

Corporate profile



FutureCarbon is the leading supplier of customized super-composites based on carbon nanomaterials for further processing by industry.

FutureCarbon specializes in the development and manufacture of carbon nanomaterials and their refinement to create what are called carbon super-composites, primary products for further processing by industry. Carbon super-composites are combinations of materials that unfold the special characteristics of carbon nanomaterials in the macroscopic world of real applications. All of our materials are manufactured on an industrial scale.

Our aim is to provide solutions matching the requirements of customers who use our products to create new, high-performance materials with specific mechanical, electrical or thermal characteristics.

Application focus

Key applications for our products are in the following areas:

- automotive engineering,
- battery design,
- power engineering,
- building services,
- aerospace,
- mechanical engineering,
- military technology,
- environmental technology.

Expertise

FutureCarbon has an exceptional command of:

- the manufacture and application-specific functionalization of carbon nanomaterials,
- the placement of carbon nanomaterials in very different matrix systems,
- the combination of carbon and other materials

Products and performance

FutureCarbon delivers standard products for general applications, custom products for special requirements, plus a variety of services supporting its products.

Products cover the following categories:

- electrically conductive dispersions based on epoxy resin, water and solvents,
- electrically conductive dispersions based on epoxy resins, cyanate ester resins and silicones,
- dispersions with metalized carbon nanomaterials (Pt, Pd, Cu, Fe, Ni, etc),
- special-purpose dispersions with plasticizers, oils, etc
- granulates of carbon nanotubes (CNTs)
- duroplastic and thermoplastic CNT powders
- special-purpose graphites
- functionalized CNTs and graphites
- electrically heated coatings.

Common to all FutureCarbon products is how their function is matched to the specific requirements of the application, and the implementation of carbon nanomaterials in a straightforward and reliable form for further industrial processing.

DOU YEE ENTERPRISES (S) PTE.LTD.

2304 Bedok Reservoir Road phone: (65) 6444 2678
 Bedok Industrial Park C fax: (65) 6743 7172
 e-mail: cpyuen@douyee.com.sg
 SINGAPORE 479223 website: www.douyee.com

FutureCarbon GmbH

Gottlieb-Keim-Strasse 60 phone: +49 (0)921 507 388-40
 95448 Bayreuth fax: +49 (0)921 507 388-99
 e-mail: sales@future-carbon.de
 GERMANY website: www.future-carbon.de

Product portfolio



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FutureCarbon's product portfolio divides into three groups – in addition to standard products we offer customized products plus services for purifying and treating third-party materials.

Standard Products

Product	Outline	How delivered	Material class
<i>CarboBlend</i>	Duroplastic/thermoplastic CNT powder mixtures	Powder	CNT
<i>CarboBond</i>	Antistatic adhesives based on epoxy resin	Dispersion	CNX / Graphite
<i>CarboCat</i>	Platinized (20 and 30 weight %) carbon nanoparticles for catalytic applications	Powder	CNX
<i>CarboCond</i>	Electrically conductive epoxy resins (10 ² – 10 ⁷ Ω·cm) for cold, warm and hot hardening	Dispersion	CNX / Graphite
<i>CarboDis</i>	Aqueous CNT dispersions different stability	Dispersion	CNT
<i>Carbo e-Therm</i>	Highly conductive coating systems for heating applications	Dispersion	CNX / Graphite
<i>CarboFlex</i>	Antistatic silicone resins	Dispersion	CNX / Graphite
<i>CarboGran</i>	Simply dispersed CNT granulate	Granulate	CNT
<i>CarboImpreg</i>	Conductive impregnation for electrical heating of absorptive surfaces	Dispersion	CNX / Graphite
<i>CarboLube</i>	High-performance lubricant containing graphite	Dispersion	Graphite
<i>CarboShield</i>	Coating system as protection against electromagnetic radiation	Dispersion	CNX / Graphite

Custom products

In addition to its standard products FutureCarbon offers customized products for a variety of purposes. We work precisely to the customer's requirements, delivering the specified product in the required quantities.

