ELECTRIC MOBILITY ENERGIZED BY

LANXESS
Energizing Chemistry

Innovative iron oxides for the production of lithium-iron-phosphate for use in rechargable batteries

Bayoxide® E B

Bayoxide®

STRONG GROWTH IN LITHIUM-IRON-PHOSPHATE-BATTERIES

Electric drives are playing an increasingly important role as an eco-friendly alternative to conventional engines in vehicles. Lithium-ion-batteries are usually used as a power source due to their high energy density. For mobile applications, the preferred cathode material is lithium-iron-phosphate ($LiFePO_4$ or LFP) owing to its good technical properties, long service life, good reliability, environmental compatibility and comparatively low cost.

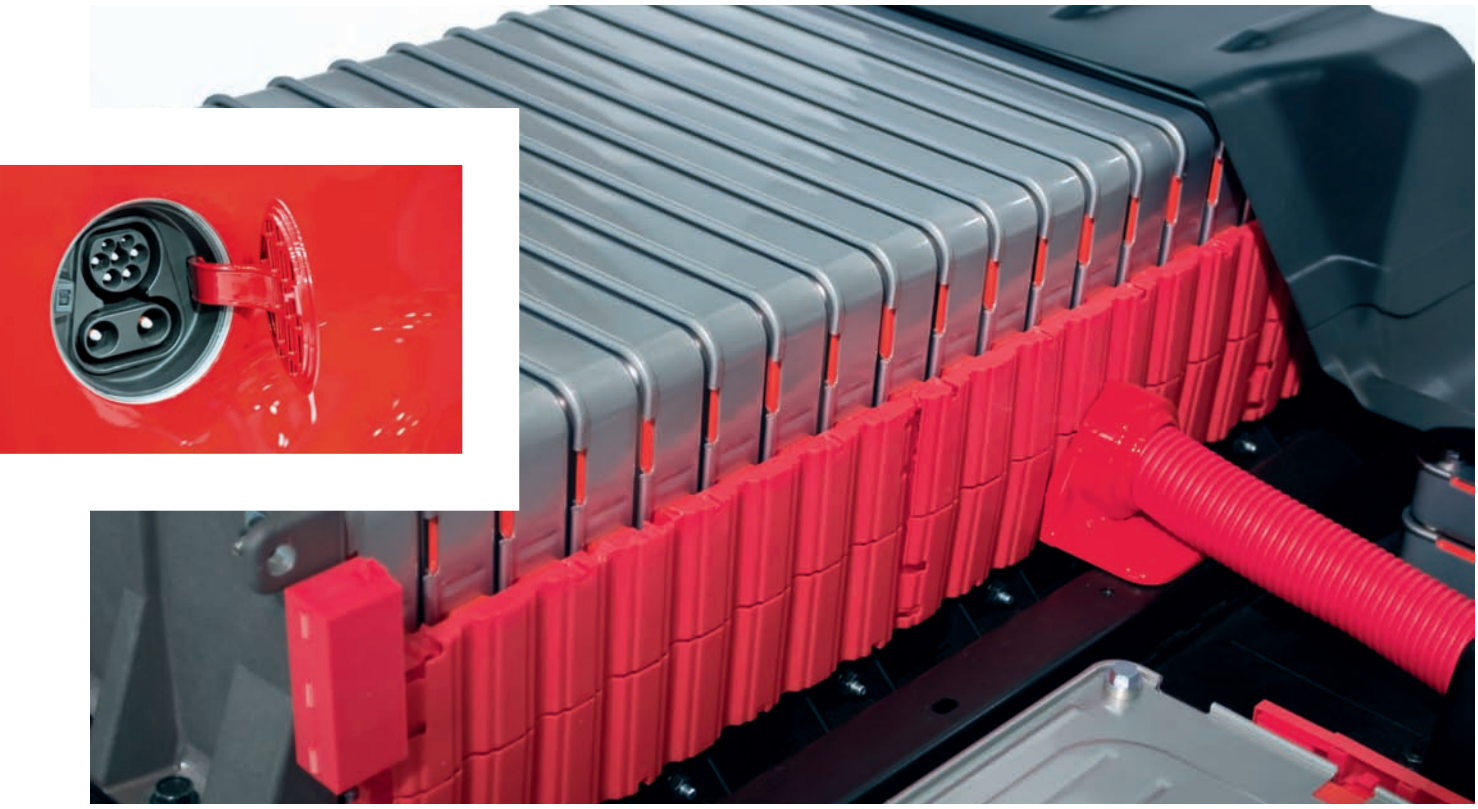
Requirements for lithium-ion batteries

Rechargeable lithium-ion batteries were first commercialized in the early 1990s and are now used in laptops, cell phones and other portable electronic devices. Lithium-cobalt oxide is the most commonly used cathode material in these systems. However, due to the high cost, poor environmental compatibility and potential safety problems, compounds containing