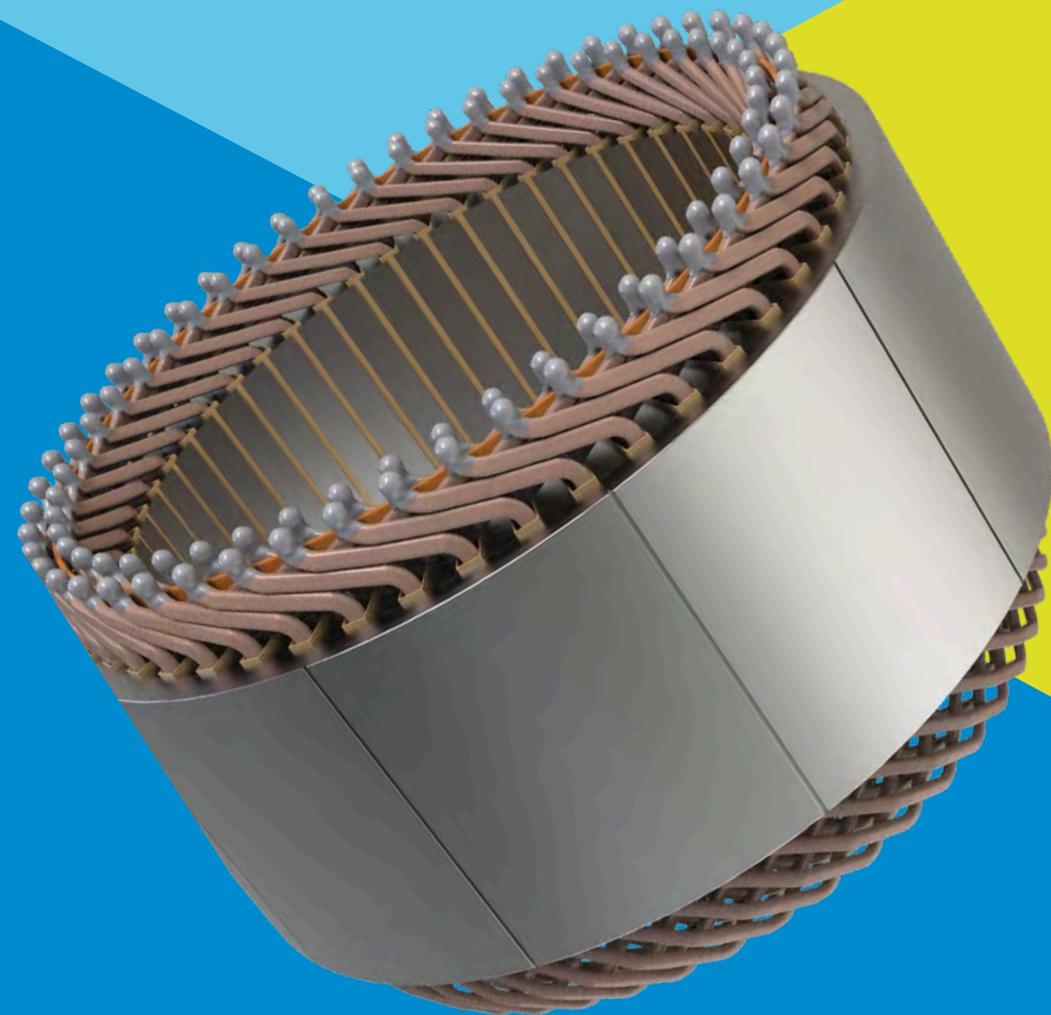




ADVANCED ELECTRICAL INSULATION

**VICTREX XPI™**  
**PEEK MAGNET**  
**WIRE COATING**

DELIVERING VALUE IN HIGH-VOLTAGE  
ELECTRIC MOTORS





## CONTENTS

New technologies, new challenges

When PEEK performs at its best

Key properties comparison Enamel vs. PEEK

What is VICTREX XPI™?

Key benefits

Why Victrex?

Leveraging the Victrex ecosystem

Enabling security of supply

Contact our mobility team

# THE NEED FOR SPEED.

## ELECTRIC CARS NEED MORE POWER AND FASTER CHARGING.

The move to electrification in the automotive industry requires new approaches in design and material selection, driven by the need for increasing vehicle range, reducing cost, enhancing driving experience and faster charging – all without compromising on reliability and safety.

As a result, electric drives must provide higher torque, more power, and greater efficiency – all without compromising on safety and reliability.



