Platinum – a valuable raw material

Sophisticated recycling processes from Heraeus prepare precious metals for further use

More than 90 percent of what people consume or use either contains platinum group metals in some form or comes into contact with them during the production process. Mines in South Africa and Russia are the primary sources for these raw materials, but they cannot supply the entire demand for precious metals on a sustained basis. For that reason, the use of secondary sources is gaining in importance, and Heraeus is a leading global player in refining platinum metals from these sources. There is no precious metal that the specialists at Heraeus cannot refine. The precious metals cycle at Heraeus is a fascinating contribution to safeguarding resources and protecting the environment.

Precious metals are very valuable and very rare. In one year, just 20,000 tons of silver and a mere 2,500 tons of gold are extracted from mines. Platinum group metals are even rarer. In 2007, total worldwide output of these metals amounted to about 530 tons. The amount of platinum itself produced each year, about 207 tons, could easily be stored in a garage. And the amount of rhodium, which is essential for the automotive industry and segments of the chemical industry, would fit under a desk. To produce one gram of these metals, 200 to 800 kilograms of rock must be mined.

These small quantities – in comparison to the millions of tons extracted of such metals as iron or copper – stand in stark contrast to the essential role precious metals play in our everyday lives. Modern cars would not run without them, computers would not work, there would be no flat screens, and major portions of the chemical industry would not exist. Furthermore, the glass and oil industries would face considerable difficulties and we would even have to live without cold drinks.

For years, output from the mines has not been enough to meet constantly growing demand from the automotive, jewelry, glass, and chemical industries. Thus, recycling and refining precious metals from various industrial applications is gaining importance and has become a major component of the business of precious metals specialist W. C. Heraeus. Since as far back as the 1980s, the company has been expanding recycling and refining as basic parts of its precious metals cycle. Long-term supply agreements with mining companies ensure that Heraeus has access to precious metals. Gold and silver are produced by means of special and highly developed processes, as are the platinum group metals (PGMs) – i.e., platinum, palladium, rhodium, iridium, ruthenium, and osmium. The Recycling Business Unit refines and recycles primary and secondary concentrates, industrial catalysts, alloys, and residues from the precious metals processing industry to produce fine metals in accordance with international standards.

“Our versatile wet chemical and smelting processes allow us to extract all precious metals in an ultra-pure form,” states Dr. Steffen Völk, head of the Recycling Business Unit, in describing one of the company’s major strengths. Heraeus does this all over the world with refining and recycling facilities in Germany (Hanau), the United States (Santa Fe Springs, California and Newark, New Jersey), China (Hong Kong and Shanghai), India (Udaipur), and South Africa (Port Elizabeth). Völk believes that “continuous technology transfer enables us to have common standards, production processes, and purity levels in accordance with internationally established guidelines at all our locations around the world.”

In recent years, meeting the needs of industrial customers has become more demanding. As business cycles get shorter and shorter, precious metals must nevertheless be recycled with perfect quality and the greatest possible efficiency. Research and development departments staffed with chemists and process engineers are working hard to optimize processes and develop new ones. While keeping a close eye on every phase of production, they are increasing the efficiency of existing processes, testing and developing new precipitation methods, honing the development of finer-grained precious metal powders for better processing, and much more. For example, they are researching ways to achieve even better throughput frequencies in on-exchange distillation processes to improve capacities for producing valuable metals. “Close integration and excellent communication between production, engineering, and R&D are important here. This way, new knowledge can be put into practice immediately, and problems that arise during production can be rectified on the spot,” according to Steffen Völk, speaking from experience.

Mastering the precious metals cycle

Studies by the International Platinum Association (IPA) indicate that about 25 to 30 percent of the global demand for PGMs (excluding gold and silver) is already being met through recycling. These figures are only estimates, however, because Heraeus considers exact figures to be a trade secret. Nevertheless, the fact remains that the recycling rate depends on the product in question. Precious metals in industrial catalysts – such as platinum gauze for the fertilizer industry or bulk-material catalysts for industrial
chemical processes – are recycled at a rate of more than 90 percent. A stunning 97 percent recycling rate is achieved for platinum catalysts used to refine crude oil. Experts call this a nearly closed cycle of materials, which is to say that almost everything that goes into a product in the first place is returned to the precious metals cycle again. As a result, only a very small amount of the valuable resources are lost.

Unfortunately, this is not possible for all industries or applications. There are likewise recycling systems for automobile catalytic converters and for mobile phones and other electronic devices. However, the recycling percentages are lower for these, because there are so many different end users, and collecting the materials containing the precious metals in emerging and developing countries is difficult. Thus, tons of precious metals remain beyond the reach of the recycling effort, although the material flows are becoming more and more closed.