cobalt are less suitable for use in larger batteries in vehicles, scooters and e-bikes. Of the various cathode materials, lithium-iron-phosphate (LFP) in particular has been gaining ground in recent years due to its good energy and power density, service life, cycle stability and reliability. LFP also permits the use of high charging currents. Like many iron compounds, LFP is environmentally friendly and can be produced at a relatively low cost.

Advantages and disadvantages of various cathode materials

Cathode material	Safety	Energy density	Power density	Charging rate	Cycle capacity	Calender service life	Cost/kWh x no. of cycles
$Li(Ni, Co)O_2$	-	+	+	-	o	+	-
$Li(Ni, Co, Mn)O_2$	o	+	o	-	+	+	o
$LiMn_2O_4$	o	o	+	-	-	-	-
$LiFePO_4$	+	o	o	+	+	o	+

Lithium-iron-phosphate-cathodes offer a good balance between various requirements.

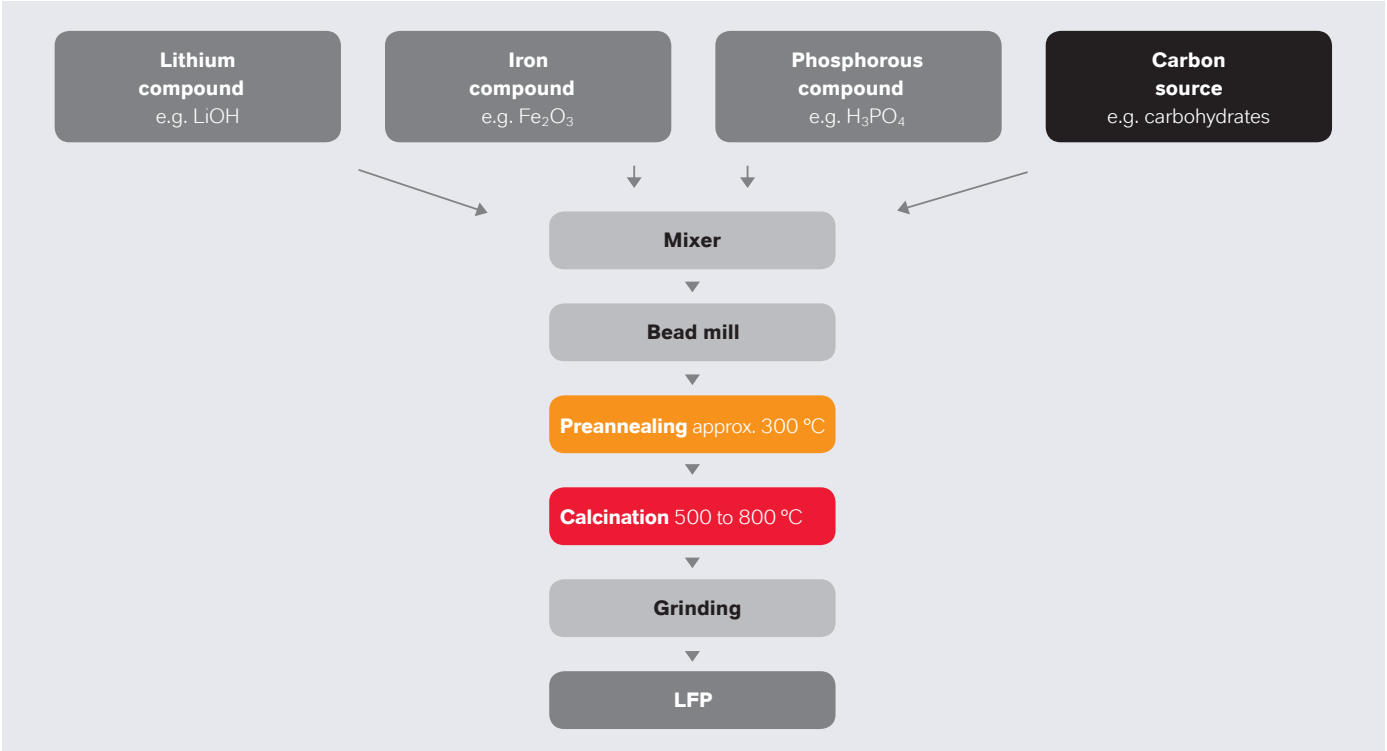


INNOVATIVE IRON OXIDE FOR THE PRODUCTION OF LITHIUM-IRON-PHOSPHATE-CATHODES

Carbothermic reduction is playing an increasingly important role in the production of lithium-iron-phosphate and is paving the way for the use of customized iron oxide precursors.

