

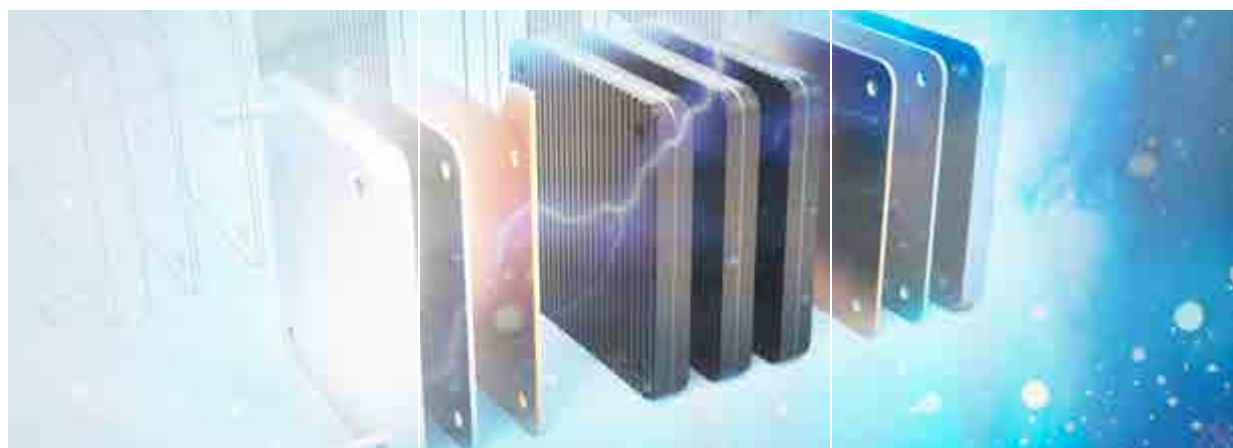


Mobile
Energy

SPECIALTY CARBONS FOR BIPOLAR PLATES OF FUEL CELLS

TIMREX[®]
Graphite

ENSACO[®]
Carbon Black



www.imerys-graphite-and-carbon.com

Imerys Graphite & Carbon

A STRONG COMPANY

Imerys Graphite & Carbon, member of the Imerys Group, is the reference for innovative capability in the field of carbon-powder-based solutions: natural graphite and synthetic graphite powders, conductive carbon blacks, as well as silicon-carbon composites and water dispersions.

High standards in terms of employee health and safety, social behaviour and environmental responsibility are core values of the company, which is capturing opportunities by developing new products and applications, investing in assets & people, and growing its commercial presence worldwide.



FINANCIAL STRENGTH



Profitable company, part of Imerys, the world leader in mineral-based specialty solutions for industry, listed on the Paris stock exchange

IMERYS GROUP 2017	
WORKFORCE	18,300
REVENUE	4.6 Bn
OPERATING MARGIN	14.1 %

RELIABLE PARTNER



INNOVATION STRATEGY
■ Focused on the market and the Customer's needs
SECURITY OF SUPPLY
■ 5 Industrial sites
OUR DRIVING FORCE
■ Customer Service

RESPONSIBLE GROWTH



COMMITMENT TO
■ Green Technology and Sustainable Development
REDUCTION OF
■ CO ₂ Footprint
ENGAGEMENT WITH
■ Local Communities