- Electrically conductive epoxy resin dispersions with CNX/graphites
- Water based dispersions with CNX/graphites

- Solvent based dispersions with CNX/graphites
- Special dispersions with CNX/graphites (e.g. in softening agents, oils)
- Metalized CNX (e.g. Pt, Pd, Cu, Fe)
- Special graphites
- Cyanate ester resin dispersions with CNX/graphites
- Functionalized CNX/graphites
- Dispersions with CNX/silicones

Services

FutureCarbon also offers the following services:

- Purification of CNX/graphites (removal of metallic catalysts)
- Functionalization of CNX/graphites

- Refinement of a large variety of polymers, solvents, etc (influencing electrical, mechanical or thermal properties of substances) with CNX/graphites

CNT – carbon nanotubes, CNF - carbon nanofibers
CNX – collective term for CNT and CNF

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Carbo e-Therm



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Carbo e-Therm is a high-efficiency, electrically heated coating developed for use in the non-hazardous low-voltage range. Its excellent applicability to very different geometries and surfaces plus high heating power open up a wide field of possible uses.

Carbo e-Therm is a heated coating based on carbon nanomaterials, developed especially to operate with non-hazardous low voltages.

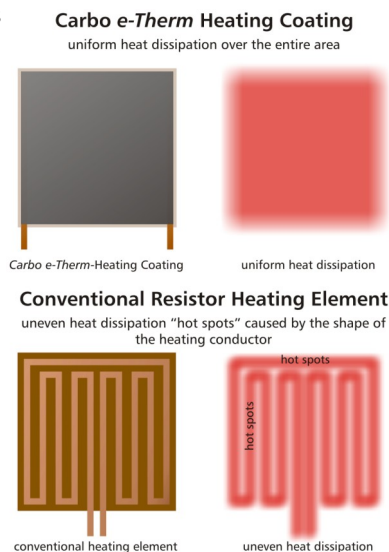
Compared to conventional heating elements

Carbo e-Therm presents numerous advantages:

- excellent application, manually or mechanically like paint,
- heating of surface geometries of any shape,
- extremely high electrical safety by working on non-hazardous low voltage,
- direct use of low-voltage sources (e.g. 12/24 V onboard, solar power),
- very simple electrical connection,
- easy supervision and control,
- high heating power for low supply voltage,
- perfectly even heating of large surface areas without hot spots,
- very attractively priced compared to conventional heating systems.

Depending on the product type, **Carbo e-Therm** consists of a binder matrix and a specially matched carbon formulation. The excellent conductivity of the coating (R_{\square} to 1Ω) makes it possible to implement high heating power on non-hazardous low voltage (e.g. 12/24 V). Compared to conventional resistance heating, **Carbo e-Therm** distributes heat absolutely evenly without hot spots.

The illustrations on the right show the heat distribution of a **Carbo e-Therm** heating layer versus a conventional resistance heating element.



Carbo e-Therm heating layers are highly rugged mechanically. Depending on the product type they exhibit very good permanent elasticity or high hardness, plus they are characterized by excellent resistance to water and alkalis.

Carbo e-Therm goes a long way: one liter suffices to coat a surface of up to 4 sqm. It can be applied manually or mechanically, by brush, blade, roller or spraying. Coatings dry and can then be painted within a few minutes.

Matching the requirements of different applications, we offer a number of **Carbo e-Therm** variants differing in their bonding systems (e.g. acrylate, PVDF, silicone and epoxy resins) and the temperatures for their use:

Product variant	Max. temperature of use
Carbo e-Therm ACR-100 1W	100°C
Carbo e-Therm ACR-180 1W	180°C
Carbo e-Therm SIL-250 1S	250°C
Carbo e-Therm WGS-500 1W	500°C

Illustrated on the right is a radiant panel heater integrated in an automobile door.



There are a wide variety of possible applications for **Carbo e-Therm**:

- panel heating for automobiles,
- floor heating (wet areas, mobile homes),
- wall heating (renovated buildings),
- workplate temperature control (stone worktops),
- temperature control of measuring devices (optics),
- heating in mechanical engineering,
- heating for forms (CFK/GRP laminates),
- heating of food (catering),
- devices in medical engineering,
- frost protection.