Increase power and energy density



Improve thermal management



Higher Voltage powertrains/e-motor



Faster charging



# NEW TECHNOLOGIES – NEW CHALLENGES

- ▶ Faster vehicle charging speeds require higher system voltages
- ▶ Faster (inverter power electronics) Silicon Carbide or Gallium Nitride switching technology – will lead to higher voltage overshoot/spikes

Traction e-machines need to cope with high temperatures, difficult chemical environments, and - with 800 V technology becoming a main stream solution - higher voltages, too. Moving to faster switching SiC or GaN invertors to reduce losses places additional constraints as the high rate of change of voltage makes the insulation layers degrade faster over time.

All these requirements need to be suitable for effective, state-of-the-art high-volume manufacturing processes.

To achieve these goals, the magnet wires used in the stator are a major factor to be considered in the motor design. Coating the winding wires with VICTREX XPI™ PEEK (polyetheretherketone) can provide an opportunity to resolve a number of these issues.



# WHEN THE GOING GETS TOUGH – VICTREX™ PEEK PERFORMS AT ITS BEST

With its unique combination of material properties PEEK (PolyEtherEtherKetone) is widely regarded as one of the highest-performing polymers in the world. For more than 40 years, VICTREX™ PEEK has been the material of choice in countless applications in the most demanding environments across different markets.

## TEMPERATURE RESISTANCE

Extreme thermal endurance and stable operation from -40°C up to 260°C

## MECHANICAL STRENGTH

Wide range of product grades with excellent strength, stiffness and ductility properties

## ELECTRICAL PERFORMANCE

Proven dielectric properties (high break-down voltage, PDIV, resistivity, low permittivity & loss etc.)



## CHEMICAL RESISTANCE

Outstanding resistance to chemical attack from a wide range of materials including ATFs and dielectric fluids

## THERMAL CONDUCTIVITY

Has around 2x the thermal conductivity of other super engineering polymers (e.g. PI)

## WATER ABSORPTION

Low levels of moisture absorption combined with excellent hydrolysis resistance



'WHAT IS PEEK?' - a 3 minute video

[CLICK TO WATCH](#)



# WHY VICTREX XPI PEEK MAGNET WIRE INSULATION FOR HIGH-PERFORMANCE MOTORS

## A KEY PROPERTIES COMPARISON

Using VICTREX XPI™ PEEK insulation for magnet wires can help solve some of the demanding requirements in high-performance motors compared to Enamel (PAI)

	Enamel (PAI)	Extrusion (VICTREX XPI™)
Thickness	5-100 micron	80-300 micron
Breakdown Voltage	★★★★	★★★★
PDIV	★★★	★★★★
Temperature Class (°C)	180	220
Ductility for bending	★★★	★★★★
Thermal ageing resistance	★★	★★★★
Corona resistance	★★	★★★
Average faults per length	★★	★★★★

★ not favourable    ★★★★★ very favourable

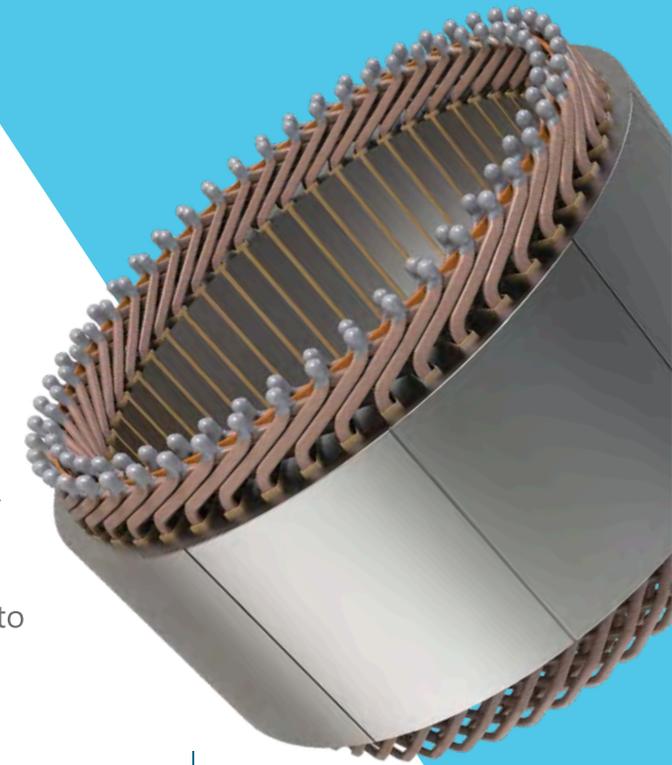
(Victrex internal assessment)

# WHAT IS VICTREX XPI?

## VICTREX XPI™ - PEEK MAGNET WIRE INSULATION FOR HIGH-PERFORMANCE MACHINES

The new VICTREX XPI polymer grades are designed to meet all extrusion wire manufacturing processing needs and offer a combination of excellent electrical, mechanical, high-temperature and chemical resistance performance for e-motor magnet wire to enable reliable insulation performance, extended vehicle range, reduced cost and faster charging for high-performance motors.

