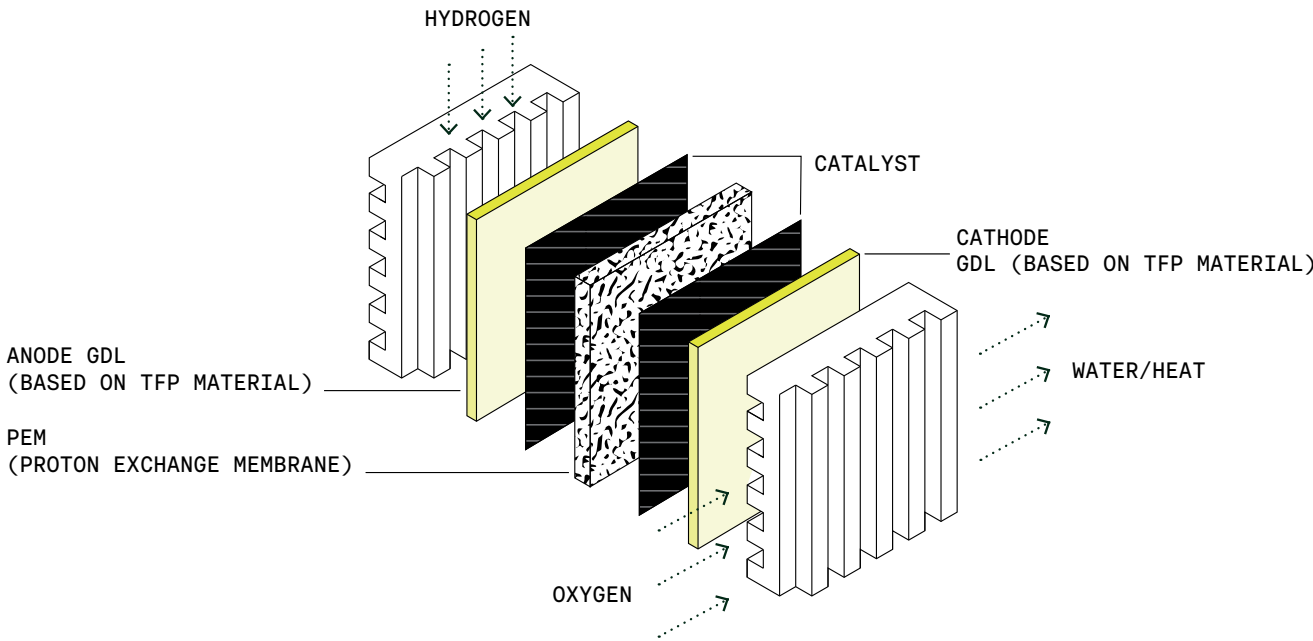
GAS DIFFUSION LAYER (GDL) SUBSTRATE

Our carbon nonwoven is widely utilised as a substrate for fuel cell Gas Diffusion Layers (GDLs), a critical component of the Membrane Electrode Assembly (MEA) at the heart of the fuel cell. The GDL forms the basis of both the anode and cathode, and is responsible for water management, the transport of reactants, reaction by-products, electricity and heat, as well as providing structural support to the assembly.

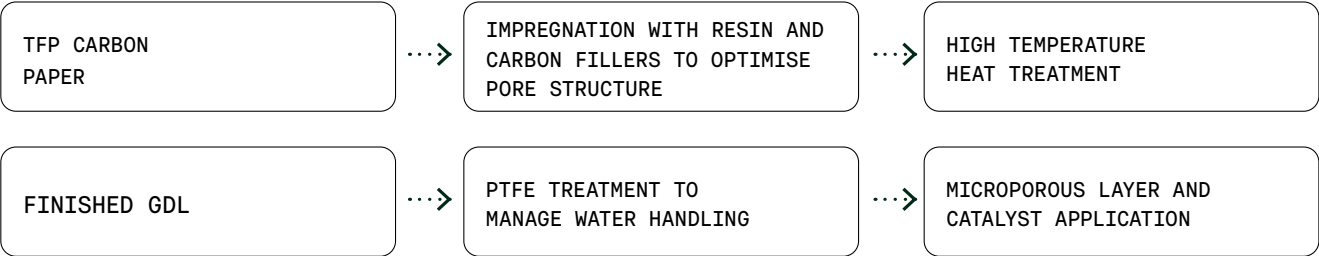
We have been developing and optimizing carbon nonwovens for use as GDL substrate since 1988, enabling a unique understanding of the material characteristics necessary to achieve a high performance GDL substrate, including electrical and thermal conductivity to allow current flow, optimum pore structure for mass transport and mechanical integrity.

