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BACKGROUNDER

Silver Catalysts

Catalysis is an important, but not a generally well understood or appreciated branch of science and technology. The efficient production of almost all industrial chemicals that we all rely on is dependent on catalysts, and many aspects of 'green chemistry' would not be possible without them. Simply put, they are critical to the world in the 21st century.

But what is a catalyst, and how do they work? A catalyst is a material that accelerates or alters the path taken to transform one chemical entity into another, generally without changing itself. Such chemical reactions are often extremely slow, and require external influences to progress at an efficient pace. These influences are generally heat, pressure and the presence of an appropriate catalyst (and sometimes a combination of all three). Metals make excellent catalysts because they are chemically 'pliable.' They can interact as required with the starting materials and solvents within a reaction, while being relatively stable to heat and pressure themselves. This gives them longevity: a fundamental characteristic of an efficient catalyst.

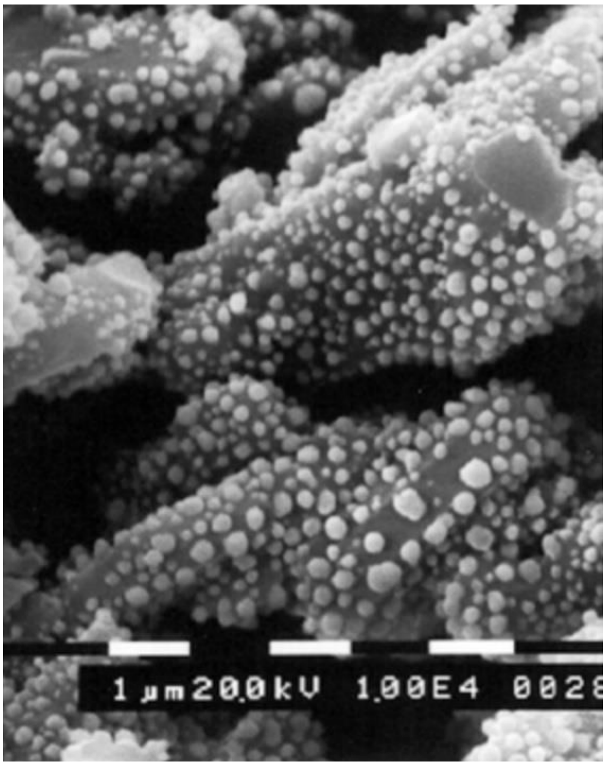
Precious metals have found particular application in chemical catalysis – probably the most widely known example of this is catalytic convertors on vehicles that contain combinations of platinum, palladium and/or rhodium. The reasons are simple; these metals are capable of removing large amounts of the pollutants generated by diesel and petrol engines over the course of a vehicle's life. The device itself is relatively costly as a consequence of the precious metals contained within, but can operate efficiently for many years in the harsh environment of an exhaust system. Even after 40 years of R&D in the field, only precious metals have been shown to be capable of delivering these performance characteristics.

Generally speaking, while catalytic convertors are in the public consciousness to a certain extent, catalysts that drive the efficient production of chemicals are not. It is this critically important, yet largely 'hidden,' field of science where silver finds ever increasing importance and relevance.

Ethylene Oxide – Unknown by Most, Used by All

Ethylene Oxide (EO) is one of the most important and commonly used chemicals many people have never heard of, and its efficient manufacture is reliant on silver catalysts. EO is the building block for a range of plastics including polyester, the textile used in both mainstream fashion and specialty clothing. This same substance is an ingredient in various moulded plastic items such as insulating handles for stoves, key tops for computers, electrical control knobs, domestic appliance components and electrical connector housings. In 2015, the GFMS Team at Thomson Reuters, which produced the Silver Institute's *World Silver Survey 2016*, estimated that 137.5 Moz of silver resided in EO plants around the world, a number equivalent to over half of the world's entire demand for silver jewelery in 2015.

What makes this number even more significant is that the silver is in the form of tiny particles on the surface of a range of matrices which act as a support, with the silver itself generally making up approximately 10-15% of the catalyst by weight. Larger particles of silver would have a much reduced catalytic activity – the particles must be small to maximize the surface area available to the reactants, which in turns drives the efficiency of the catalyst.