Designers can benefit from improvements in increased copper density and stator thermal efficiency to enable extended electric vehicle range.



Very good electrical properties enabling increased reliability for advanced winding & switching technologies



Combination of excellent ductility and thermal endurance properties



New coating technologies offer e-motor insulation design opportunities to increase efficiency and electric vehicle range



Resistance to chemical attack from a wide range of materials including ATFs, even in higher (800V) vehicle voltage systems

**Let's explore together how we can support you in achieving greater efficiency in your electric machine designs.**

# RELIABILITY

Excellent electrical properties of VICTREX XPI polymer for a given thickness enables increased reliability when using new switching technologies (e.g. SiC and GaN)

- ▶ Higher Partial Discharge Inception Voltage (PDIV) vs. enamel
- ▶ Material ductility allowing tighter bending radii while retaining mechanical strength
- ▶ Stable PDIV with no coating shrinkage in use
- ▶ Outstanding resistance to chemical attack from a wide range of materials including ATFs and dielectric fluids at 180° up to 2,000 hrs
- ▶ Enhanced breakdown voltage and retention of PDIV performance after thermal cycling

**ENHANCED INSULATION RELIABILITY WITH STATE-OF-THE-ART WINDING AND SWITCHING TECHNOLOGIES**



# EFFICIENCY

Excellent electrical properties (PDIV) for a given thickness of insulation enable new more energy efficient e-motor insulation designs vs. enamel that improve vehicle range for given battery capacity

- ▶ Reduced average end winding temperature and increased normalised continuous torque in water and oil/ATF cooled motors
- ▶ Increased power density through better utilisation of packaging space
- ▶ Improved vehicle range for given battery capacity through better thermal efficiency and reduced energy losses

**IMPROVED MOTOR EFFICIENCY ENABLING LESS ENERGY CONSUMPTION AND EXTENDED ELECTRIC VEHICLE RANGE**



# DESIGN FREEDOM

VICTREX XPI™ polymer offers bespoke characteristics for use in new, more efficient insulation designs and winding processes such as hairpin and wave winding.

- ▶ Excellent coating ductility enables smaller winding heads supporting increased power density
- ▶ 2x tighter bending radius with VICTREX XPI vs. enamel
- ▶ Choice of different cooling system designs and vehicle integration due to thermal cycling and chemical attack from ATF or dielectric fluids
- ▶ Very good electrical properties enable more thermally efficient insulation system designs
- ▶ VICTREX XPI coating capabilities offering potential to remove/reduce secondary insulation materials

**ENJOY THE FREEDOM TO CHOOSE AND OPTIMISE  
YOUR MOTOR AND COOLING SYSTEM DESIGN**



# COST-EFFECTIVENESS

Comparative simulations showed the VICTREX XPI outperformed enamel magnet wire coating in terms of loss generation and copper temperature over the drive cycle.

- ▶ Reduced total energy consumption vs. enamel based on e-motor efficiency map, vehicle statistics and drive cycle WLTP-3b
- ▶ 2% less battery capacity requirement for the VICTREX XPI PEEK variant vs. the enamel coated variant
- ▶ Potential cost saving of \$270 per battery unit\*

**REDUCE COST OF YOUR BATTERY UNITS WITH  
VICTREX XPI HIGH-PERFORMANCE PEEK INSULATION**

\*based on 2018 battery pack prices

# SUSTAINABILITY

Supporting net zero emission goals throughout the supply chain with VICTREX XPI PEEK magnet wire coating

- ▶ Up to 60% less energy required for VICTREX PEEK extrusion versus traditional enamel coating processes
- ▶ Eliminates need for hazardous solvents associated with wire enamels; simplifying storage, processing and minimising waste.
- ▶ PEEK is recyclable, enhancing life time circularity of e-motor
- ▶ Growing number of accreditations from leading sustainability programs

