TIMCAL
GRAPHITE & CARBON

The Power of Synergies

TIMREX®
Graphite

ENSACO™
SUPER P™ Li
Carbon Black

Carbon powders for Lithium battery systems

a member of IMERYS

Who are we?

TIMCAL Graphite & Carbon has a strong tradition and history in carbon manufacturing. Its first manufacturing operation was founded in 1908.

Today, TIMCAL facilities produce and market a large variety of synthetic and natural graphite powders, conductive carbon black and dispersions of consistent high quality.

Adhering to a philosophy of Total Quality Management and continuous process improvement, the TIMCAL manufacturing plants comply with ISO 9001-2000.

TIMCAL Graphite & Carbon is committed to produce highly specialized graphite and carbon materials for today and tomorrow customers' needs.

TIMCAL Graphite & Carbon is a member of IMERYS, a world leader in adding value to minerals.

What is our vision?

Timcal's vision is to be recognized worldwide as a leader in realizing challenging solutions for its customers by means of special carbons and related applications.

What do we offer to our costumers?

"Providing customer-related solutions"

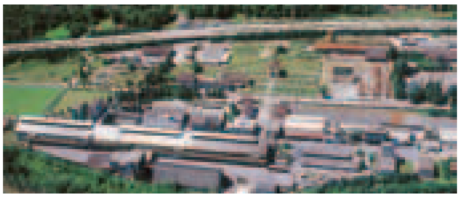
TIMCAL Graphite & Carbon produces a variety of synthetic and natural graphite powders, conductive carbon blacks, calcined petroleum cokes, aqueous dispersions and silicon carbide with a common keyword: **consistency**. They are manufactured under stringent process control conditions from the raw material stage through the end product.

Additionally, our team of specialists cooperates very closely with customers and research institutes to provide the very best advice and assist clients with today's and tomorrow's solutions.

For further information, please contact our team who are ready to help you or visit our website: **www.timcal.com.**

Where are we located?

With headquarters in Switzerland, TIMCAL Graphite & Carbon has an international presence with facilities and commercial offices located in key markets around the Globe. The Group's industrial and commercial activities are managed by an experienced multi-national team of more than 300 employees from many countries on three continents.



Bodio, Switzerland

Willebroek, Belgium

Lac des Îles, Canada

Terrebonne, Canada

Changzhou, China

Fuji, Japan

Carbon powders for Lithium battery systems

This document is intended to help our customers to make the best possible selection from the wide range of TIMCAL's carbon additives available for the use in their lithium battery.

TIMCAL Graphite & Carbon offers a strong technical expertise to its existing and potential customers through its Marketing and Technological Groups. Our team of specialists has an extensive knowledge of carbon materials and corresponding application processes, as well as an excellent problem-solving record. Besides providing customer support, our experts work closely with the battery manufacturers to meet the growing challenges facing this industry.

The next pages will be devoted to the following topics:

Introduction to the Lithium battery

The proliferation of modern technologies, as well as the growing demand for unlimited mobility throughout society has created a boost in the demand for mobile energy storage systems and stimulated the phenomenal growth in the primary and rechargeable batteries industry. Portable electronic devices such as cellular phones, portable computers, video cameras and other consumer products require energy sources providing high energy and power density.

Sustained demand for primary high-power battery has led to the development and production of the primary lithium battery. Similarly, strong market drive for a safe and high-energy rechargeable battery has allowed the fast development and market acceptance of the lithium-ion (Li-ion) battery technology.

In addition, OEM manufacturers of stationary and automotive applications like hybrid electric vehicles, 42V-dual battery systems, as well as large sized batteries for telecommunications and space applications are intensively searching for battery technologies with improved energy and power density as well as an extended cycle life. In these areas, lithium-ion battery is being a serious candidate.

For thermodynamic and kinetic reasons, lithium battery systems could meet the requirements for energy and power density for most battery applications in portable, stationary and traction (HEV and EV) equipment.

Primary battery

Lithium metal is attractive as a primary battery anode material because of its high specific capacity, high voltage, and good conductivity. Primary cells using lithium display superior performance such as high voltage of about 4 V, specific energy and energy density two to four times better than conventional primary alkaline batteries, flat discharge curve, shelf life exceeding 10 years and wide operating temperature range.

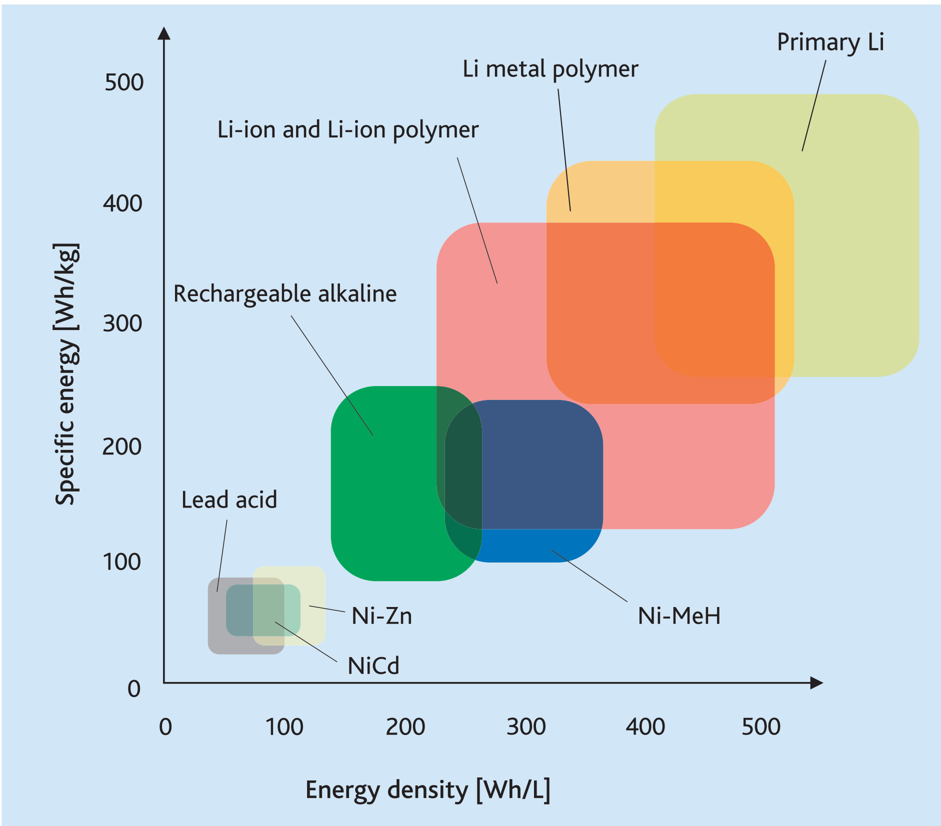
In the positive electrode of primary lithium battery, carbon materials are mixed with active materials to provide the needed conductivity.

