ALBEMARLE®

Who is Albemarle?

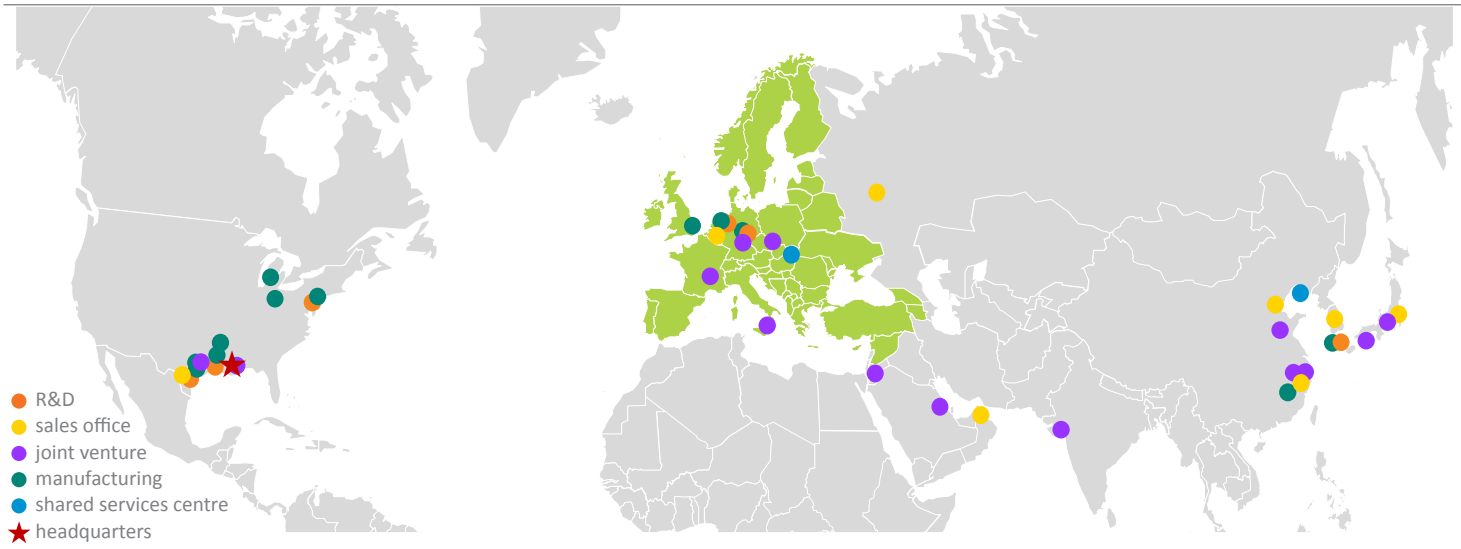
Albemarle Corporation is a leading global developer, manufacturer and marketer of highly engineered specialty chemicals for consumer electronics, petroleum refining, utilities, packaging, construction, automotive and transportation applications, pharmaceuticals, crop protection, food safety, and custom chemistry services.

The company employs nearly 3,200 employees, with over 1,500 supporting its Catalyst Solutions business. More than 45 offices worldwide help to serve customers in approximately 100 countries.

Albemarle is committed to global sustainability and is advancing its eco-practices and solutions in its two global business units: Performance Chemicals and Catalyst Solutions. The company made Corporate Responsibility Magazine's prestigious "100 Best Corporate Citizens" list for 2010, 2011 and 2013.

Albemarle's primary refinery catalyst production and research facilities are located in Amsterdam, the Netherlands and Bayport (Texas), USA. Our strong presence in Europe is also supported by facilities in Louvain-la-Neuve, Belgium; Cambridge, United Kingdom; and Budapest, Hungary, which hosts Albemarle's global shared services centre. Through EURECAT, a 50:50 joint venture with Institut Français du Pétrole Investissements, we also have operations in La Voulte-sur-Rhône, France; Gela, Italy; and Bitterfeld, Germany.

Albemarle's global presence



How do our catalysts help the refining industry?

We have two business units within our refinery catalyst operations: Clean Fuels Technologies, which largely promotes our hydroprocessing catalysts, and Heavy Oil Upgrading, which primarily involves catalysts for fluidised catalytic cracking.

Our hydroprocessing catalysts are used throughout the refining process and enable the upgrading of oil fractions to clean fuels and other usable oil products by removing sulphur, nitrogen and other impurities from the feedstock. Additionally, they improve product properties by adding hydrogen and, in some cases, enhance the performance of downstream catalysts and processes.

Albemarle continuously seeks to add more value to refinery operations by offering hydroprocessing products that meet its customers' requirements for performance and regulatory compliance, ensuring competitiveness in what is a very demanding market.

What is a catalyst?