**VICTREX XPI PEEK SUPPORTS A MORE SUSTAINABLE APPROACH TO MAGNET WIRE COATING**



# VICTREX IS COMMITTED TO SUSTAINABILITY

Aligned to UN Sustainable Development Goals 2030

52%

of revenues from sustainable products (products offering a quantifiable environmental or societal benefit)

88%

of R&D project investment focused on sustainable products

100%

Renewable electricity across all Victrex global locations

38%

Reduction in hazardous waste disposed to landfill (after treatment) vs FY2023

4%

Reduction in Scope 1, 2 CO2 emissions vs FY2023



- Decarbonisation: carbon net zero emissions by 2050 aligned to SBTi (Scope 1, 2 & 3)
- Increase the use of sustainable products which support CO2 reduction & clinical benefit
- Enhance circularity of our products and recycling rates
- Minimise resources (Carbon, Waste and Water) used in our operations
- Further inspire our employees and communities to positively impact sustainability

[LEARN MORE ABOUT OUR SUSTAINABILITY STRATEGY](#)





# WHY VICTREX?

From the commercialisation of PEEK over 40 years ago, Victrex has continually pioneered PAEK-based polymer solutions that have transformed markets, delivering global impact in the toughest environments.

## Supporting our customers' productivity

- ▶ Custom formulations optimised for your specific requirements
- ▶ Expert 'On-site or remote' processing support

## Accelerating innovation

- ▶ Rapid response through deep automotive sector market insight
- ▶ Faster innovation and product development up through PEEK - dedicated R&D and manufacturing facilities.



### THE VICTREX E-MOBILITY ECOSYSTEM

Watch the 90 second video here



Dr. David Simkin, Head of Winding Centre of Excellence  
WMG Group @ Warwick University



**PEEK  
EXPERT**



**YEARS OF  
EXPERIENCE**



# LEVERAGING THE VICTREX ECOSYSTEM

Beyond offering an innovative high-performance product Victrex is collaborating with a network of partners.

In anticipating customer needs, we have been doing extensive work to underpin the value of VICTREX XPI magnet wire insulation. We partner with our customers to reduce risk, give them peace of mind and help accelerate their time to market.

## ACCELERATE YOUR E-MOTOR PROJECTS

### Computer modelling data

for e-motor & vehicle drive cycle analysis, together with associated hardware validation

### Access to wide range of electrical data

associated with winding, bending & forming of magnet wire

### Thermal cycling test data

of hairpin-shaped XPI coated wire

### Oil compatibility data

demonstrating retention of electrical properties of XPI after heat ageing from OEM partner oil experts

### Extensive electrical testing data

from our partner network demonstrating higher BDV, PDIV and lower permittivity of XPI vs. enamel