In addition to wet chemical methods such as hydrothermal synthesis and coprecipitation, many manufacturers use solid-state reactions for the production of LFP. In traditional solid-state synthesis, iron (II) compounds such as iron oxalate are used as a source of iron. Many of these compounds are relatively expensive while exhibiting less storage stability and relatively undefined morphological properties. Increasing interest is therefore being shown in LFP production based on carbothermic reduction using iron (III) compounds such as iron oxides. Graphite, carbon black or organic substances are used as reducing agents that produce carbon during the calcination of the raw materials. Another advantage of this method is that the low electrical conductivity of the LFP powder can be increased to a sufficiently high level by separating off conductive carbon, and grain coarsening can be suppressed during the sintering process. Only then does the material satisfy the prerequisites for use in batteries.

Typical synthesis path for the production of lithium iron phosphate according to the carbothermic process



THE ADVANTAGES OF BAYOXIDE® E B

With Bayoxide® E B, the specialty chemicals company LANXESS has developed a product line for the production of high-quality lithium-iron-phosphate using solid-state synthesis. During the carbothermic reduction process, the quality of the resulting LFP is influenced by both the process parameters and, above all, the chemical and morphological properties of the iron oxide precursor. The use of Bayoxide® E B products offers numerous advantages:

Broad range of products

There are many different variations of the carbothermic process. To meet the various requirements of our customers, the LANXESS Inorganic Pigments business unit offers a broad range of LFP precursors, such as iron oxide red (alpha-Fe_2O_3/hematite), yellow (alpha-FeOOH/goethite) and black (Fe_3O_4/magnetite).

Optimized particle size

Short diffusion paths enable solid-state synthesis at a moderate temperature and in a reasonable time. Product properties can therefore be optimized, costs reduced and throughput – and plant capacity – increased.

Narrow particle size distribution

An iron oxide precursor with a broad particle size distribution would have a negative impact on the particle size of the LFP powder. To prevent this during the production of Bayoxide® E B, LANXESS uses an optimized precipitation process that enables the production of oxides with a narrow particle size distribution.

High reactivity

The reactivity of iron oxide precursors is affected by defects in the crystalline lattice and can be controlled during iron oxide production. Similar to a narrow particle size, high reactivity has a positive effect on LFP synthesis, optimizing product properties and reducing costs.

High purity

Impurities can have a negative effect on the electrochemical properties of LFP cathodes. This is why only selected raw materials that have also undergone a special purification step are used for the production of Bayoxide® E B.

Good dispersibility and optimized mixing behavior

Before LFP synthesis, raw materials are mixed and often subjected to intensive grinding. A non-homogeneous blend or traces of agglomerates that cannot be broken down would lead to an incomplete solid-state reaction and a high proportion of coarse particles. Both have a negative effect on the electrochemical properties of LFP. To ensure that highly homogeneous blends of raw materials can be produced with reasonable effort, LANXESS products undergo an additional production stage to optimize dispersibility.