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CarboShield



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CarboShield is a new kind of coating as protection against electromagnetic radiation. Compared to conventional shielding materials, **CarboShield** absorbs electromagnetic radiation instead of reflecting it.

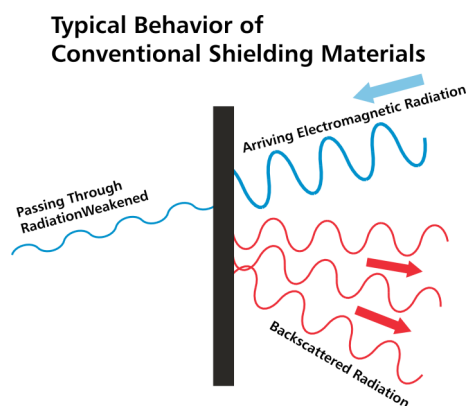
CarboShield is a coating based on carbon metamaterials intended to guard rooms in buildings, technical installations, electronic modules and components, etc against electromagnetic radiation.

CarboShield is optimized for radiation extinction over a very wide frequency band. It absorbs electromagnetic radiation, i.e. the radiation enters into the material and is not backscattered.

Special features of **CarboShield** are:

- simple processing by all common workman-like and industrial means of application,
- applicable to very different surfaces and geometries,
- thin coatings produce excellent results,
- maximum protection through absorption.

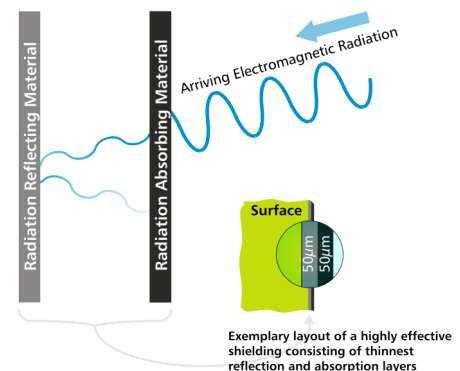
The illustration shows the principle of conventional shielding materials, e.g. sheet metal or metalization. They prevent the penetration of electromagnetic radiation into the shielded region by reflection on the coating shield.



This reflected or backscattered radiation can very often present problems because the radiation does not just disappear but, by directional reflection, can even amplify locally and lead to interference or damage elsewhere.

CarboShield exhibits high and constant absorption in a very wide frequency range. Just a very thin, singular coating can produce attenuation of more than 50%.

Highly Effective Shielding by Combination of Reflection and Absorption Layers



The attenuation or extinction properties required in a technical application can be set quite arbitrarily through the layer structure.

CarboShield is suitable for all applications in which effective suppression of electromagnetic radiation is called for, ensuring the necessary reliability and functionality of sensitive technical devices for example, safeguarding humans and animals against exposure to radiation, or maintaining the security of information by preventing electromagnetic espionage.

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CarboGran

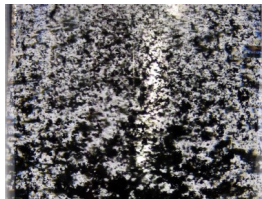


CarboGran is a dry and low-dust granulate of carbon nanotubes (CNTs) with excellent dispersion capability. **CarboGran** enables direct further processing without elaborate predispersion, making it extremely straightforward to import CNTs into industrial manufacturing processes.

Products of the **CarboGran** series are easily dispersed and dosed granulates of carbon nanotubes. **CarboGran** can be used direct in most manufacturing processes. Consequently, for the first time it shows the way for every user to safely and simply further process CNTs without the extra effort of predispersion.

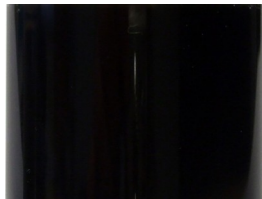
The positive features of **CarboGran** stem from the fact that the CNTs in the microgranulates are present in a form resulting in very good distribution and very pronounced separation of CNTs in liquids.