The experts at Heraeus focus on precious metal concentrates from the mining industry and on spent industrial catalysts (refining-, fixed bed-, supported-, and organ- ic, catalysts) or metallic precious metal residues from products like sputtering targets, which for example are used to coat the magnetic data storage devices in computer hard disk drives.

Dr. Horst Meyer and Gerald Ritter, Heads of the Chemicals Division at W. C. Heraeus, describe what is most important for Heraeus in terms of the precious metals cycle: “We want to be more than just a specialist in the manufacture of high-quality PGM products. We offer our customers a truly integrated service. Through our precious metals cycle we take used materials back from our customers, refine the precious metals they contain, and then produce new precious metals products before starting all over again.”

Our mastery of the entire precious metals cycle underscores the range of expertise at Heraeus. Along with recycling, refining, and production, precious metals trading is a significant factor in this system. Precious metals trading at Heraeus is not just a matter of trading with external customers. It also means that there are channels within the company through which precious metals flow. So each day, all sales of precious metals conducted by the product divisions are conducted through Precious Metals Trading, as are the purchases that take place in the course of refining precious metals.

From scrap metal to precious metal – pretreatment and analysis
Refining primary and secondary materials requires very complex manufacturing processes. The steps involved are similar for all precious metal residues: Pretreatment/analysis of a homogeneous sample, preenrichment, wet-chemical extraction processes and isolation of the various precious metals, refining into pure precious metals, and finally production of the precious metals.

Many deliveries, especially of used catalysts, are made in the form of unimpressive, sometimes unsightly but very valuable residues. Through heat treatment in special furnaces (the HeraCycle® process), Heraeus incinerates this material and concentrates the precious metal portion for the next step in the process. Heat treatment is essential, particularly for organometallic catalysts from the chemical, petrochemical, and pharmaceutical industries. Using this method, the organic components are incinerated in a safe and environmentally friendly manner so that an ash containing precious metals remains. This ash can then undergo further wet-chemical or smelting processes.

The rest of the steps in the refining process vary greatly, as does the equipment used for them: Reaction vessels – as tall as a person – made out of special glass in which red, orange, or yellow solutions bubble away; multi-story reactors for dissolving bulk-material catalysts; ion exchangers and smelting furnaces in which free platinum sponge is melted at temperatures over 1800°C.

An important intermediate step is to homogenize the primary and secondary material beforehand so that a uniform form analysis sample can be taken. Analysis is also a core competence at Heraeus. The in-house analytical laboratory determines what proportion of precious metal is present in
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the sample; this serves to ensure quality and is important for accounting. “We have global sampling standards. The samples are ground in the same way, sieved, mixed, and thereby homogenized,” Voll explains. Nothing would be worse than to have an erroneous test result in determining an incorrect proportion of precious metal. R&D and the Analytical Department work hand in hand in this field as well.

Expertise in technical chemistry a key to refining

Precious metal concentrates from primary and secondary sources are dissolved in hydrochloric acid under oxidizing conditions prior to isolation of the individual precious metals, in the resulting solutions the platinum group metals can be purified with selective process steps such as precipitation and ion exchange.

The following example from the ruthenium “cookbook” demonstrates the complexity of wet-chemical refining: Highly volatile ruthenium tetroxide (RuO₂) is distilled from the solution containing ruthenium via oxidation; it is then absorbed in hydrochloric acid as hexachlororuthenic acid. The metal can then be manufactured from sparingly soluble ammonium hexachlororuthenate by calcination and after several process steps, by reduction with hydrogen. Sputtering targets are a particularly important secondary source for recycling ruthenium, as are other ruthenium-containing residues from industrial applications like catalysts. Heraeus supplies high purity ruthenium sputtering targets for depositing extraordinarily thin layers in a complex layer structure on computer hard disk drives. The most prominent application of ruthenium is now in magnetic data storage media (hard disk drives). Heraeus has been using a new process since 2004, quantifying the amount of ruthenium it produces and making it one of the world’s leading companies.

Refining platinum is similarly complex. Pure platinum in the form of platinum sponge is produced by wet-chemical reduction or an electrolytical process. Via additional steps, it can be made into platinum salts for further processing into anti-tumor agents, such as cis-platin. Above all, platinum is used to make a wide range of catalysts. Heraeus supplies supported catalysts for purifying exhaust emissions, platinum-hodium gauzes for fertilizer and hydrocyanic acid production and compounds for homogeneous catalysis, for example the Kastell catalyst for hydroisylolation in the production of silicones. Heraeus manufactures a broad array of laboratory equipment, such as crucibles, dishes, and special products made from platinum and platinum alloys. These materials are also fabricated into feeder systems, large components, and glass fiber bushings for the glass industry. The platinum in many of these products is not consumed; instead, it can be reintroduced to the precious metals cycle after use – and the whole process starts over again.

To sum up: Our world would certainly be poorer without platinum group metals – and with its recycling expertise, Heraeus is ensuring an ample supply.

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Want to know more?

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