Anything that increases the rate of a process can be considered a catalyst in colloquial terms. In the field of chemistry, however, a catalyst is a substance that initiates, accelerates or selectively directs a chemical reaction without being consumed in the reaction.

Catalysts come in all shapes and sizes and are essential to the production of thousands of end products from cleaner burning, low-emission fuels to packaging for consumer goods. It is estimated that catalysts are used in the manufacture of 90% of commercially produced chemicals.

In the refining industry, catalysts are used to convert heavy oil into valuable, distillable products. They can be regenerated and used with a wide range of feedstocks to bring improved performance to refineries around the world.

Hydroprocessing catalysts can take on various shapes and colors depending on their properties and functions

What is catalytic hydrotreating?

Catalytic hydrotreating is a critical process in petroleum refining for removing over 99% of contaminants such as nitrogen, sulphur, oxygen and metals from liquid petroleum fractions.

In a typical refinery, the hydrotreating process takes place in a fixed-bed reactor that is packed with a series of hydroprocessing catalyst layers, each providing a different level of impurities removal to create cleaner burning fuels.

Hydrodesulphurisation (HDS) and hydrodenitrogenation (HDN) are two common hydrotreating processes used to remove sulphur- and nitrogen-containing impurities from crude petroleum feedstocks and fuels.

Both processes are important, as the impurities they remove

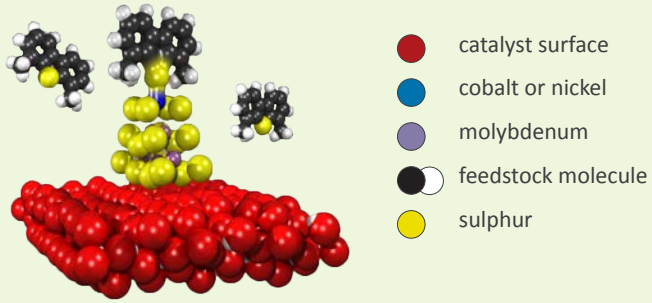
- have a severe environmental impact. Sulphur and nitrogen oxides, which are produced during combustion, contribute to acid rain.
- are catalyst poisons that prevent crude feedstocks from being used for subsequent chemical transformations.

HDS and HDN use catalysts typically made up of an alumina base impregnated with different combinations of cobalt, molybdenum and/or nickel compounds. These metals are uniquely well suited for use in catalysts for these processes because they exhibit high levels of activity, are resistant to poisoning from impurities and are easier to regenerate than other metals.

As a feedstock flows through a bed of hydroprocessing catalyst, the individual hydrocarbon molecules come into contact with these metal active sites and are stripped of impurities. This results in a cleaner feedstock for cracking reactions.

Removing the sulphur from the feedstock reduces the sulphur dioxide emissions created during the combustion of fuels used in automotive vehicles, aircraft, railroad locomotives, ships and power plants. The resultant cleaner-burning fuels enable refiners to meet increasingly stringent environmental regulations.

HPC catalyst removing sulphur from a feedstock molecule

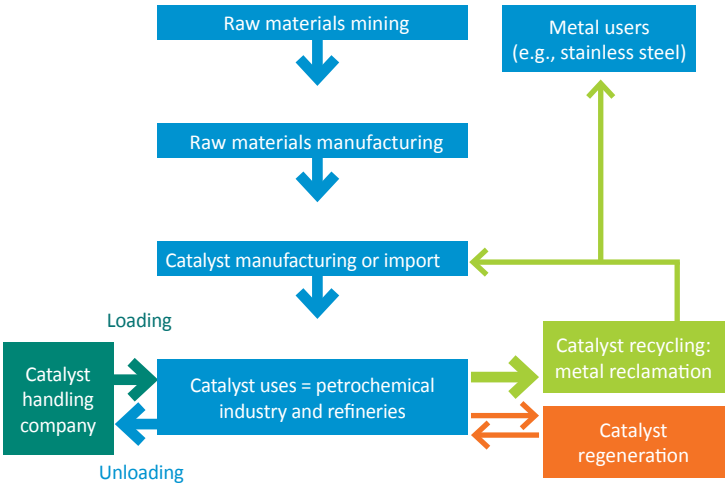


What is catalyst regeneration?

During the hydrotreating process, impurities in the feedstock eventually foul the catalyst and cause it to lose activity. Regenerating catalysts for reuse can restore activity, which translates to significant cost and environmental savings compared with buying new catalysts and disposing of the spent catalyst after each cycle. Furthermore, regeneration and reactivation minimise the environmental impact of hydroprocessing catalyst use.

To ensure safe operations during regeneration, the production unit at the downstream user is shut down and the spent catalyst is unloaded from the reactor. After unloading, the reactor is cleaned and inspected before re-loading with either a fresh batch of catalyst or a regenerated catalyst. The loaded catalyst is activated in the unit and the unit is taken back into production.