Secondary battery

As a material in the negative electrode, lithium metal is mainly used in primary battery systems, the reason being the limited rechargeability of metallic lithium for safety reasons.

The substitution of lithium metal electrodes with insertion materials showing relatively high lithium activities initiated the break-through for the rechargeable lithium battery, the so-called Lithium-ion, Swing, or Rocking-Chair battery. The first Li-ion battery manufactured industrially appeared on the market in 1990.

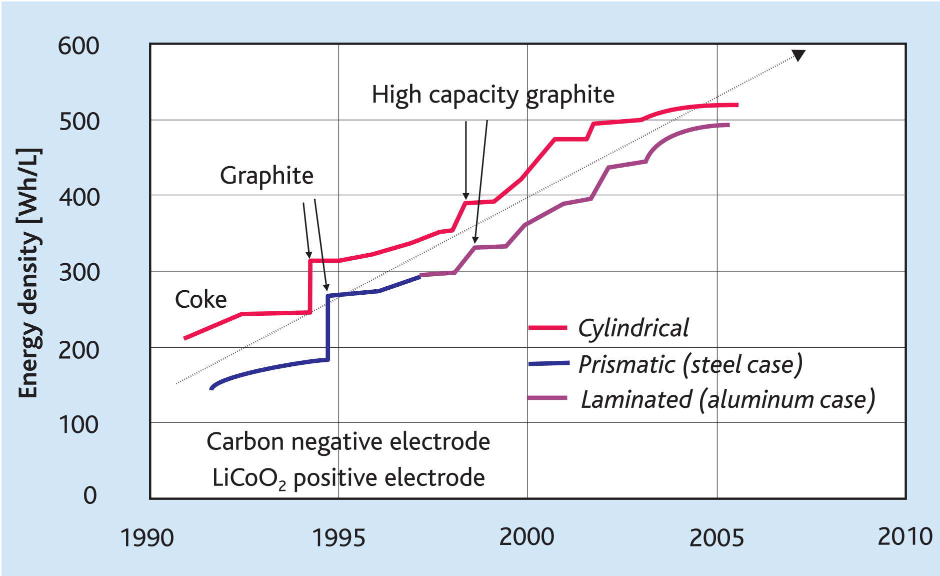
Since then, this battery system enjoys a steady growth in demand compared with other rechargeable energy storage systems for the same fields of application. While offering remarkable safety, the Li-ion-system provides unique performance regarding high capacity, energy as well as power density, as the highly reactive lithium metal is bound in a carbon-electrode.



Secondary and primary batteries - energy density and specific energy

Introduction to the Lithium battery

While optimizing the cell's design, developers and researchers at the same time concentrated their attention on the improvement of the carbon negative electrode materials. In particular, graphitic carbons have become more and more attractive to be used as lithium insertion material. It was the progress in the carbon negative electrode materials, which has led to a major improvement of the lithium-ion batteries in terms of energy density. This has been achieved by replacing amorphous carbon by graphite materials, i.e. by increasing the crystallinity of the carbon negative electrode material.



Improvement in energy density of Li-ion battery

A typical Li-ion-battery contains film electrodes of a thickness typically ranged from 40 to 120 µm and arranged on metal foil current collectors.

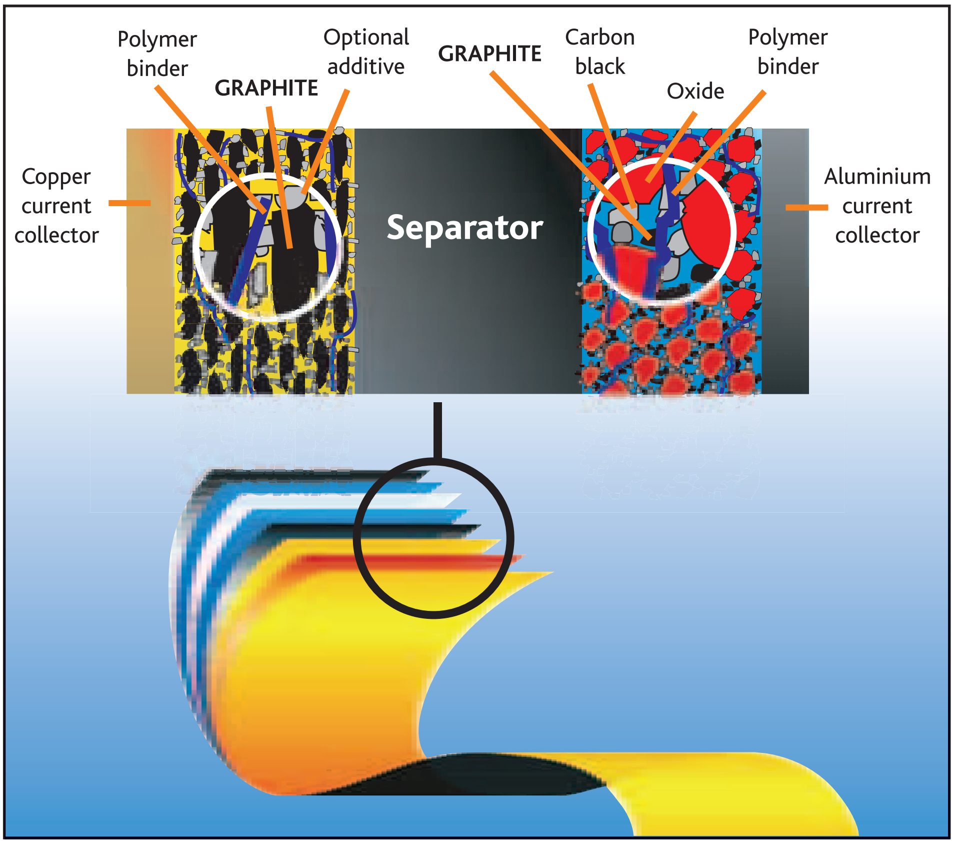
In the negative electrode **carbon materials are used both as conductive agents and as electrochemically active materials**. They are combined to binders and additives, and applied on a copper foil which acts as the current collector.