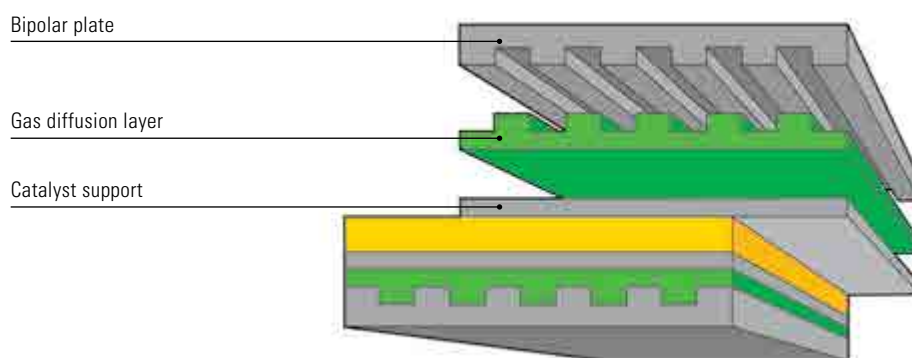
Carbons in Fuel Cells

CARBON POWDERS FOR BIPOLAR PLATES OF FUEL CELLS

Carbon materials are an essential element of most key components of fuel cells. This document is dedicated to carbon-polymer composite bipolar plates currently used in various fuel cell technologies. It is intended to help our customers to make the best possible selection from the wide range of Imerys Graphite & Carbon's materials available for the use in their bipolar plate. Imerys Graphite & Carbon offers technical expertise to its customers through its Marketing and R&D Groups. Our team of specialists possesses extensive knowledge of carbon materials, polymers, compounding and corresponding application processes, as well as an excellent problem solving record.

CARBON MATERIALS IN OTHER COMPONENTS OF FUEL CELLS

Carbon material powders as well as dispersions, are used in gas diffusion layers, catalyst supports and as coatings for metal bipolar plates in fuel cell systems. Finally, graphite powder is also used as pore former in SOFC components.



BIPOLAR PLATES

The bipolar plate (BPP) is one of the key components in PEM and other fuel cell systems. It performs four basic functions in the fuel cell stack operation:

These functions correspond to key functional requirements for BPPs such as in-plane and through-plane (z direction perpendicular to the plane) electrical conductivity, and thermal conductivity to achieve stack cooling. Other functional requirements for BPPs include mechanical stability for stack integrity, hydrogen impermeability, resistance to corrosion for long life, low cost materials, and ease of manufacturing.

Graphite-based bipolar plates meet or exceed most of these key requirements.

BIPOLAR PLATES TARGET PROPERTIES	CARBON POWDER REQUIREMENTS
High electrical conductivity (through-plane)	High crystallinity and high pressed density, low anisotropy and rounder particle shape
High thermal conductivity (in-plane)	High crystallinity and high pressed density
Long life operation (low corrosion)	High purity carbons (> 99.8 %C)
Good mechanical properties	High pressed density
Easy processing of compound (low viscosity at high carbon loading)	Optimized particle size distribution, rounder particle shape

Imerys Graphite & Carbon's TIMREX® and ENSACO® Specialty Carbons for Bipolar Plates

OUR SPECIALTY CARBONS

Our carbon-related solutions for carbon-polymer composites have been optimized by selecting unique graphite grades as conductive and reinforcing fillers or by combining several carbon materials.

Our carbon-related solutions are compatible with both thermoplastics and thermosets and can be processed under a wide range of composition and conditions. The corresponding carbon-polymer composite bipolar plates can be produced by either compression or injection molding.

Our solutions are based on high-purity primary synthetic graphite, high aspect ratio graphite, and highly conductive carbon black.

CARBON TYPE	ROLE	HIGH ELECTRICAL CONDUCTIVITY (THROUGH-PLANE)	HIGH THERMAL CONDUCTIVITY (IN-PLANE)	LONG LIFE OPERATION (LOW CORROSION)	GOOD MECHANICAL PROPERTIES	EASY PROCESSING (LOW VISCOSITY)
TIMREX® primary synthetic graphite	Main filler	+++	++	+++	++	+++
TIMREX® high aspect ratio graphite	Additive	+++	+++	+++	++	+
ENSACO® carbon black	Additive	+++	+	+++	++	+