The picture on the right shows a mixture of commercial carbon nanotubes and water: The CNTs agglomerate and immediately precipitate, so dispersion is not stable.



A mixture of **CarboGran** and water on the other hand shows a completely different reaction.

CarboGran dissolves immediately, and the CNTs distribute evenly in the liquid. The result is stable dispersion with extremely fine distribution of particles.



The product advantages of **CarboGran** are:

- straightforward application through good solubility,
- randomly adjustable powder concentration in the application,
- extremely simple further processing by virtually all conventional mixers,
- safe handling through the low-dust nature of the product,
- unlimited stability in storage through dry presentation form.

CarboGran easily disperses by stirring it into water, alcohols, ethylene glycol and similar solvents. For media of higher viscosity all common mixing processes are suitable with somewhat higher shear force.

CarboGran can be processed into all water-based or water-compatible systems. It is used to create special electrical or mechanical properties in the end-product. Examples of **CarboGran** application include:

- coatings,
- surface finishing,
- adhesives,
- sealants,
- varnishes,
- ceramic slurry,
- building materials.

CarboGran can also serve as an additive in the manufacture of antistatic plastic flooring and coatings. Electrostatic discharge is effectively prevented and safety thus enhanced.

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CarboDis



CarboDis are extra-high-grade, dustfree dispersions of carbon nanotubes of graduated concentrations in water for creating specific mechanical and electrical properties in an end-product.

Products of the **CarboDis** series are dustfree, simply dosed and stable dispersions of carbon nanotubes. They can be used to create specific electrical and mechanical properties in an end-product. The special dispersion processes mean that small amounts are sufficient to achieve an optimal effect. Different product variants open up a wide field of applications, and can be worked into all water based and water-compatible systems.

The dispersions of the **CarboDis** product series give the user an optimal basis for successfully working carbon nanotubes (CNTs) into their material.

CarboDis is characterized by the following features:

- ready dispersed CNTs, without agglomerates,
- uncomplicated, safe handling through water-bound nanotubes,
- highly stable dispersion through suitable additives or functionalization (no surfactants),
- ionogeneity matched to the range of use.

All dispersions come to standard with a CNT content of 1 weight % and 2 weight %. Dispersions with up to 4 weight % CNTs can be produced for custom requirements.

CNTs are optimally dispersed and stabilized in a multi-stage process developed inhouse by FutureCarbon. This enables us to produce dispersions with especially low viscosity of less than 100mPa·s.

The stability of **CarboDis** dispersions is achieved by different additives or chemical pretreatment of the CNTs. A selection of types ensures compatibility of the dispersion with very different applications:

- **CarboDis TN** with electrically neutral surfactant,
- **CarboDis TK** with cationic surfactant,
- **CarboDis TA** with anionic surfactant,
- **CarboDis ES** with functionalized nanotubes.

CarboDis can be worked into all water based or water-compatible systems to create specific electrical or mechanical properties in an end-product.

CarboDis has already proved successful in the following fields of application:

- coatings,
- surface finishes,
- adhesives,
- sealants,
- lacquers,
- ceramic glazes,
- building materials.

Only small quantities of **CarboDis** are needed for it to demonstrate its positive effect. It can also be used as an additive in the manufacture of antistatic plastic flooring and coatings. This is an effective safeguard against electrostatic discharge – a means of improving safety.

In addition to improving electrical properties, **CarboDis** can also be used to enhance mechanical parameters such as resistance to abrasion.

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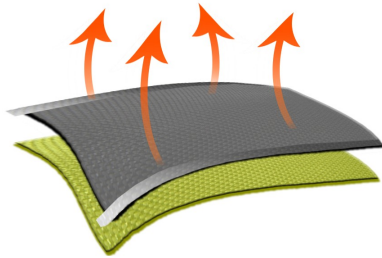
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95448 Bayreuth
GERMANY
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Carbolmpreg

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Carbolmpreg is an electrically conductive impregnation for heating absorptive surfaces up to 100°C. Very simple application, operation on non-hazardous low voltages plus high-performance heating mean a whole variety of possibilities of use.