The result of this long-term development is a range of high quality carbon papers (20352F) suitable for use in both stationary and

portable fuel cell systems. These materials are designed to meet key GDL criteria and subjected to rigorous testing throughout manufacturing to ensure thickness uniformity and mechanical strength to aid cell assembly. To date our nonwovens have been used extensively within the industry as GDL substrate for proton electrolyte membrane (PEMFC), phosphoric acid (PAFC) and direct methanol (DMFC) fuel cells.



PROCESSING - CREATING A GDL:
THE PROCESS TO PRODUCE GDL FROM OUR CARBON NONWOVEN IS AS FOLLOWS:



PRODUCT RANGE – OUR 20352F GRADE CARBON NONWOVEN IS SPECIFICALLY DESIGNED FOR GDL MANUFACTURE.

THICKNESS AT 50KPA / (1.45LB/IN ²)	mm	0.165	0.310	0.440
	mil	6.5	12.2	17.3
AREAL WEIGHT	g/m ²	17	34	50
	oz/yd ²	0.5	1	1.5
MD TENSILE STRENGTH	N/15mm	46	70	90
	lb/in	18	27	34

SECTORS:
PEM WATER ELECTROLYSERS
HYDROGEN FUEL CELLS

KEY PROPERTIES

The properties of our carbon nonwovens are designed specifically to meet the performance requirements and material characteristics needed from a GDL substrate. These attributes include:

- **UNIFORM THICKNESS** - Aiding consistent construction of the GDL and manufacturing of the fuel cell.
- **CONTROLLED POROSITY** - Tailored pore structure to accommodate different types of carbonaceous filler and post treatments, enabling flexibility in GDL design and processing.
- **CONDUCTIVITY**- High in-plane & through-plane electrical and thermal conductivity. This enables effective electrical conduction and heat transfer between catalyst and current collector plates to improve cell efficiency.
- **CHEMICAL RESISTANCE** – excellent chemical and corrosion resistance to reactant gases, this increases cell durability and reduces maintenance.
- **HIGH SURFACE AREA** - Enabling optimum control of reactant gas and water movement during operation, helping to maintain effective mass transport and efficient cell performance.
- **DURABILITY** - Excellent durability & strength, as well as controllable & repeatable compressibility. Ideal for accommodating thickness variation in cell stacks during stack assembly, and adapting to thermal expansion during operation.
- **EVEN SURFACE** – An even and consistent fibre distribution provides a suitable architecture for application of smooth microporous layer coating



PRODUCT PORTFOLIO

BATTERY

ELECTRODE MATERIALS

Interconnected conductive networks which can be activated through coating to provide high C-rate capability.

ELECTROCATALYSTS

A range of materials which increase the round-trip efficiency in advanced flow battery technology.

CELL SEPARATORS

A range of chemically resistant glass nonwovens, including E, C & ECR glass, which are designed to meet the requirements of lead acid and lithium thionyl chloride battery systems.

BATTERY
ELECTRODE MATERIALS

SECTORS:
LITHIUM ION
SODIUM NICKEL CHLORIDE
SODIUM-ION
LITHIUM SULPHUR
FLOW BATTERIES'

KEY PROPERTIES

- High Electrical Conductivity: Highly porous interconnected conductive framework facilitates the efficient flow of electrons during charge and discharge cycles.
- High Ionic Conductivity: Allows for the efficient movement of ions within the electrode.
- Chemical Stability: Resists degradation and maintains performance over many charge and discharge cycles.
- Mechanical Stability: Withstands the physical stresses of expansion and contraction during battery operation without degrading.
- High Energy Density: To store a large amount of energy in a small volume or mass.
- Compatibility with Electrolyte: Ensures that the electrode materials do not react adversely with the electrolyte.

James Cropper regularly collaborates with battery manufacturers to advance power and energy device technology. Our nonwovens, featuring carbon fibre networks, offer high C-rate capability when coated, and are produced using proprietary wet-laid technology to ensure high surface area and porosity. These carbon veils can be used as electrodes or current collectors in flow battery systems, significantly increasing the surface area for electrochemical reactions and enhancing electrical transfer kinetics.