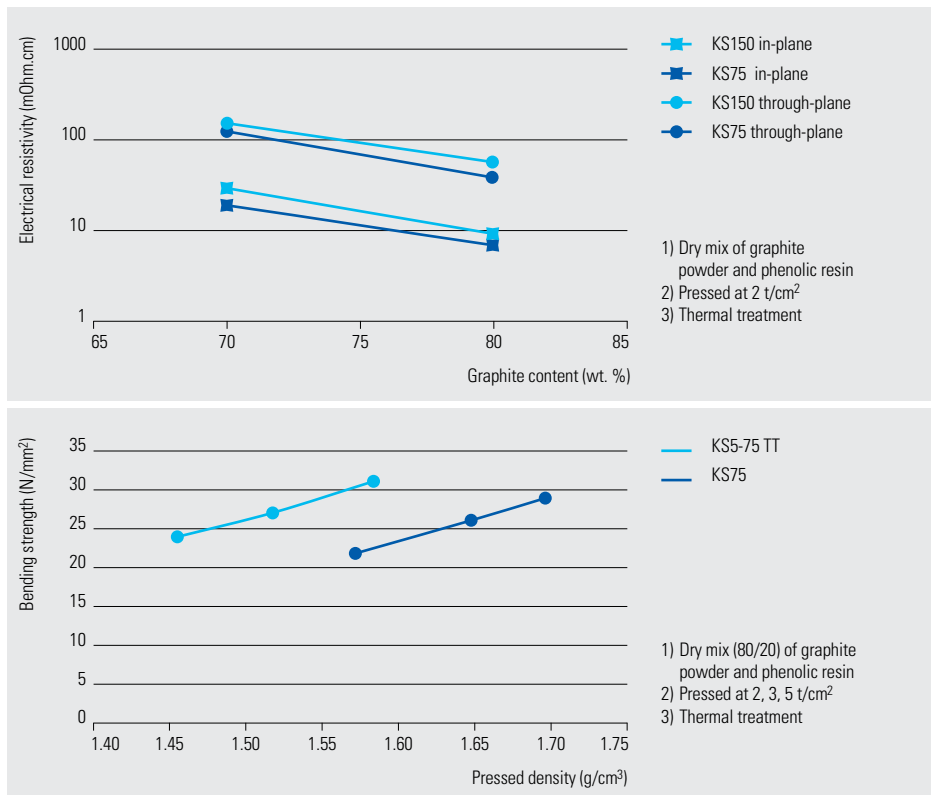
OUR GRAPHITE AS MAIN FILLER

TIMREX® highly crystalline primary synthetic graphite grades feature optimal particle shape, large crystallite size to ensure the mechanical stability, and high electrical conductivity. Primary synthetic graphite, with particle sizes (d90) ranging from 50 to 150 microns, performs very well in graphite polymer systems, while allowing the compound to be easily processed. Finer graphite is more difficult to handle (i.e. low density, dusting, and high compound viscosity) and typically results in lower conductivity, which is due to higher interparticulate contact resistance.

Coarser graphite powders display higher conductivity and allow better processing, yet reduce the mechanical stability of bipolar plates. Because the purity of primary synthetic graphite exceeds 99.9% in carbon content, this allows the carbon to exhibit superior performance and long life.

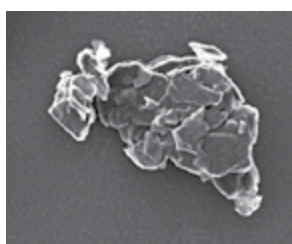
TIMREX® KS grades with medium to coarse particle size are commonly used in graphite-polymer composites. The highly isometric particle shape of KS grades results in good flowability, even at very high carbon loading that makes the compound easier to process. This allows the production of composite bipolar plate with high through-plane conductivity. Thus the low anisotropy of primary synthetic graphite is essential for optimum stack performance. The high crystallinity and the unique particle texture results in low oil (binder) absorption and more isotropic electrical conductivity.