Carbolmpreg enables impregnation of rough or absorptive surfaces of very different materials, for example leather or textiles. Surfaces impregnated in this way can be electrically heated by applying a non-hazardous low voltage (e.g. 12 or 24 V).



Unlike coatings, **Carbolmpreg** will soak into the surface of a material and fuse with it internally. In this way full processing of the material without any restrictions is still assured. And additionally it becomes highly wear-resistant.

Compared to conventional heating elements **Carbolmpreg** offers many other advantages:

- very simple application, by manual or mechanical means,
- heating of surface geometries of any shape, and flexible materials (e.g. natural materials),
- extremely high electrical safety through operation on non-hazardous low voltage,
- direct use of low-voltage sources, e.g. 12/24 V on-board networks and solar current,
- entirely even heating of large areas without hot spots,
- straightforward electrical connection,
- simplicity of control,
- highly cost-attractive compared to conventional heating systems.

Carbolmpreg consists of a binder matrix and a special, highly conductive carbon preparation. Excellent conductivity (R_{\square} up to 1Ω) allows high heating performance solutions on non-hazardous low voltages (e.g. 12 or 24 V). Furthermore, treated surfaces exhibit high ampacity, enabling very fast heat buildup rates.

Carbolmpreg heating solutions are highly robust. The impregnation does not degrade the processing characteristics of the carrier material, and exhibits excellent resistance to water and alkalis.

Unlike more common resistance heating, **Carbolmpreg** radiates heat absolutely uniformly without the risk of hot spots. The illustrations show the heat distribution of a **Carbolmpreg** heating surface compared to the response of a conventional resistance heating element.

Carbolmpreg Heating Coating

uniform heat dissipation over the entire area



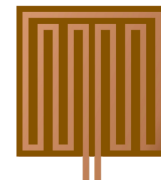
Carbolmpreg-Heating Coating



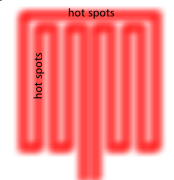
uniform heat dissipation

Conventional Resistor Heating Element

uneven heat dissipation ("hot spots") caused by the shape of the heating conductor



conventional heating element



uneven heat dissipation

Carbolmpreg can be applied manually and mechanically, by brushing, rolling, squeegeeing, spraying or printing, and dries in a matter of minutes.

Carbolmpreg is suitable for a broad spectrum of applications, for example:

- surface heating for vehicles,
- heating of natural and synthetic fiber fabrics or fleeces,
- heating of leather,
- heating of fiberglass fabrics,
- wall heating (e.g. for building renovation),
- heating in machine and plant engineering,
- heating for molds (e.g. CRP/GRP parts),
- anti-frost protection.

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CarboCond



CarboCond are electrically conductive epoxy resins filled with carbon nanoparticles. They exhibit very much improved mechanical properties compared to conventional systems.

Products of the **CarboCond** series are electrically conductive, solvent-free and stably crystallizing epoxy resins. They consist of low-molecular bisphenol A and bisphenol F components, and contain carbon nanoparticles. The electrical conductivity of **CarboCond** can be optimized for a very wide selection of applications by simply varying the carbon concentration.

CarboCond exhibits numerous advantages compared to conventional systems filled with carbon black or graphite:

- unequaled electrical conductivity (specific resistance in the region of $10^2 \Omega \cdot \text{cm}$),
- substantially improved mechanical properties compared to commercial, electrically conductive epoxy resin systems,
- adjustable electrical conductivity through matched carbon content,
- obtainable in different versions, e.g. for mold making or coatings.

CarboCond products have dynamic viscosity of 3 to 13 Pa·s. They consist of low-molecular epoxy resins based on bisphenol A and F, and contain carbon nanoparticles plus graphite.