The positive electrode consists of blends of a lithium metal oxide (cobalt, nickel or manganese oxide) with **carbon black or/and graphite as conductive agent** and a binder. Aluminium foils are commonly used as a current collector for the positive electrode.

The separation of the electrodes is granted by an electrolyte, typically a lithium salt dissolved in an organic liquid carbonate soaked in a microporous polymer film.

Solid ion-conducting polymers have been developed recently to be used as electrolytes in the so-called Lithium Polymer Batteries. The electrochemically active electrode materials in these batteries are similar to the conventional lithium-ion battery.

Polymer electrolytes allow the cell to become an "all-solid-state battery" offering a variety of completely new potentials regarding manufacturing technologies and cell designs.



Rechargeable lithium-ion battery: arrangement of the film electrodes and schematic view of the galvanic cell

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Carbon for secondary Lithium battery

Carbon materials as conductive additives

TIMCAL Graphite & Carbon offers a large variety of carbon conductive additives that can be used in both the positive electrode and in the negative electrode of secondary lithium batteries. The chemical and physical properties, and the high purity of synthetic graphite and conductive carbon black make those carbon materials very suitable for secondary lithium batteries.

Conductive carbon black displays large surface area (50-770 m^2/g) and high structure due to aggregation of nano-sized primary particles, while micro-sized graphite particles display moderate surface area (5-25 m^2/g) and high anisotropy. The dimensions of the single crystal domains in the graphite particle are by more than a factor of ten larger than in a carbon black particle resulting in complementary properties.

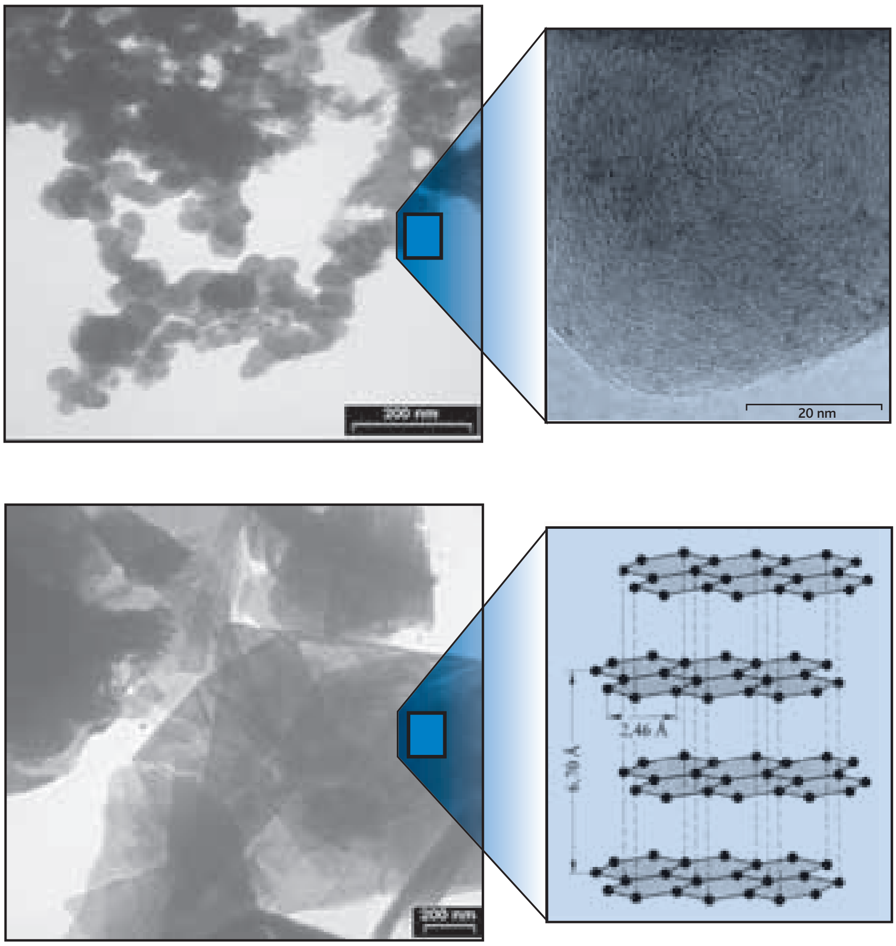
Typical properties of carbon black and synthetic graphite

	Super P™Li	Graphite KS6
Particle size	40 nm [1]	3 µm [2]
BET (m^2/g)	62	20
Density (Kg/m^3)	160 in bag	70 Scott [3]
Ash (%)	0.01	0.06

[1] *Average primary particle size from TEM pictures*
[2] *D50 from laser diffraction.*
[3] *Non-tapped*

Purity of carbon black and synthetic graphite

ppm	Super P™Li	Graphite KS6
Al	1	10
Ca	8	90
Co	<0.1	< 1
Cr	2	< 1
Cu	<0.2	< 1
Fe	5	75
Mo	1	< 1
Ni	1	2
V	0.2	3



TEM Pictures of Super P™Li and TIMREX® graphite

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Carbon for secondary Lithium battery