Imerys Graphite & Carbon's TIMREX® and ENSACO® Specialty Carbons for Bipolar Plates



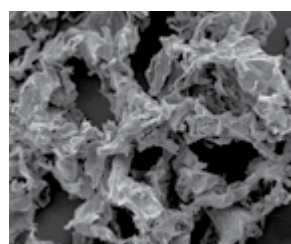
PRIMARY SYNTHETIC GRAPHITE AS MAIN FILLER					
TIMREX®	Carbon content	Surface area BET	Oil absorption	Particle size	Scott density
KS150	> 99.9 %	3.9 m²/g	47 %	96% < 150 µm	0.34 g/cm³
KS75	> 99.9 %	7.2 m²/g	84 %	d90 = 56 µm	0.24 g/cm³
KS5-75TT	> 99.9 %	4.4 m²/g	39 %	d90 = 70 µm	0.44 g/cm³

Typical values



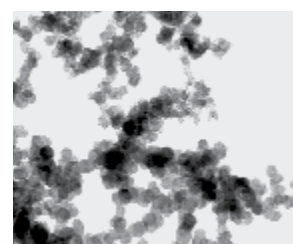
10 µm

SEM picture of primary synthetic graphite TIMREX® KS75



50 µm

SEM picture of high aspect ratio graphite TIMREX® C-THERM™



100000:1

200 nm

TEM picture of carbon black ENSACO® 250G

Imerys Graphite & Carbon's TIMREX® and ENSACO® Specialty Carbons for Bipolar Plates

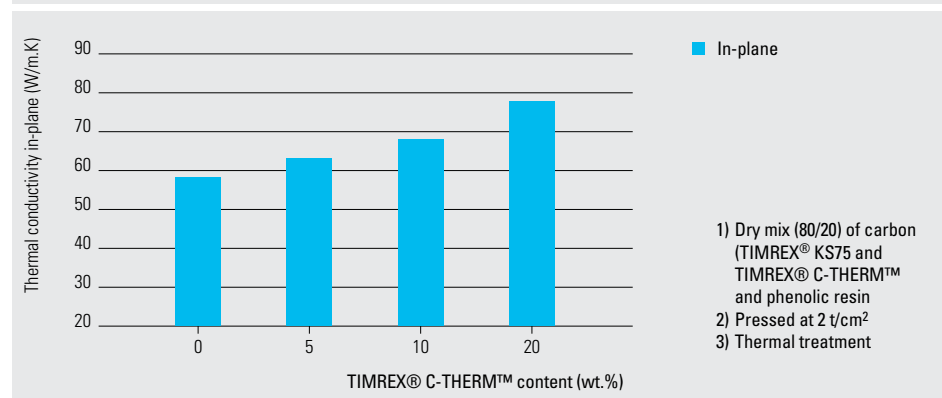
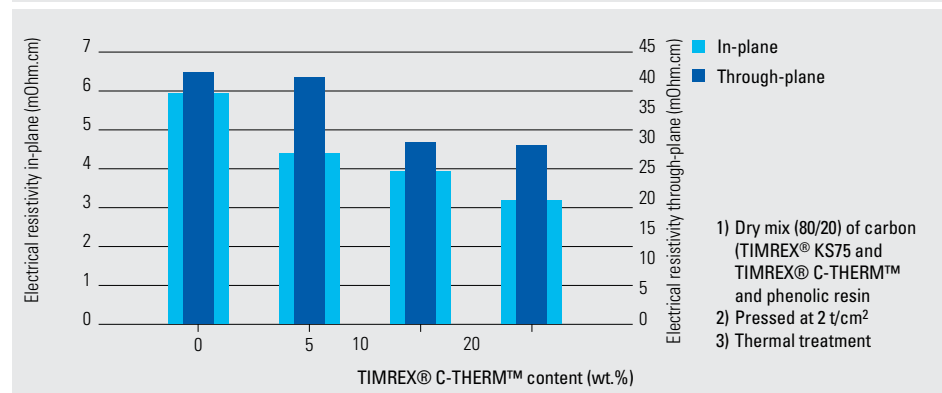
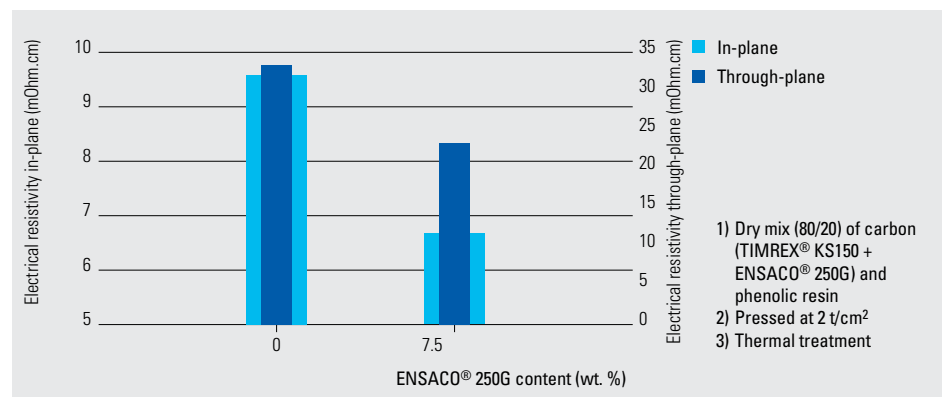
OUR CARBON ADDITIVES AS MINOR FILLERS