Aimed at as wide a range of applications as possible, **CarboCond** is obtainable in two basic types for different viscosity and hardening parameters:

- **CarboCond 171**, with dynamic viscosity of approx. 13 Pa·s, is suitable for cold, warm or hot hardening.
- **CarboCond 471** is reactively diluted, its dynamic viscosity is approx. 3 Pa·s, and it is suitable for cold or warm hardening.

The two systems come in three different ranges of conductivity:

- 0.1 weight % carbon nanoparticles, specific resistance 10^5 to $10^7 \Omega \cdot \text{cm}$
- 0.4 weight % carbon nanoparticles, specific resistance 10^3 to $10^5 \Omega \cdot \text{cm}$
- 0.6 weight % carbon nanoparticles, specific resistance 10^2 to $10^3 \Omega \cdot \text{cm}$

CarboCond can be used wherever very high electrical conductivity is called for, e.g.

- floors,
- coatings,
- cast parts,
- ESD protective components.

CarboCond products are compatible with very different epoxy resin systems, and can also serve as a master batch in various concentrations.

The resulting specific resistance will implement diverse standards in the area of ESD/explosion protection.

A number of aminic and anhydrous hardeners are obtainable for **CarboCond**.

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CarboBlend



CarboBlend are electrically conductive fine powders of thermoplastic or duroplastic polymers. Carbon nanoparticles give the products their high electrical conductivity. The minimum specific electrical resistance that can be achieved is in the region of $100\Omega\cdot\text{cm}$.

CarboBlend are polymer powders enriched by carbon particles. A variety of nanocarbons are used as coating materials. This combination produces excellent electrical properties while maintaining the original mechanical properties of the polymers.

Products of the *CarboBlend* series are notable especially for the following:

- specific electrical and mechanical properties produced by composition of the carbon nano-materials,
- very much improved mechanical properties compared to carbon black filled polymers,
- minimum specific electrical resistance about $100\Omega\cdot\text{cm}$,
- good thermal conductivity,
- dustfree, free-flowing.

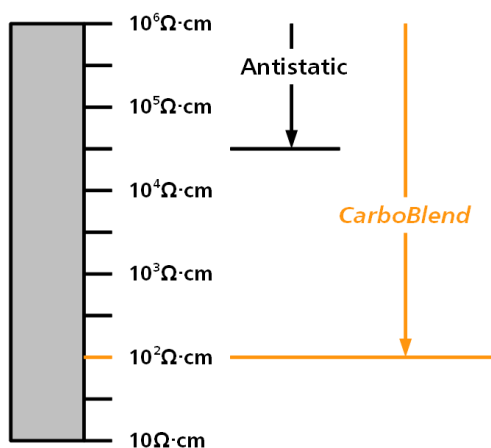
CarboBlend products are obtainable based on the following polymers:

- polyethylene, HDPE and LDPE,
- polyamide 11,
- polyamide copolymers,
- polyetheretherketone (PEEK),
- epoxy resin,
- phenol resin,
- melamine resin.

CarboBlend can be further processed as follows:

- antistatic powder coating,
- extrusion,
- rapid prototyping,
- injection molding,
- sintering/molding,
- scattering (textile coating).

Specific electrical resistance



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CarboFlex



CarboFlex are electrically conductive silicone resins filled with carbon nanoparticles. The large degree of flexibility of the materials shows the way for using **CarboFlex** products in all applications calling for a silicone-based sealing compound with electrical conductivity.

CarboFlex are electrically conductive, dual-component systems consisting of silicone resins filled with carbon nanoparticles. Fillings are selected to match the particular application and the electrical and mechanical properties aimed at. There are both addition cross-linking and condensation cross-linking systems.

