## Umicore Platinum Engineered Materials

The Umicore concept of working in closed loops with complementary competencies provides tailor-made engineered solutions of high economic and technological value to our customers.

The main concerns of the chemical catalysis industries are the highly volatile PGM prices and tremendous costs of energy that challenge these industries to keep their manufacturing processes at an economical scale. Additionally, the end user markets dictate a permanent increase in the quality standards of products. Ecological drivers are considerable additional challenges for this industry.

Several years ago we realised how these demands translate into our strategy and started to adapt our portfolio of products and services to the needs of the supply chain. It takes far more than excellent PGM components made of sophisticated materials to increase the functionality of any PGM component. It has also become our duty to support our customers to better understand how the catalyst and its periphery interact. Only by perfectly synchronising the boundary conditions and the PGM catalyst can a status be reached that yields maximum efficiency, stability and security - what we call process excellence!

The cost-structure of nitric acid production is threefold: raw materials (ammonia/natural gas), capital and personnel and, finally, the catalyst gauzes, which are made from precious metals (specifically PGMs). If you look only at the PGM gauzes, again their cost structure has different components. First, and perhaps most obvious, the PGM placed inside the ammonia burners are fixed in the process and cannot be utilised elsewhere. Consequently, their financial value (which can easily add up to a few million Euros) is captive to the production process, unavailable for other use or investment. The cost of financing this fixed capital is, however, only a fraction of the total cost of PGM involved in the production process.

Of more long-term significance is the loss of PGM from the catalyst pack during the oxidation process. There are chemical and mechanical losses: Chemically, primarily platinum (Pt) is lost through oxidation, forming gaseous Pt-Oxide ($PtO_2$). Mechanically, Rhodium (Rh) losses are caused when tiny fractions are carried downstream by the gas flow (e.g. through vibrations which loosen re-crystallised Rh-oxide at the wire surface). Although some portion of lost PGM can be recovered every few years by cleaning the plant, a significant portion of the metal is simply lost for good.

Even though the market prices of PGMs have plummeted over the last several months the long term trend will likely be toward higher prices. It is thus reasonable to predict that it will become increasingly costly – perhaps cost-prohibitive – to continue to lose PGM in such industrial processes as the production of nitric acid.

Reflecting this trend of climbing prices for raw materials, the suppliers of gauze catalyst have, over the years, increased their efforts to bring down the rate of irrevocable PGM losses.

Umicore has always used long-lasting, extremely stable alloys in the manufacture of its gauzes. Another hallmark of Umicore's approach to catalyst gauze, single piece production, carries a decided advantage, making it possible to configure a specific catalyst pack by adjusting and fine-tuning each single gauze inside the pack.

Aware that precious metals are a crucial cost driver, Umicore has made significant R&D investments in an effort to bring down PGM losses over the years. Additionally it releases two new product innovations which aim at decreasing losses even further.

### MKS precise3D - lowest PGM losses

For several years now the industry has increasingly established so called 3-element catalyst gauzes. These gauzes consist of Pt, Rh and Pd, with the addition of palladium replacing some of the traditional rhodium. Generally the rhodium is replaced evenly over the entire gauze pack. This may,

however, be detrimental to the performance of the overall pack. The specific characteristics (e.g. conversion rate, $N_2O$ emission) of the single gauze must be used according to its particular role: High conversion rate for the top layers, stability and endurance for the lower layers. Umicore's new product MKS precise3D can do exactly that since every single layer may be composed differently.

Moreover, performance requirements of gauzes are primarily driven by the parameters of the nitric acid reactor in correlation with the particular position in the gauze pack. Like no other product solution, MKS precise3D, with its adjustability layer by layer, is capable of taking care of these singular needs of different installations. It can precisely adapt to the given parameters which result in lowest ammonia consumption, lowest PGM losses and long campaign durations and therefore generates the highest possible economic benefit.

MKS precise3D makes use of the individual quality of its alloy elements:

- platinum assures high selectivity;
- rhodium increases stability, and in consequence the durability;
- palladium brings down PGM losses.

The challenge in designing 3-element catalyst gauzes is to increase the Pd content without adversely affecting either the efficiency or durability of the gauze. Extensive research has been undertaken to categorise and qualify the behaviour of specific Pt/Rh and Pt/Rh/Pd alloys with respect to the aforementioned qualities of the ammonia oxidation process.

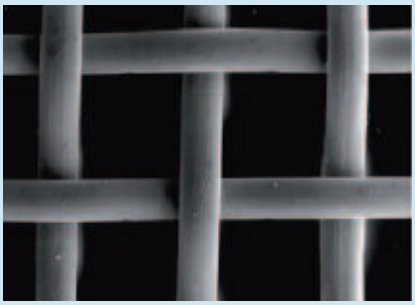
To reach these insights, multiple alloy samples were placed in different layers of industrial applications. Afterwards the wire morphology and development was investigated; finally used and unused samples of selected alloys were tested again to prove their efficiency. It is therefore ensured that the beneficial characteristics of each metal are matched ideally to the entire gauze pack.