### Intellectual property

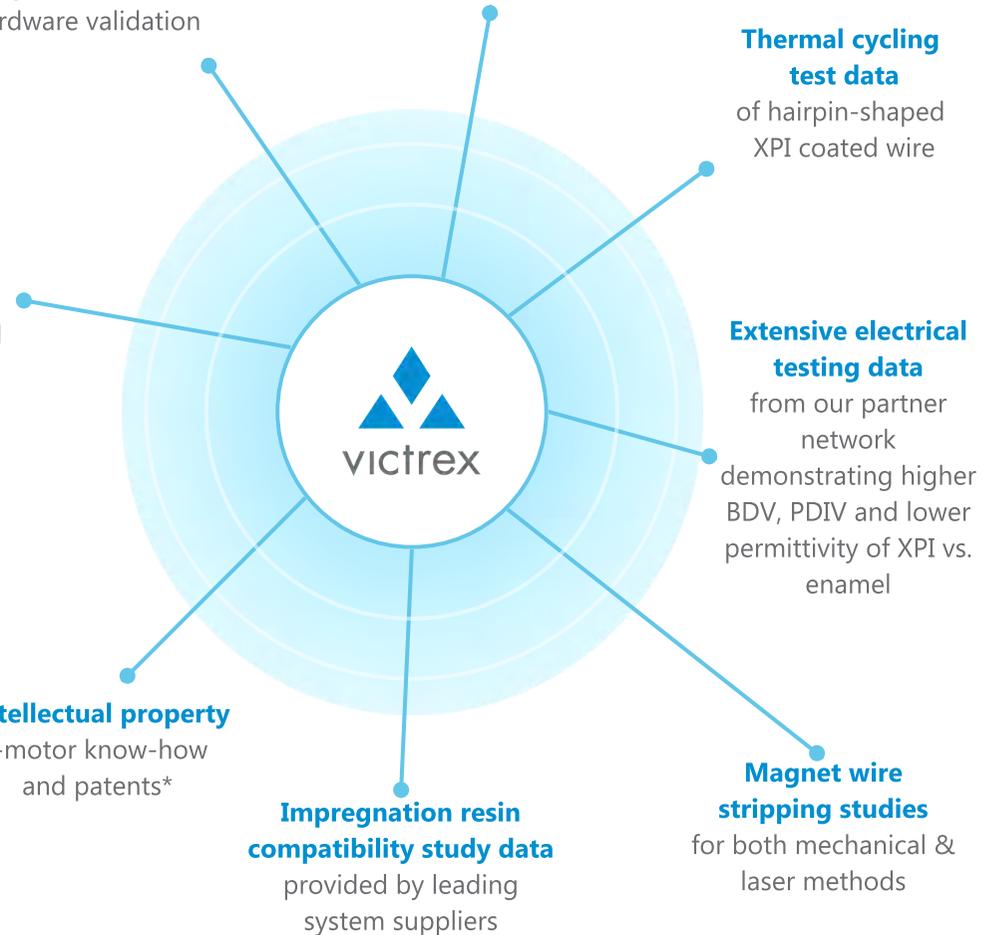
E-motor know-how and patents\*

### Impregnation resin compatibility study data

provided by leading system suppliers

### Magnet wire stripping studies

for both mechanical & laser methods



\*Patents granted: US10186345B; JP6782238B; EP3250627B and EP4036152B  
Patents pending: EP4098681A

# ENABLING SECURITY OF SUPPLY

- ▶ Upstream integration enabling greater control of formulating flexibility & supply
- ▶ Global facilities providing short lead times and strengthening overall logistics
- ▶ Strategic commitment to supply chain security supported through Class A certified Integrated Business Planning
- ▶ #1 global PEEK production capacity – Invested and ready for growth now

## EUROPE

Warehouses in Germany and the UK

Monomer production in the UK - upstream integration of key raw material for supply & quality control



## JAPAN

Warehouses in Tokyo



## NORTH AMERICA

Warehouses in Philadelphia & Houston



## ASIA/PACIFIC

Warehouses in Shanghai, Hong Kong, Korea & Singapore

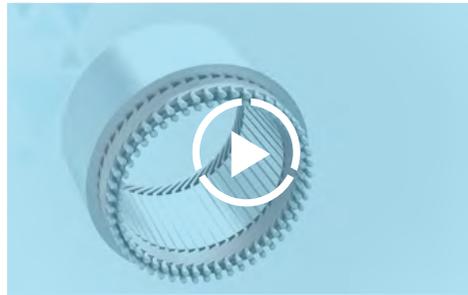


# THIS MIGHT ALSO BE OF INTEREST TO YOU...



This whitepaper discusses test results and benefits of VICTREX XPI polymer insulation vs. enamel with detailed evidence.

[DOWNLOAD WHITEPAPER](#)



VICTREX XPI Polymer for high-performance magnet wire Coating in high-voltage electric motors

[WATCH ANIMATION](#)



E-motor slot liners using PEEK-based APTIV XPI film for advanced electrical insulation solutions

[WATCH VIDEO](#)

CHECK OUT OUR [E-MOTOR SOLUTIONS PAGE](#) FOR MORE INFORMATION



STAY UP TO DATE AND  
**SIGN UP**

FOR TOPICS THAT  
INTEREST YOU!

VICTREX XPI offers OEMs and e-motor manufacturers reliability, efficiency, range and cost benefits in high-performance machines that can help solve the challenges in electric vehicle adoption

Contact our team directly to discuss your next development. We would be more than happy to support you.

**CONTACT OUR E-MOBILITY TEAM NOW!**





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#### About Victrex

Victrex is an innovative world leader in high performance polymer solutions, focused on the strategic markets of automotive, aerospace, energy (including manufacturing & engineering), electronics and medical. Every day, millions of people use products and applications, which contain our materials – from smart phones, aeroplanes and cars to oil and gas operations and medical devices. With over 40 years' experience, we develop world leading solutions in PEEK and PAEK-based polymers, semi-finished and finished parts which shape future performance for our customers and our markets, and drive value for our shareholders. Find out more at [www.victrex.com](http://www.victrex.com)