With TIMREX® KS grades as the main carbon filler, the performance of bipolar plates can be enhanced by the addition of high aspect ratio graphite and/or conductive carbon black. ENSACO® 250G is a conductive carbon black that can boost both in-plane and through-plane electrical conductivity of polymer-carbon composites.

TIMREX® C-THERM™ is a high aspect ratio graphite designed for applications requiring high electrical and thermal conductivity at low carbon contents.

TIMREX® C-THERM™ can not only boost both in-plane and through-plane electrical conductivity, but also increase the thermal conductivity.

These materials are added in small quantities, since they may drastically increase compound viscosity. The best solutions and the optimum concentration of minor fillers depend upon the target performance of bipolar plate, selection of polymer, compounding conditions, and molding process.



YOUR PARTNER FOR CARBON

CUSTOMIZED SOLUTIONS

Imerys Graphite & Carbon produces a variety of specialty synthetic and natural graphite powders, conductive carbon blacks, silicon-carbon composites, calcined petroleum cokes, aqueous dispersions and silicon carbide, with highly consistent quality.

Our products are manufactured under stringent process control conditions, from the raw material stage through to the end product.

As we own our raw material sources, we are today the only integrated player that can offer a complete range of products with security of supply, integrated with our innovative technologies, and sustainable processes.

Our teams of Marketing and Research & Development specialists cooperate in a synergetic manner with our customers, in order to fully understand their needs and provide them with customized solutions.

For further information, feel free to contact us, or visit our website:
www.imerys-graphite-and-carbon.com

Primary synthetic graphite powders

- Isotropic & anisotropic
- Coarse, medium, fine, ultra fine
- High & very high purity

Natural flake graphite powders

- Flake
- Purified
- High aspect ratio
- High crystallinity
- Coarse, medium, fine, ultra fine
- High purity

Conductive carbon blacks

- Granulated
- Powder

Silicon-Carbon composites

Water-based dispersions

Coke powders

- Coarse, medium, fine

Silicon carbide

Carbon Materials

- Natural Flake Graphite
- Synthetic Graphite
- Carbon Black
- Silicon-carbon Composites

Research & Development

- Product Development
- Application Development
- Scientific Support to Customers

APPLICATIONS



Mobile Energy



Polymers



Engineering Materials



Refractories & Metallurgy

Security of supply

Synergies

Innovative Sustainable solutions

Customization

- Size Reduction
- Surface Modification
- Shape Modification
- Purification

Added Value Processes

- Exfoliation
- Mixing
- Sieving
- Milling
- CVD Coating
- CVD Silicon Nanowires



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