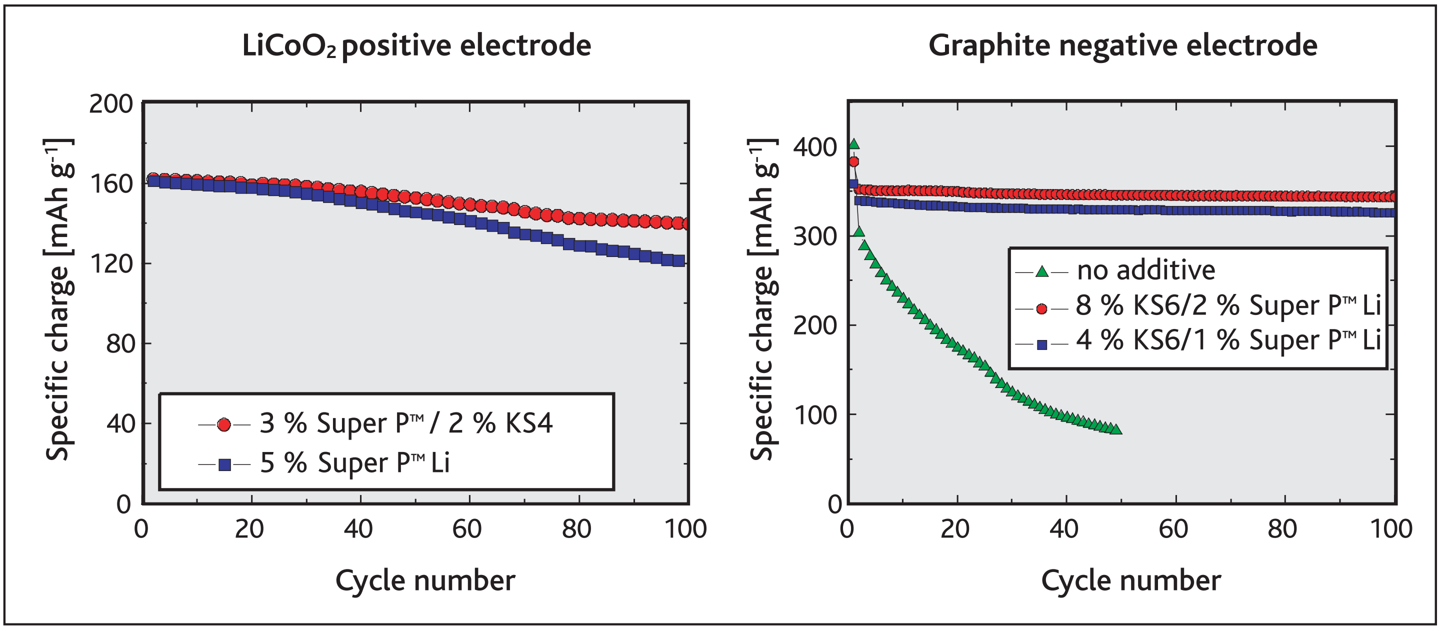
Carbon materials as conductive additives

On top of their purity and their physico-chemical properties, TIMREX® Graphite and SUPER P™ Li / ENSACO™ carbon blacks display very favorable synergy as conductive additives in Li-ion electrodes due to complemetary effects in the electrodes.

Such a synergy has been demonstrated in both the positive and the negative electrodes when TIMREX® KS graphite has been mixed with SUPER P™ Li carbon black. Capacity retention during cycling and corresponding cycle life are significantly improved with this formulation based on Timcal carbon materials.

	CARBON FUNCTIONS	
Cell parameters	**Carbon Black**	**Graphite**
Electrical conductivity of electrode	Particle-particle contact and contact to collector	Conductive paths through electrode
Ionic electrode conductivity	Electrolyte absorption	Porosity control
Energy density of the cell	Low amounts required	Compressibility Low swelling
Electrode manufacturing process	Stable dispersions Binder compatibility	Low binder amounts Low slurry viscosity

Graphite and carbon black are complementary products



Synergy of graphite and carbon black used as conductive additives blends in positive and negative electrodes

TIMCAL Graphite & Carbon Black as conductive additives:
The solution for the negative and positive electrodes in rechargeable lithium-ion batteries.

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Carbon for secondary Lithium battery: the positive electrode

TIMCAL graphite and carbon black as conductive additives

TIMCAL Graphite & Carbon offers a variety of carbon additives, which may be used in the positive electrode of secondary lithium batteries.

Used in the positive electrode, they fulfill the following functions:

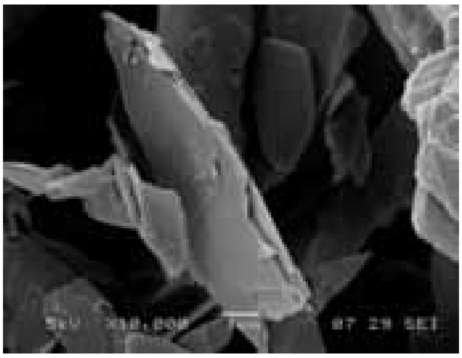
- **They enhance the electrical conductivity at low or very low concentration.**
- **They ensure ideal contact between the electroactive oxide particles and the current collector as well as optimal inter-particle contacts.**
- **They control the electrode porosity for an optimized electrolyte access to the oxide particle.**
- **They do not interfere with the electrochemical mechanism.**

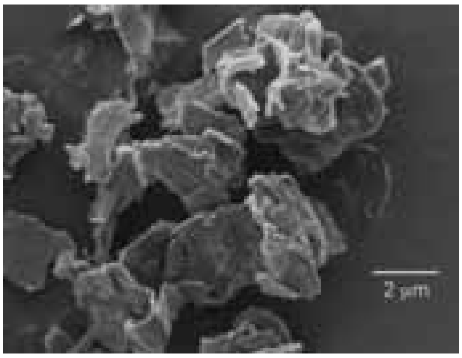
The following grades are suggested as conductive additives in the positive electrode of secondary lithium batteries:

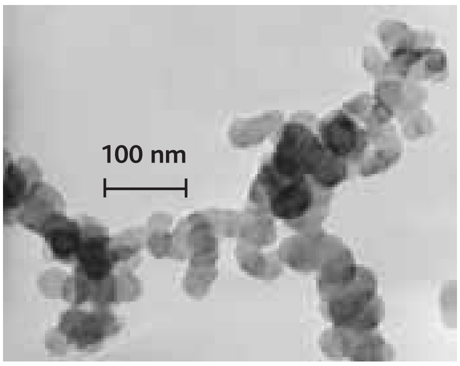
- **Graphite:**
  - TIMREX® KS
  - TIMREX® SFG
- **Carbon Black:**
  - SUPER P™ Li
  - ENSACO™ 250G
  - ENSACO™ 350G

The choice of the optimal carbon or carbon blend gives you flexibility to adjust, besides the electrical conductivity, the electrolyte absorption properties and process-related parameters like electrode slurry rheology and compressibility.

TIMREX® is also used as a coating on the aluminium current collector. This coating decreases the corrosion of the metal and lowers the contact resistance on the electrode/current collector surface.