A typical EO silver catalyst at ~5,000x magnification in a Scanning Electron Microscope (SEM). The silver particles are clearly visible on the surface of the support

Rebsdat & Mayer: Ullman's Encyclopedia of Industrial Chemistry – Ethylene Oxide. Page 553. 2000. Copyright Wiley-VCH Verlag GmbH & Co. KGaA. Reproduced with permission.

A well-designed silver catalyst in a modern EO plant may have a lifetime of up to five years. However, as the catalyst is used its efficiency can be compromised in a number of ways. Overheating within the reactors can cause sintering, a process by which the small silver nanoparticles accumulate, reducing the catalysts overall surface area and hence activity. The silver particles themselves can also be 'masked' by other chemicals within the system (known as poisoning). Again, this acts to reduce the quantity of silver available to catalyze the reaction, lowering efficiency. Once the catalyst is spent (i.e. its efficiency drops to a level deemed uneconomical), it is removed from the reactor and replaced with fresh material. The spent catalyst can often be regenerated and reused at a later date.

Silver's Projected Use in Catalysis

According to the GFMS Team at Thomson Reuters, 2015 saw a 103% increase in the amount of silver entering the world's EO plants compared with 2014. Looking further ahead, GFMS predicts that this trend will continue with 160 Moz forecast to reside in the world's EO plants by the year 2020, a 3.1% Compound Annual Growth Rate (see figure 1). Over this period, the U.S. is also expected to surpass China as the largest consumer of silver in the EO industry. Silver used in catalysts for new plants coming online by 2020 is expected to amount to 7.5 Moz in the U.S., slightly higher than 7.3 Moz forecast in China.

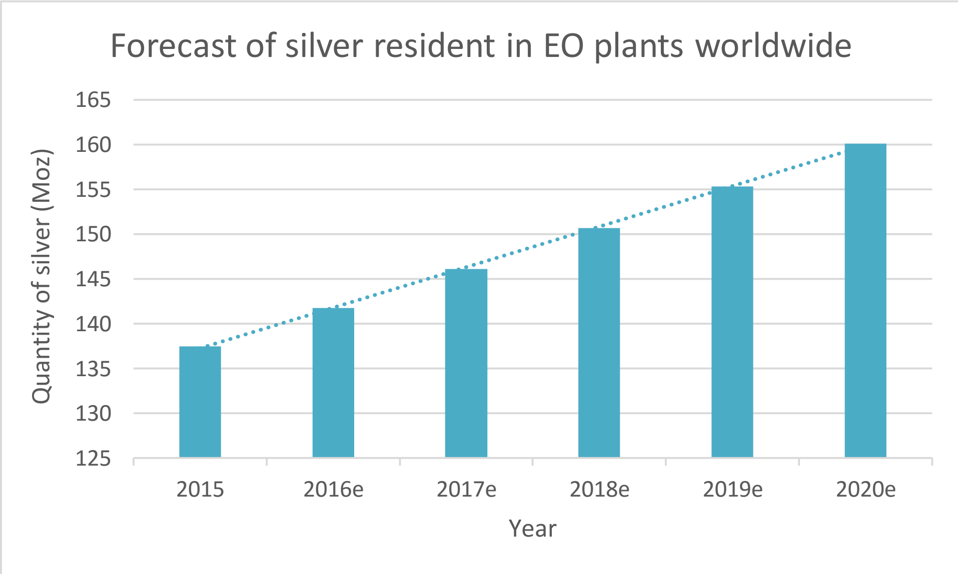


Figure 1: Forecast of silver resident in EO plants worldwide. Source: GFMS;Thomson Reuters

The reason for this is that leading chemical companies, including Huntsman, Sasol and PTT Global, are all investing in new facilities in the United States to take advantage of lower natural gas and oil prices. It is estimated that these projects represent over 1 million tons of EO capacity which could be added in the United States alone in the coming 5 years, driven by both growing downstream demand for EO and upstream advantages associated with feedstock chemical costs.

Millions of ounces of the silver catalyst critical in this process will continue to feed newly commissioned plants around the world. This part of the story is rarely told, but without these tiny particles of silver there would be no discussion of manufacturing plants and EO demand because there would simply be no way to synthesize it efficiently at scale.

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