Products of the **CarboFlex** series are notable especially for the following:

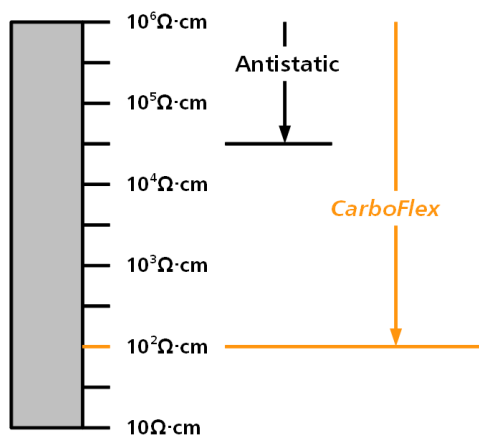
- specific electrical resistance up to $400\Omega\cdot\text{cm}$,
- high flexibility accompanied by high electrical conductivity,
- very much improved mechanical properties compared to conventional electrically conductive sealing compounds,
- creation of specific electrical and mechanical properties by different degrees of filling,
- high thermal conductivity.

The excellent electrical properties of the carbon nanoparticles allow a low degree of filling. That maintains the good elastic properties of the silicone resins.

CarboFlex is used where good electrical conductivity and high elasticity are needed, for example:

- antistatic sealing compounds (sealing rings),
- antistatic hoses,
- sealing materials with extra thermal conductivity,
- cable sheaths,
- thermally conductive molds and solid materials.

Specific electrical resistance



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CarboBond



CarboBond are electrically conductive, dual-component adhesives filled with carbon nanoparticles. The minimum specific electrical resistance that can be achieved is in the region of $100\Omega\cdot\text{cm}$.

Products of the **CarboBond** series are dual-component adhesives based on epoxy resin to which carbon nanoparticles are added to produce excellent electrical, thermal and mechanical properties. Variation of carbon composition and concentration allows fast and simple optimization for the particular purpose or application.

Products of the **CarboBond** series are notable especially for the following:

- adaptable electrical and mechanical properties,
- minimum specific electrical resistance about $100\Omega\cdot\text{cm}$,
- good thermal conductivity,
- very good adhesion,
- adjustable viscosity.

CarboBond comes in different types for application by common methods (e.g. spraying, squeegee, silk screening).

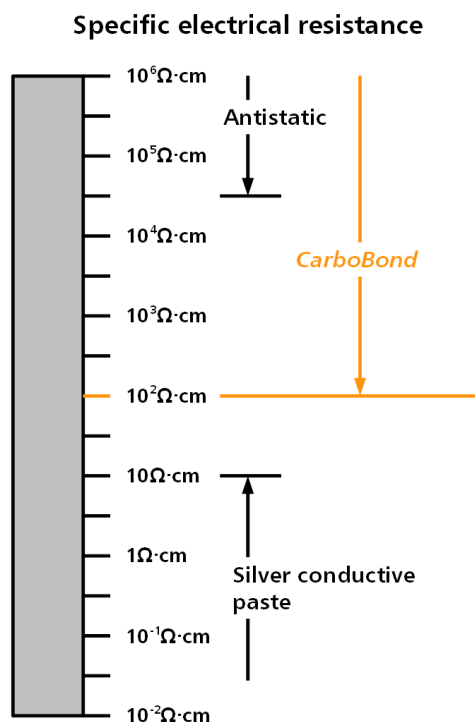
The following **CarboBond** products are obtainable:

- epoxy resin/amine (RT, warm hardening),
- epoxy resin/anhydride (hot hardening).

CarboBond is especially suitable for the kind of adhesive application where electrical conductivity is of primary importance, e.g.

- current and heat conducting adhesion of CFP components,
- thermal adhesives in electronics,
- antistatic adhesives.

Matching hardener systems are obtainable for **CarboBond**.



DOU YEE ENTERPRISES (S) PTE.LTD.

2304 Bedok Reservoir Road phone: (65) 6444 2678
 Bedok Industrial Park C fax: (65) 6743 7172
 e-mail: cpyuen@douyee.com.sg
 SINGAPORE 479223 website: www.douyee.com

FutureCarbon GmbH

Gottlieb-Keim-Strasse 60 phone: +49 (0)921 507 388-40
 95448 Bayreuth fax: +49 (0)921 507 388-99
 e-mail: sales@future-carbon.de
 GERMANY website: www.future-carbon.de

CarboLube



CarboLube is a high-performance lubricant and mold release containing a large proportion of special graphites. The product ensures an excellent lubricating and parting effect even in extreme conditions.