Pictures of TIMCAL graphites and carbon black suitable as conductive additives.
Pict. 1: SEM Picture of TIMREX® SFG 15
Pict. 2: SEM Picture of TIMREX® KS6
Pict. 3: TEM Picture of Super P™-Li

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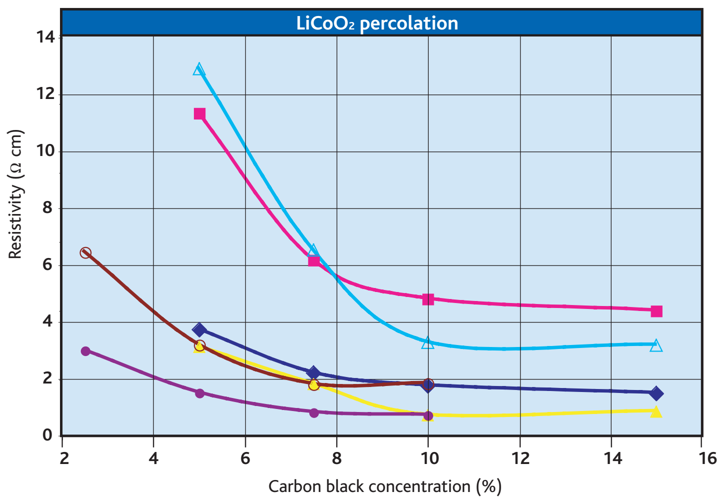
Carbon for secondary Lithium battery: the positive electrode

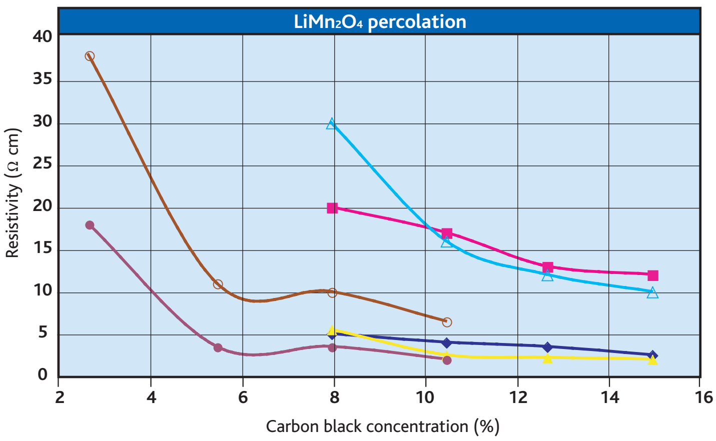
TIMCAL graphite and carbon black as conductive additives

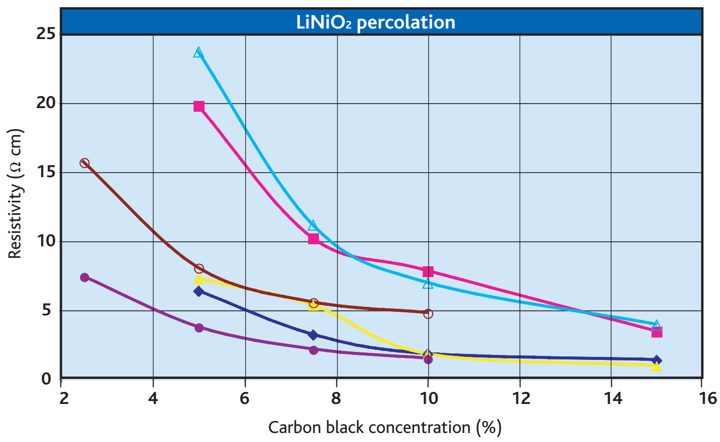
The electrical performance of selected dry electrode formulations shows that most of the formulations display a drastic drop in resistivity for carbon concentrations ranged from 2 to 6%, while they reach a stable resistivity at about 8%. The resistivities are reported for the dry electrodes and for the electrolyte soaked electrodes

The graphs show the evolution of the positive electrode resitivity as a function of the carbon black concentration. The evolution is reported for three active materials: $LiCoO_2$, $LiNiO_2$ and $LiMn_2O_4$, and three conductive additives: SUPER P™ Li, ENSACO™ 250G and ENSACO™ 350G.

In general, where a carbon black gives a percolation threshold with a low concentration (%), the higher the structure and oil absorption number are.







SuperP™- Li | SuperP™- Li+electrolyte | Ensaco 250 | Ensaco 250+electrolyte | Ensaco 350 | Ensaco 350+electrolyte

TIMCAL Graphite & Carbon Black as conductive additives:
The solution for the positive electrodes in rechargeable lithium-ion batteries.

Carbon for secondary Lithium battery: the negative electrode

TIMCAL graphite and carbon black as conductive additives

The negative electrode containing low BET graphite as electrochemically active materials, often shows a relatively low electrical conductivity. The electrode resistivity is dependent on the intercalation host.

High electrical conductivity is very important in the performance of the battery especially in the case of heavy discharge and charge abilities.

Both, graphite and carbon black can be used as additives to enhance the electrical conductivity.

TIMCAL additives satisfy the following criteria:

- **Increase conductivity at low concentration**
- **Increase electrode density**
- **Very limited interference with the intercalation and desintercalation mechanism**
  - High purity (metal, sulphur)
  - No oversize contamination
  - No metallic particles
- **Maintain conductivity of the electrode in the charged and uncharged states**
- **Low irreversible Li capacity**
- **No negative impact on electrode consistency and production process**
- **Control viscosity of the coating slurry**

TIMCAL Group offers specially conditioned, tailor-made graphite materials for the negative electrode of the Li-ion cell.

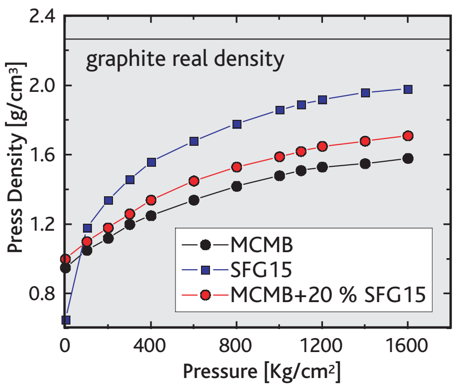
The selection of the tailor-made grade is a function of the negative electrode formulation, the process, and the expected performance.

TIMCAL negative electrode materials have optimised parameters which are expressed by an improved electrochemical performance in the battery.

Designed, developed and optimised for this particular application, TIMREX® SLP grades as well as other grades of the S-family have proven their performance in industrial use.

Suggested grades as conductive additive to the negative electrode:

- **Graphite:**
  - TIMREX® SFG
  - TIMREX® SLP
- **Carbon Black:**
  - SUPER P™ Li
  - ENSACO™ 250G



Higher compressibility and optimized electrode density can be obtained by adding TIMREX® graphite to the negative electrode.