## Reconit – recovery for HP applications

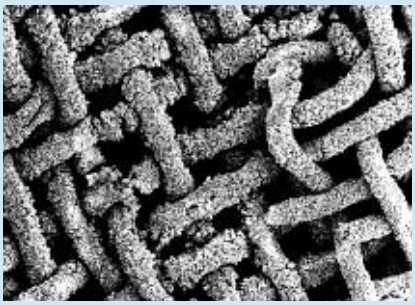
High-pressure plants are particularly subject to very high PGM losses. This is partly due to the lack of an adequate catchment system, as well as to the process itself. HP installations are therefore becoming increasingly difficult to operate profitably.

A seeming contradiction is the fact that HP reactors, despite their high primary losses very rarely use recovery gauzes.

Fig 7: **Woven gauze**



Woven gauze in conventional catchment sytem



Space between the meshes quickly accrue and clog in HP plants

Fig 8: **Top view of Reconit** (dense)

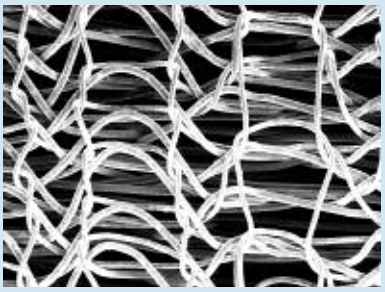


Fig 9: **Side view of Reconit** (open structure)

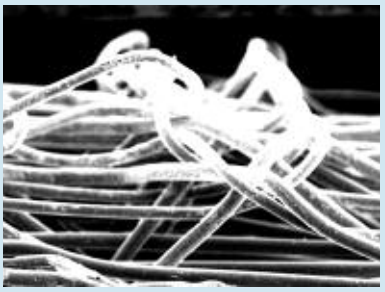
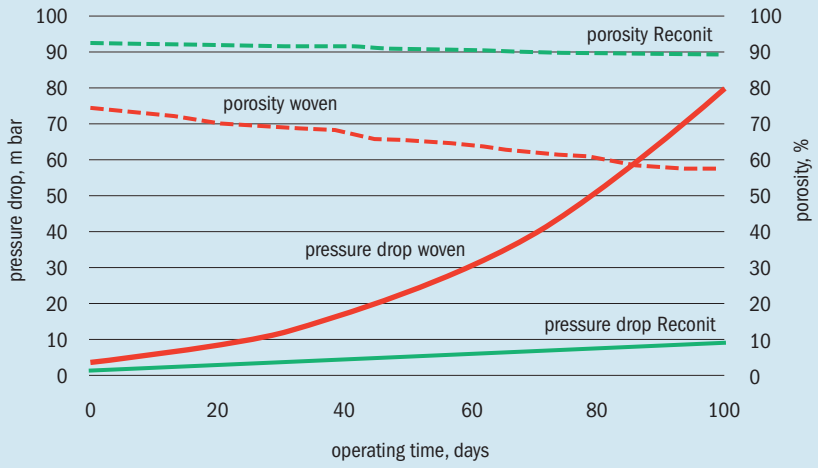


Fig 10: **Umicore Reconit in high pressure plant**




This is true because of the fact that conventional catchment systems can only be used a short time in installations with high primary losses. Since they consist of dense woven gauzes the spaces in-between the meshes quickly accrue and become clogged (Fig. 7). Additionally the pressure drop rises disproportionately which leads to increased stops and downtimes of the reactor. On the other hand, when using a more wide-meshed gauze type, the recovery rate goes down and the process will no longer be economically viable.

By using the flat bed knitting technology Umicore is in the position to produce catchment gauzes, which are dense from the top view (Fig. 8) but open-structured from the side view (Fig. 9).

Umicore's new product Reconit assures that a major part of the $PtO_2$-molecules will get close enough to a Pd-wire to be caught in the alloy. Due to the very high porosity of

Reconit the likelihood of clogging up is close to zero even when a lot of PGM is already bound to its surface. Regular catchment gauzes have a porosity of 70-80%. By contrast Reconit, with its three-dimensional structure, possesses a porosity of over 90%. This is why it can be used over even the longest production period (Fig. 10).

Depending on operation parameters, desired recovery rate and installed precious metal, even several Reconit gauzes may be used to increase the recovery rate but without increasing the pressure drop significantly. It is thus possible to win back a major part of the primary losses without interfering negatively with the process itself.

## Refining

As always in life, every coin has two sides. One may use the most economic PGM catching catalyst system possible, but without a sophisticated and accurate refining process at the end these benefits would be lost. As Umicore is one of the biggest precious metals recycler in the world it always strives to fulfill the entire product loop from production to recycling.

The cost of financing the precious metals is however only a tiny fraction of the total cost of PGM. Although it is possible to calculate realistic PGM losses during the oxidation process, gauze manufacturers tend to widen the range of expected PGM losses in their commercial offers. The objective is to cover all likely operating conditions which impact PGM losses and, of course, thereby minimise the risk on the suppliers' side when it comes to guarantees. The real PGM loss however can only be determined after sampling and analysis of the spent catalytic gauzes. Knowing these two factors, it is advisable to either have a very trustworthy refiner and gauzes supplier at hand, or to always use the services of a so called inspector, who will be present during sampling of the spent gauzes. An inspector will take samples of the homogenised fraction of the gauzes and will analyse those by comparing his analysis results with those determined by the refiner.

Using the services of an approved inspector will minimise the risk of loosing PGM after refining and will further eliminate the possibility of a mixed calculation which influences the pricing of new gauzes.

One has to keep in mind that the price battle for gauzes neglects the fact that the real costs for production of new gauzes are subsidised by physical PGM gains during refining.