LANXESS IS A RELIABLE PARTNER

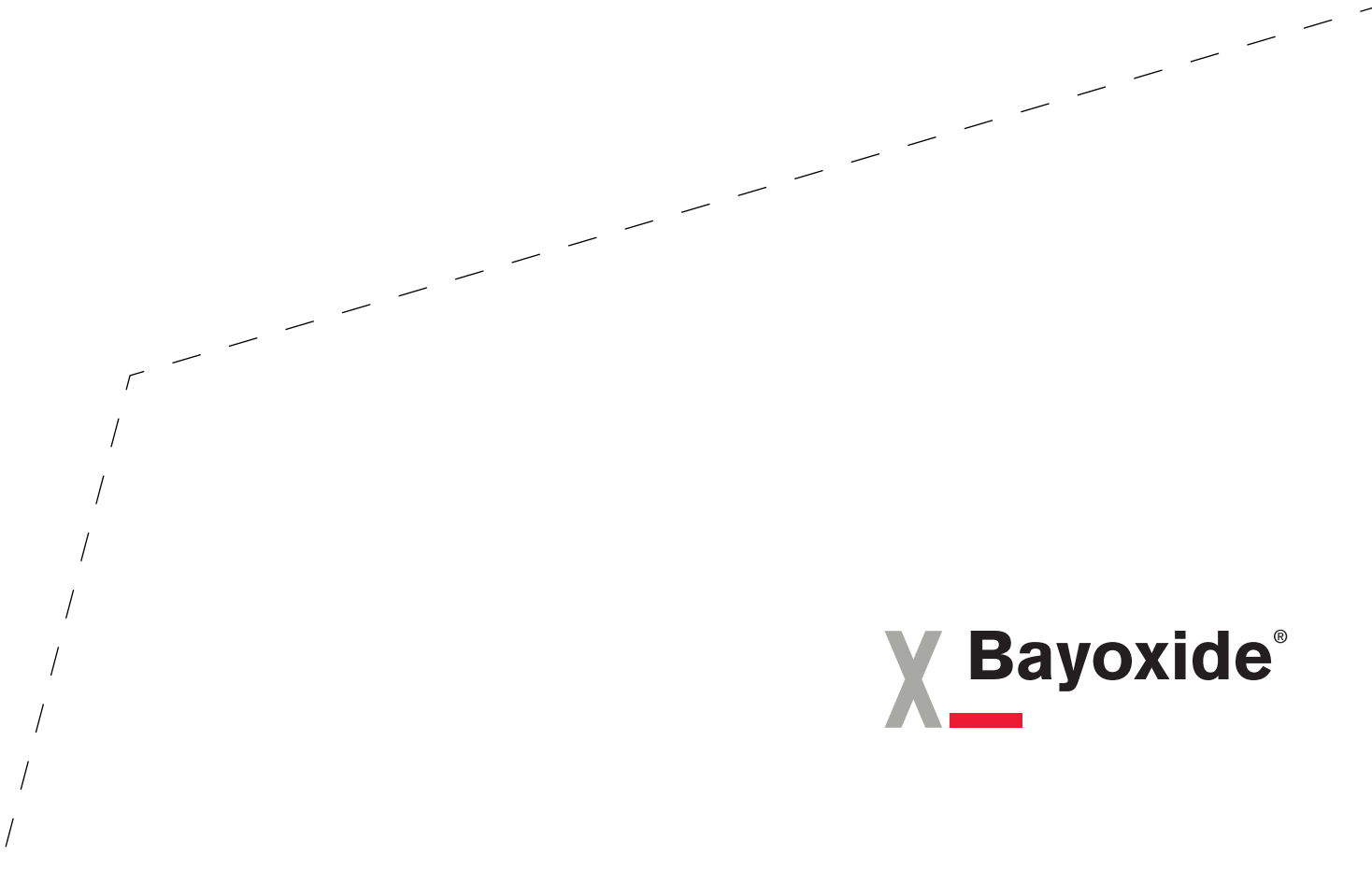
LANXESS is a leading specialty chemicals company and operates in all of the world's key markets. With its extensive portfolio, the company is focusing on premium products. Its core business comprises the development, manufacture and sale of plastics, rubber, specialty chemicals and intermediates. In addition, LANXESS supports its customers in developing and implementing tailormade system solutions.

LANXESS Inorganic Pigments is one of the world's biggest producers of inorganic iron oxide and chromium oxide pigments and has production sites on five continents that meet the highest technical and ecological standards.

In addition to Bayferrox® and Colortherm® color pigments, LANXESS also offers products where the technical properties are essential. Examples include the production of brake pads and airbag inflators and the synthesis of lithium-iron-phosphate for high-quality batteries. Products in the Bayoxide® range have to meet a variety of requirements. LANXESS Inorganic Pigments therefore develops a broad range of technical oxides optimized for a whole host of applications. It also manufactures tailored products for customers on request.

Crucial to the business philosophy of LANXESS Inorganic Pigments is its commitment to sustainability and responsibility in all its dealings with the environment, customers and society. Production processes are resource-friendly and, where emissions cannot be avoided completely, the waste products are cleaned to minimize their environmental impact before being released into the air or water. LANXESS is setting global industrial standards in this area.

However, sustainability means more than just environmental protection. It also means being a long-term and reliable partner to customers. That is why LANXESS Inorganic Pigments continuously invests to expand capacities and application areas. Indeed, that is the only way that the rising demand for the quality products Bayferrox®, Colortherm® and Bayoxide® can be met in the long term.



Bayoxide®

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