Graphite parameters

- High crystallinity
- High xylene density
- High tap density
- High compressibility
- Optimized BET surface area

Carbon black parameters

- High purity
- High structure
- High oil absorption

Performance in the battery

- High electrical conductivity
- High energy densities
- High rate capability
- High cycling stability
- High reversible specific charges
- Optimized electrode porosity and density
- Low charge losses in the first electrochemical reduction
- Optimal price/performance ratio
- Easy handling and processing

Carbon for secondary Lithium battery: the negative electrode

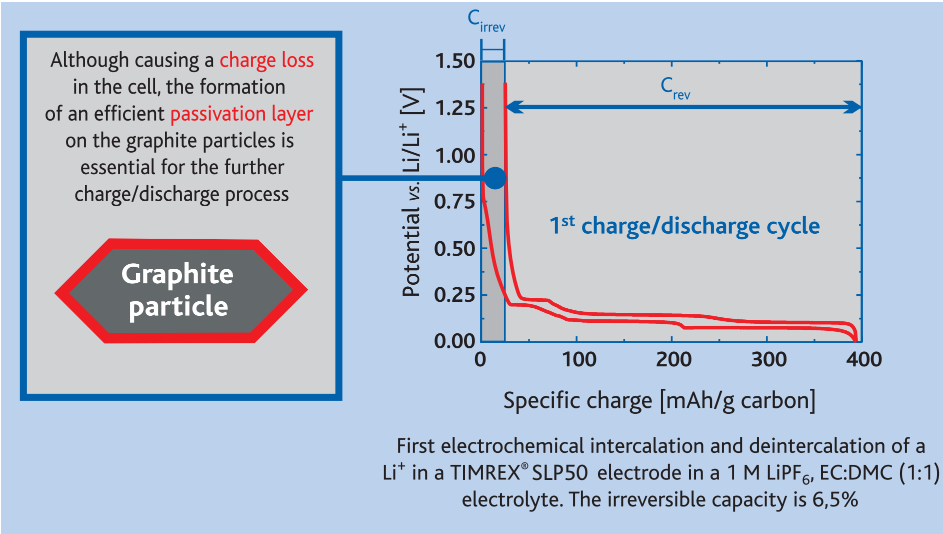
TIMCAL graphite and carbon black as conductive additives

Highly crystalline graphite in the negative electrode mass can act as conductive additive and intercalation host (electrochemically active material). This double function makes therefore graphite addition very attractive.

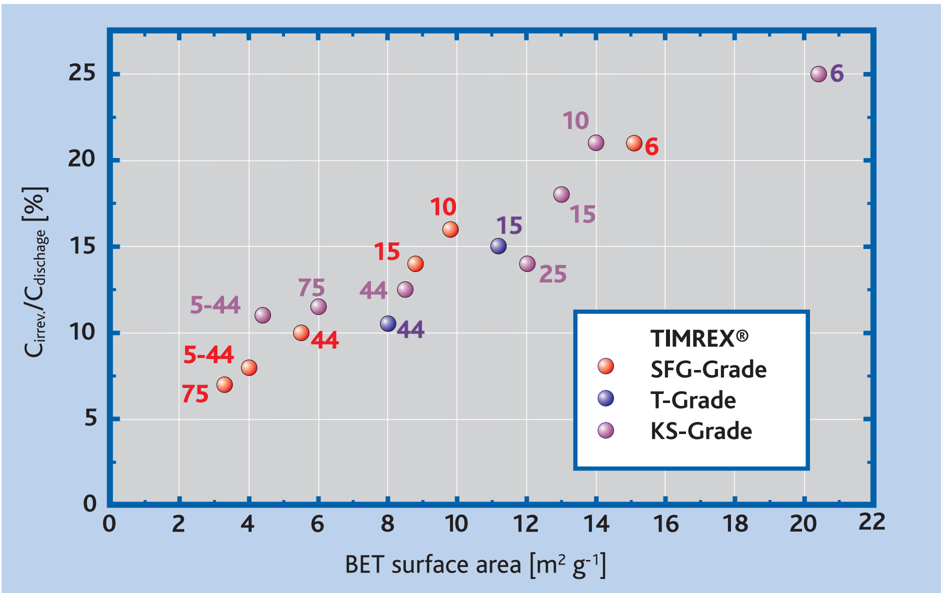
Graphite can act as host for lithium-ions, which are electrochemically intercalated between the graphite sheets. The reversibility of this process allows the multiple charge and discharge of the lithium graphite electrode. During the first electrochemical charge/discharge cycle of lithium-ion batteries using liquid or polymer electrolytes, an irreversible capacity is observed. Such an irreversible capacity has to be minimized in Li-ion battery electrode.

In order to reduce such an irreversible capacity, graphite and carbon black should have additional features, such as low specific BET surface area, because surface area of carbon materials has been clearly associated with irreversible lithium capacity.

Use of highly crystalline graphite as conductive additives allows electrodes containing low BET materials like MCMB or hard carbon coated graphites to obtain higher electrical performance and reversible capacity.



Irreversible and reversible capacities of the negative graphite electrode



Influence of the BET surface area of the graphite negative electrode material on the irreversible capacity during the 1st. charge/discharge cycle of the Lithium-ion cell.

TIMCAL Graphite & Carbon Black as conductive additives:
The solution for the negative electrodes in rechargeable lithium-ion batteries.

Carbon for secondary Lithium battery

Carbon materials as electrochemically active material

The suitability of graphite and graphitic materials to be used as electroactive materials in the negative electrode of Li-ion-cells is granted by graphite's ability to act as a host material to intercalate lithium between single graphite layers, forming lithium graphite intercalation compounds (Li-GICs) up to LiC_6, which is equivalent to the theoretically achievable specific charge of 372 Ah per kg C.

The crystal structure of graphite can be characterized as regular stacks of graphene sheets. Usually, polycrystalline graphite powder material is composed of the hexagonal graphite phase with rhombohedral defects.