Catalyst supply chain



Improving regeneration to help protect the environment

Conventional regeneration of spent catalysts can lead to activity decline. Albemarle and joint venture partner Nippon Ketjen Co. Ltd therefore developed REACT™ technology. REACT provides a 20–50% activity boost compared with conventional catalyst regeneration and it is proven to regenerate catalysts up to four times while retaining over 90% of the fresh catalyst's activity. This means significant environmental savings and reduced catalyst life-cycle costs for refiners. The patented technology was first applied in 2003. Since then, it has successfully reactivated more than 45,000 metric tonnes of catalysts.

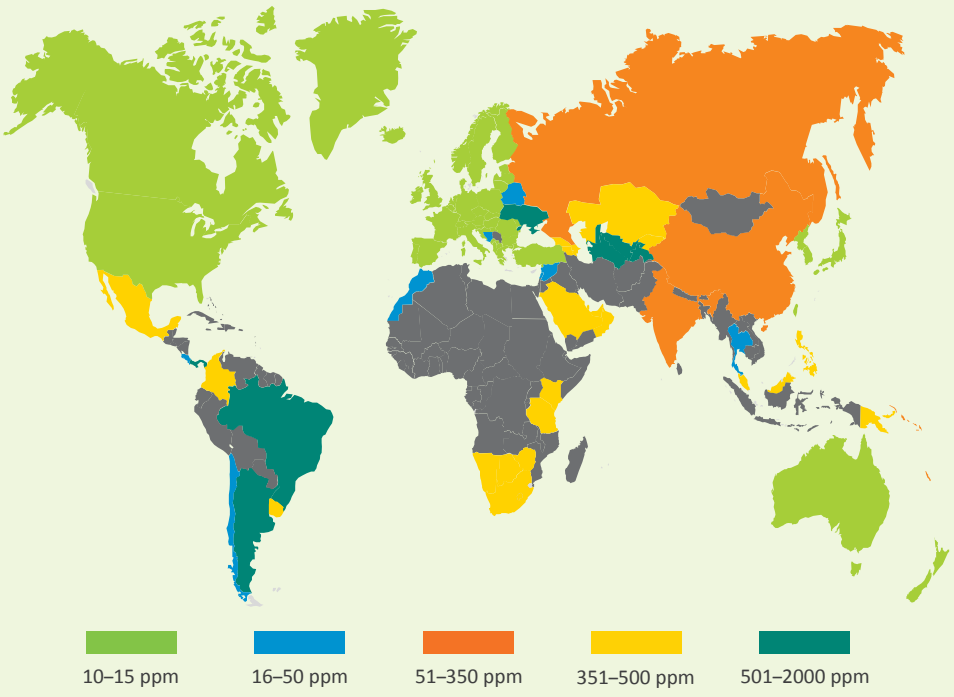
Regulatory drivers

Governments are projected to continue their drive towards lower sulphur content in transportation fuels.

The latest environmental regulations in the United States and Europe are calling for the use of ultra-low sulphur diesel, which coincides with increased demand for diesel worldwide as a commercial transportation fuel, particularly in Asia and other developing markets.

These mandates and market drivers will present a challenge to oil refiners and require substantial investment in hydrotreating capacity.

Sulphur standards per region



Source: Hart Energy Research & Consulting, September 2013

How do we ensure personnel safety?

Albemarle is committed to the safety and protection of our employees and contractors, the environment and the communities in which we operate. We protect our workers from the long-term effects of potentially hazardous substances while complying with all applicable legal requirements and company policies and procedures.

We continuously look to improve our technical processes to minimise exposure to hazardous catalyst components. Most of our operations are conducted in a controlled environment in a manner that minimises direct human contact.

All employees in the catalyst manufacturing process are equipped with the proper personal protective equipment and instructed on its proper use.

Protecting the environment

Albemarle practises continual preventive maintenance, including regular routine visual inspections and the periodic replacement of critical parts such as seals and cuffs to avoid leaks and spills.

We design our plants with sloping surfaces, covered ducts and easy-to-clean walls and surfaces to prevent the escape of dust. The plant design, along with our sophisticated technical processes, also helps to reduce the risk of a potential spill. However, Albemarle continues to prepare proactively for any situation through rigorous processes and state-of-the-art safety equipment.

"WE CONTINUOUSLY LOOK TO IMPROVE OUR TECHNICAL PROCESSES TO **MINIMISE EXPOSURE** TO HAZARDOUS CATALYST COMPONENTS. MOST OF OUR OPERATIONS ARE CONDUCTED IN A CONTROLLED ENVIRONMENT IN A MANNER THAT MINIMISES DIRECT HUMAN CONTACT."

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