CarboLube is a dispersion of water, spindle oil, paraffin oil or glycols with high-performance graphites. The material is highly fluid, can be pumped and sprayed.

Compared to conventional systems, the high-performance lubricant and mold release **CarboLube** offers advantages such as:

- superior lubricating effect even at high temperatures,
- obtainable based on different materials such as water, spindle oil, paraffin or glycol,
- very good operation after failure of lubricant and dry running properties,
- sustained release effect even after evaporation of the base material.



CarboLube is successful in its use as a mold release agent in metal casting and metal forming because - as a result of the large proportion of graphites - a very high parting effect can be achieved on handled parts even after evaporation of the base material.

This reduces the time needed for subsequent machining to release molds. The result is shorter cycle times and downtimes on production lines.

CarboLube is used in the following applications:

- lubrication of bearings, chains, etc,
- mold release agent in metal casting and metal forming.

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CarboCat



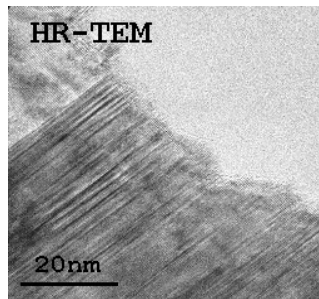
CarboCat is a platinumized catalyst material based on carbon nanoparticles. Our special metal deposition process produces optimal dispersion of platinum particles on the carbon nanoparticles, while the high oxidation stability ensures reduced aging effects.

The special properties of **CarboCat** stem from the use of carbon nanoparticles (platelet type, abbreviated CNF-PL) as a high-efficiency catalyst material plus the deposition process developed by FutureCarbon.

Compared to conventional catalysts, the material exhibits the following properties:

- The high stability of the substrate material against oxidation produces very high long-term stability of the catalyst, which shows its worth in particular in the case of high-temperature fuel cells (HT-PEM).
- The specific surface of CNF-PL (by BET) is in the region of 130 m²/g (effective as a catalytically active surface).

Illustrated on the right is a TEM picture of the carbon nanoparticles (CNF-PL). The staggered surface structure makes them optimally suited as a catalyst substrate material.

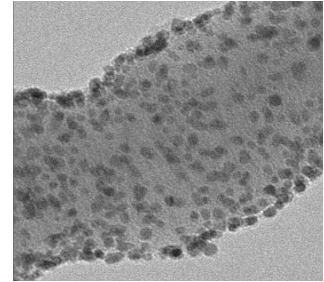


CarboCat is simply dispersed and creates porous layers of good adhesion, e.g. in membrane electrode units. **CarboCat** dispersions can be applied by the usual methods, and also combined with other materials.

The unique FutureCarbon deposition process optimally binds platinum particles to the substrate. It is general-purpose and also suitable for the deposition of many other metals.

In the righthand picture the extremely fine Pt particles deposited on CNF-PL are visible.

They exhibit high stability (reduced tendency to coalesce).



CarboCat comes to standard with Pt weight proportions of 20% and 30%. Pt particle size is approx. 3 nm for **CarboCat** PL-Pt 20% and approx. 4 nm for **CarboCat** PL-Pt 30%.

A variety of special versions are also available:

- alternative substrate materials: carbon nanotubes (CNT-MW) and other nanoparticles (e.g. CNF-HB),
- differing metal content (e.g. 5% platinum as a hydrogenating catalyst with special selectivity),
- combinations with ruthenium as a PtRu alloy catalyst,
- alternative deposition of palladium particles.

CarboCat is optimized for application in both low-temperature and high-temperature PEM fuel cells.

CarboCat is suitable as a catalyst for highly selective hydrogenation reactions in which C=O bonds in particular are hydrogenated but C=C bonds are sustained.

In addition to its catalyst application, **CarboCat** serves as a mediator layer in the field of carbon nanoparticle composites.

CarboCat comes optionally as powder or dispersed in a variety of solvents.

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