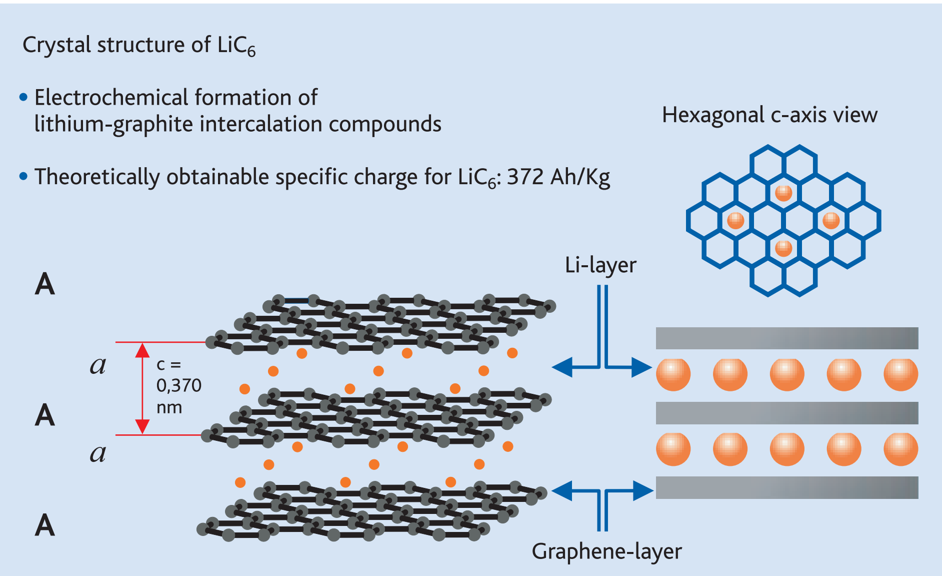
The extent of rhombohedral defects is depending on the type of graphite as well as on its conditioning.

The voltage steps observed in the discharge curve during the electrochemical intercalation of lithium (see curves on the previous page) are explained by the formation of the different existing Li-GIC's until the final LiC_6 composition is reached. The reversibility of this process allows the multiple charge and discharge of the lithium graphite electrode.

During the first electrochemical charge/discharge cycle of lithium-ion batteries using liquid or polymer electrolytes, an irreversible capacity is observed. This capacity loss is due to the formation of the so-called Solid Electrolyte Interphase (SEI) which is an electronically insulating but ionically conductive passivation layer on individual graphite particle of the negative electrode.

This SEI is essential for the further discharge/ charge process as it prevents further electrolyte decomposition, but it means a charge loss in the cell. Furthermore, an optimized SEI may increase the thermal safety of a Li-ion cell drastically.

Electrochemical measurements with electrodes containing different TIMREX® graphites show a linear relationship between the irreversible capacity and BET surface area as well as double layer capacitance. These relationships then demonstrate that surface of mesopores in synthetic and natural graphites are wetted by the cell electrolyte, thus contributing to the irreversible capacity of the Li-ion cell.



TIMREX® graphite as lithium intercalation host

Carbon for secondary Lithium battery: the negative electrode

TIMREX® S-family as electrochemically active material

TIMREX® SLP Potato®-Shape Graphite Family

TIMCAL's know-how in the field of synthetic and natural graphite, materials science, and electrochemistry made possible the development of the new S-family of high-performance graphite.

The TIMREX® SLP-grades, produced through a proprietary process by TIMCAL (filed PCT), are the first members of the new Potato®-Shape Graphite family, which are used as a main component in the negative electrode,
especially in combination with Li (Ni_x Co_y Mn_z) O_2 positive electrode materials. They may also be used in blends with other active carbon electrode materials in $LiCoO_2$ containing batteries.

The highly crystalline structure of TIMREX® SLP graphite ensures high reversible specific charge, low irreversible capacity and improved cycling stability. This, in turn, makes it possible to reach the energy density and power density expected from modern lithium-ion batteries.

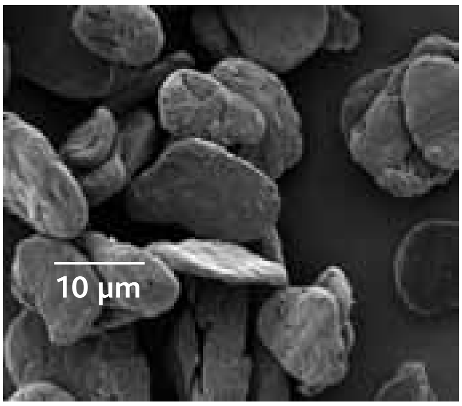
Thanks to the unique texture and morphology of the round-shaped particles, TIMREX® SLP graphite has a higher apparent density and compressibility, which leads to a higher density and more ideal porosity of the negative electrode.

Due to the special proprietary treatment, TIMREX® SLP graphite exhibits very low oil absorption, a unique property for such highly crystalline graphite. This indicates optimal binder absorption properties, which enhance the adhesion of the negative electrode to the copper current collector and improve the overall mechanical stability of the negative electrode.

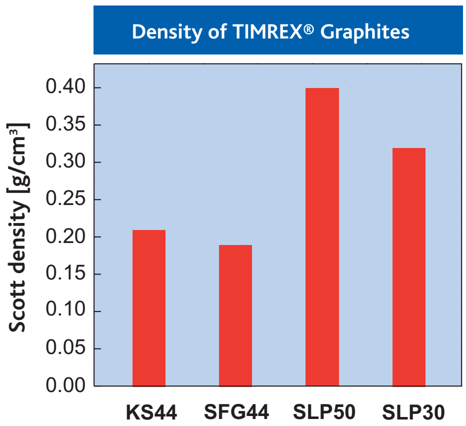
TIMREX® SLP 30 and SLP 50 are therefore ideal solutions for the negative electrode.

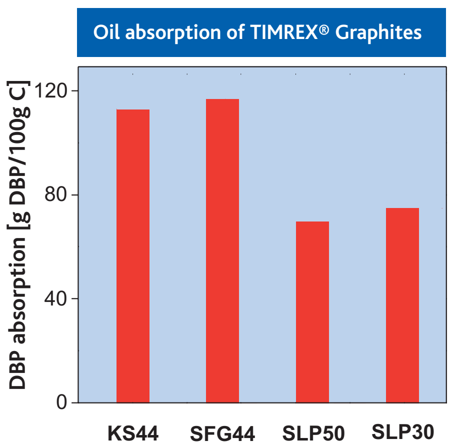
They are highly crystalline synthetic graphites for negative electrodes that display high reversible capacity under existing conditions prevailing in Li-ion batteries. Our group of experts is also developing other innovative and high performance carbon materials to enlarge our S-family of electrochemically active graphite for Li-ion batteries.

This development is being done by working very closely with our customers. Please contact us if you want to be part of this program and to get access to the newest materials (see back of brochure for contact details).



SEM picture of a TIMCAL tailor-made graphite especially optimized as negative electrode material





TIMCAL
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Selecting the appropriate carbon for secondary Lithium battery

Graphite grades

TIMREX® KS grades are the synthetic graphites mostly used as conductive additives in the positive electrode. They have relatively small single crystal domains in the particle, resulting in a relatively high isotropic electrical conductivity.