OPTIVEIL 20352 – CARBON VEIL

AREAL WEIGHT	g/m²	4	10	14	17	34
	oz/yd²	0.1	0.3	0.4	0.5	1.0
THICKNESS AT 10 KPA/(1.45LB/IN³)	mm	0.05	0.12	0.17	0.20	0.40
	mil	2	5	7	8	16
MD TENSILE STRENGTH	N/15mm	8	30	40	46	70
	lb/in	3	11	156	17	27
CD TENSILE STRENGTH	N/15mm	4	8	14	24	38
	lb/in	2	3	5	17	15
TYPICAL SURFACE RESISTANCE	ohm/sq	4 - 16				

BATTERY
ELECTROCATALYSTS

SECTORS:
FLOW BATTERIES

KEY PROPERTIES

- **High Catalytic Activity:** Our range of electrocatalysts efficiently facilitate electrochemical reactions at the electrode surfaces.
- **High Electrical Conductivity:** Ensuring efficient electron transfer during charge and discharge cycles.
- **Chemical Stability:** Highly resistant to degradation and maintain performance over many cycles, especially in the presence of reactive species.
- **Selectivity:** Formulated to favour desired reactions while minimizing side reactions, improving battery efficiency and lifespan.

James Cropper's Catalyst range features highly tuned molecular ratios and electrochemical active surface area (ECSA), to produce a catalyst demonstrating excellent durability without hindering the catalytic performance. Our range of catalysts have been developed for use in a wide range of battery applications where corrosion and oxidation tolerance are of critical importance.



MOLECULAR FORMULA	40WT% PtIr/C	IrO ₂	Ir
APPEARANCE	BLACK POWDER	BLACK POWDER	BLACK POWDER
ELECTROCHEMICALLY ACTIVE SURFACE AREA	15-30 m ² g ⁻¹	102-104 m ² g ⁻¹	119-132 m ² g ⁻¹
CRYSTALLITE SIZE	7 nm	4.3 nm	6 nm
PURITY		98%	>98%