Furthermore, they offer excellent electrolyte absorption capacity due to their unique pore structure, as well as outstanding tribological properties. Their isometric particle shape causes relatively low DBP oil adsorption values, a reason for the excellent processability and rheological behavior of KS graphites in liquid coating dispersions.

TIMREX® SFG graphite grades are synthetic flake graphites with a highly anisometric particle shape. Large single crystal domains with high L_a and L_c values are aligned in the graphite particle, resulting in highly anisotropic material properties. Due to this texture and crystallinity, these grades show lowest specific surface area and highest electronical conductivity of all synthetic TIMREX® graphites.

TIMREX® SLP grades, produced through a process patented by TIMCAL, are used as main component of the negative electrode especially in combination with Li $(Ni_xCo_yMn_{az})O_2$ positive electrode materials. Their highly crystalline structure ensures high reversible charge, low irreversible capacity, and improved cycling stability.

TIMCAL graphite in the negative electrode. Typical values and recommended application

Graphite grade	Particle size d_{90} (µm)	Particle shape	Ash (%)	Scott density (g/m³)	Specific BET surface area (m²/g)	Recommended application and concentration
SLP30	32	Potato® Shape	0,06	0,32	7	Intercalation agent stand-alone or mix-in up to 50%
SLP50	45	Potato® Shape	0,06	0,40	6	Intercalation agent stand-alone or mix-in up to 50%
SFG6	6,5	Highly anisometric flakes	0,07	0,07	17	Conductive additive, 10-20%
SFG10	12,8	Highly anisometric flakes	0,07	0,07	12	Conductive additive, 10-20%
SFG15	17,9	Highly anisometric flakes	0,07	0,09	9	Conductive additive, 10-20%
SFG44	48,8	Highly anisometric flakes	0,07	0,19	5	Conductive additive, 10-25%

TIMCAL graphite in the positive electrode. Typical values and recommended application

Graphite grade	Particle size d_{90} (µm)	Particle shape	DBP (g/100g)	Scott density (g/m³)	Specific BET surface area (m²/g)	Recommended application and concentration
KS4	4,7	Isometric, irregular spheroids	190	0,07	26	Conductive additive, up to 10%
KS6	6,5	Isometric, irregular spheroids	170	0,07	20	Conductive additive, up to 10%
KS10	12,5	Isometric, irregular spheroids	160	0,09	16	Conductive additive, up to 10%
KS15	17.2	Isometric, irregular spheroids	140	0,10	12	Conductive additive, up to 10%
SFG6	6,5	Highly anisometric flakes	180	0,07	17	Conductive additive, up to 10%
SFG10	12,8	Highly anisometric flakes	170	0,07	12	Conductive additive, up to 10%
SFG15	17,9	Highly anisometric flakes	150	0,09	9	Conductive additive, up to 10%

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Selecting the appropriate carbon for secondary Lithium battery

Carbon black grades

The low impurity levels of carbon black required by the lithium battery technology is achieved by the TIMCAL process, thanks to the absence of quenching gas, the highly pure feedstock, and the unique design and control. For an optimal performance of the electrochemical cell, the nature and concentration of carbon black in the positive and negative electrode play an important role. The selection of the optimum carbon black grade and amount requires a balance between several performance parameters.

Mixtures of graphite and carbon black can be used for the conductive matrix, as they fulfil complementary electrical functions. Carbon black improves the contact between the particles of active material, while graphite creates the conductive path through the electrode.
Positive effects of binary mixtures such as TIMREX® KS6 and SUPER P™ Li, TIMREX® SFG6 and ENSACO™ 250P have been already demonstrated.

SUPER P™ Li is a superior performing conductive additive to the cathode and anode mixes with possible positive impact on the cyclability of the battery.
ENSACO™ 250G has comparable performance to SUPER P™ Li but a noticeable advantage in handling, due to its granular form.
The use of ENSACO™ 350 G even allows the reduction of the carbon content, and as such, a higher active material concentration.

TIMCAL carbon black in the negative and/or positive electrode. Typical values and recommended application

Carbon Black grade	Sulphur content (ppm)	Oil absorption number/absorption stiffness	Density ASTM D1513-89 (gr/cm^3)	Specific BET surface area (m^2/g)	Physical form	Recommended application and concentration
Super P™-Li	50-100	290/32	n.a.	62	Powder	conductive additive, 3-6%
Ensaco™ 250G	50-100	190/18	170	65	Granules	conductive additive, 3-6%
Ensaco™ 260G	50-100	190/18	170	70	Granules	conductive additive, 2-5%
Ensaco™ 350G	50-100	320/55	135	770	Granules	conductive additive,1-3%

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GRAPHITE & CARBON

Selecting the appropriate carbon for primary Lithium battery

TIMCAL Graphite & Carbon offers a variety of carbon additives, which may be used in the positive electrode of primary lithium batteries. These additives are actually quite similar to those currently used in the positive electrode of secondary lithium batteries. Used in the positive electrode, they basically fulfil the same functions in primary as in secondary lithium batteries.

The following grades are suggested as conductive additives in the positive electrode of primary lithium battery:

- **Graphite:**
  - TIMREX® KS
- **Carbon Black:**
  - SUPER P™ Li

The choice of the optimal carbon or carbon blend gives an appreciable flexibility to adjust, besides the electrical conductivity, the electrolyte absorption properties and process-related parameters.

TIMREX® KS grades or/and SUPER P™ Li are the carbon materials commonly used as conductive additives in the positive electrode. Their properties reveal high purity, controlled size distribution, surface area and absorption that make these materials very effective conductive additives.

TIMCAL graphite in the positive electrode

Grade	Particle size d_{90} (µm)	Particle shape	Ash (%)	Scott density (g/m³)	Specific BET surface area (m²/g)	Recommended application and concentration
KS6	6,5	Isometric, irregular, spheroids	0,06	0,07	20	Conductive additive, up to 10%
KS15	17,2	Isometric, irregular, spheroids	0,05	0,10	12	Conductive additive, up to 10%

TIMCAL carbon black in the positive electrode

Grade	Sulphur content (ppm)	Oil absorption number/absorption stiffness (1)	Specific BET surface area (m²/g)	Physical form	Recommended application and concentration
Super P-Li	50-100	290/32	62	Powder	Conductive additive, 3-6%

(1) *Oil absorption number in mL/100g and absorption stiffness in mL/5g*

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TIMCAL
GRAPHITE & CARBON

Leading the way.

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