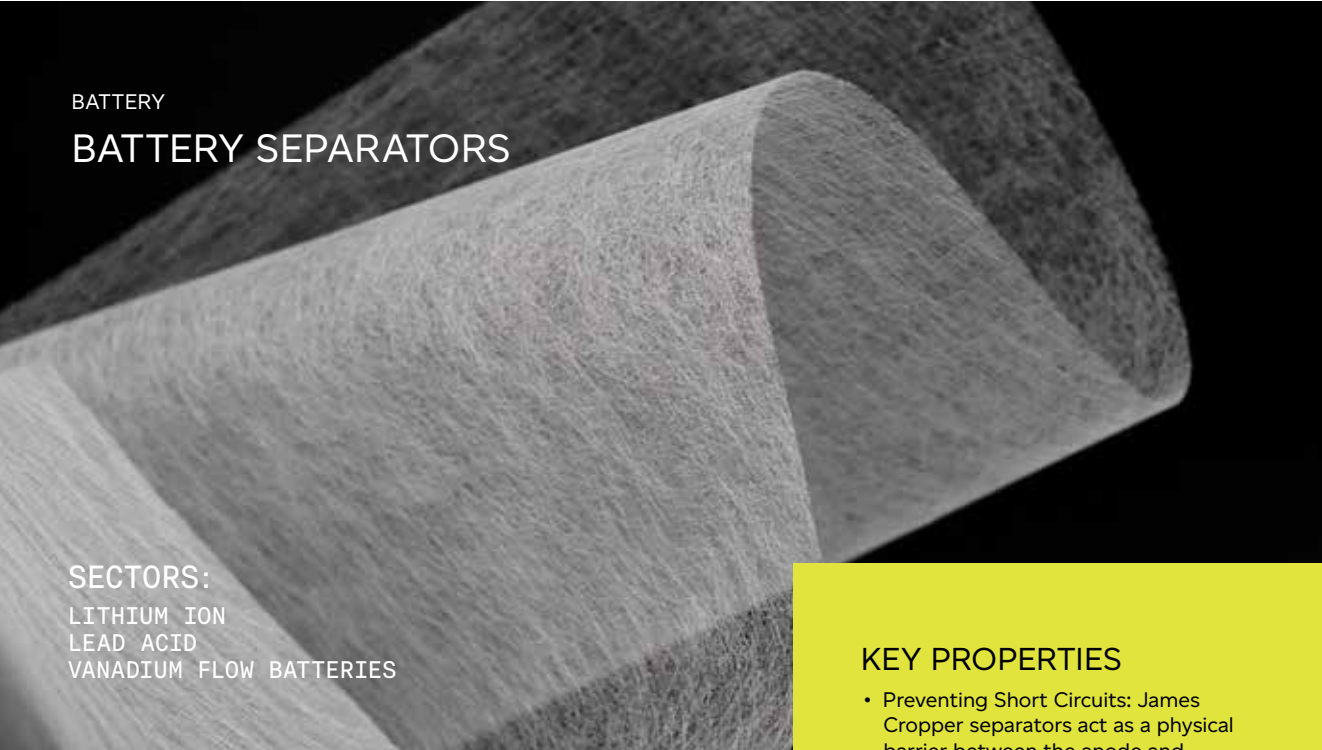
BATTERY
BATTERY SEPARATORS

SECTORS:
LITHIUM ION
LEAD ACID
VANADIUM FLOW BATTERIES

KEY PROPERTIES

- **Preventing Short Circuits:** James Cropper separators act as a physical barrier between the anode and cathode, preventing direct contact that could lead to short circuits and potential battery failure.
- **Ionic Conduction:** Our advanced nonwovens allow the flow of ions between the anode and cathode while blocking the flow of electrons, which is essential for the battery's operation.
- **Thermal Stability:** James Cropper separators can withstand the internal heat generated during battery operation, helping to maintain battery integrity and safety under high temperatures.
- **Mechanical Strength:** Our separators provide mechanical support to the electrodes, maintaining their position and structure during the cycling process, which is important for the battery's mechanical integrity and durability.
- **Chemical Resistance:** Our products resist the chemical environment within the battery, including the electrolyte, to prevent degradation and ensure long-term performance.
- **Enhancing Cycle Life:** By maintaining separation and integrity over many charge and discharge cycles, separators contribute to the extended cycle life of the battery.

James Cropper has developed a versatile range of materials tailored for both established and emerging power generation and storage systems. Our high-performance nonwovens are ideal for battery separators and have been successfully integrated into various battery types, including lead-acid and lithium batteries, delivering an optimal balance of cost and performance. Our chemically resistant glass products, such as E, C, and ECR glass, are specifically engineered to meet the rigorous demands of lead-acid and lithium thionyl chloride battery systems. These materials are perfect for use as separators, slip sheets, pasting papers, and glass retainer mats, with their design and properties customizable to meet specific requirements.



MATERIALS:
GLASS
POLYESTER
CARBON NONWOVEN



JAMES CROPPER

MATERIALS WITH PURPOSE

At James Cropper we are committed to a cleaner, greener future. We manufacture materials that empower our customers to drive global change. A key part of our vision is the aim that, within the next 5 years, the majority of our sales will come from applications that support the Global drive to 'Net Zero' carbon emissions.

James Cropper have been supporting the development of green energy technologies since the company's inception. We recognise that green hydrogen production will play a crucial role in the energy transition, but this hinges on it

becoming competitively priced compared to alternative low carbon technologies. Our coatings and electrocatalysts play an important role in this, improving the durability and efficiency of PEM electrolyzers, and ultimately contributing to the reduced cost of green hydrogen production necessary to accelerate the adoption of this technology.

Our nonwoven materials also contribute to the next generation of energy technologies, from hydrogen fuel cells and wind turbines to flow batteries and carbon capture.



REDUCING EMISSIONS

As well as enabling green hydrogen generation and use, James Cropper's nonwovens are instrumental in aerospace lightweighting and eVTOL development. They also support the transition to composite structures in automotive Battery Electric Vehicle (BEV) enclosures. All initiatives that will contribute to a reduction in vehicle weight and resulting carbon emissions.



INVESTING IN PEOPLE

Developing skills and creating opportunities for personal growth at all levels is important to us. We ensure a safe and healthy work environment through strategic planning and accredited policies.



SUSTAINABLE MANUFACTURING

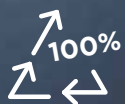
We prioritise the environment, integrating best practices and continuous improvement to minimise our environmental impact, from recycled fibre processing to energy alternatives.



READ MORE ABOUT OUR ENVIRONMENTAL AND SUSTAINABILITY GOVERNANCE:
jamescropper.com/about-us/environmental-social-and-governance/

Paper trail

Tracing the lineage of paper right to the source;
FibreBlend Upcycled Technology.



Upcycled
Fibre Content

RYDAL NATURAL WHITE
120 gsm



Upcycled
Fibre Content

VANGUARD WHITE
380 micron

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