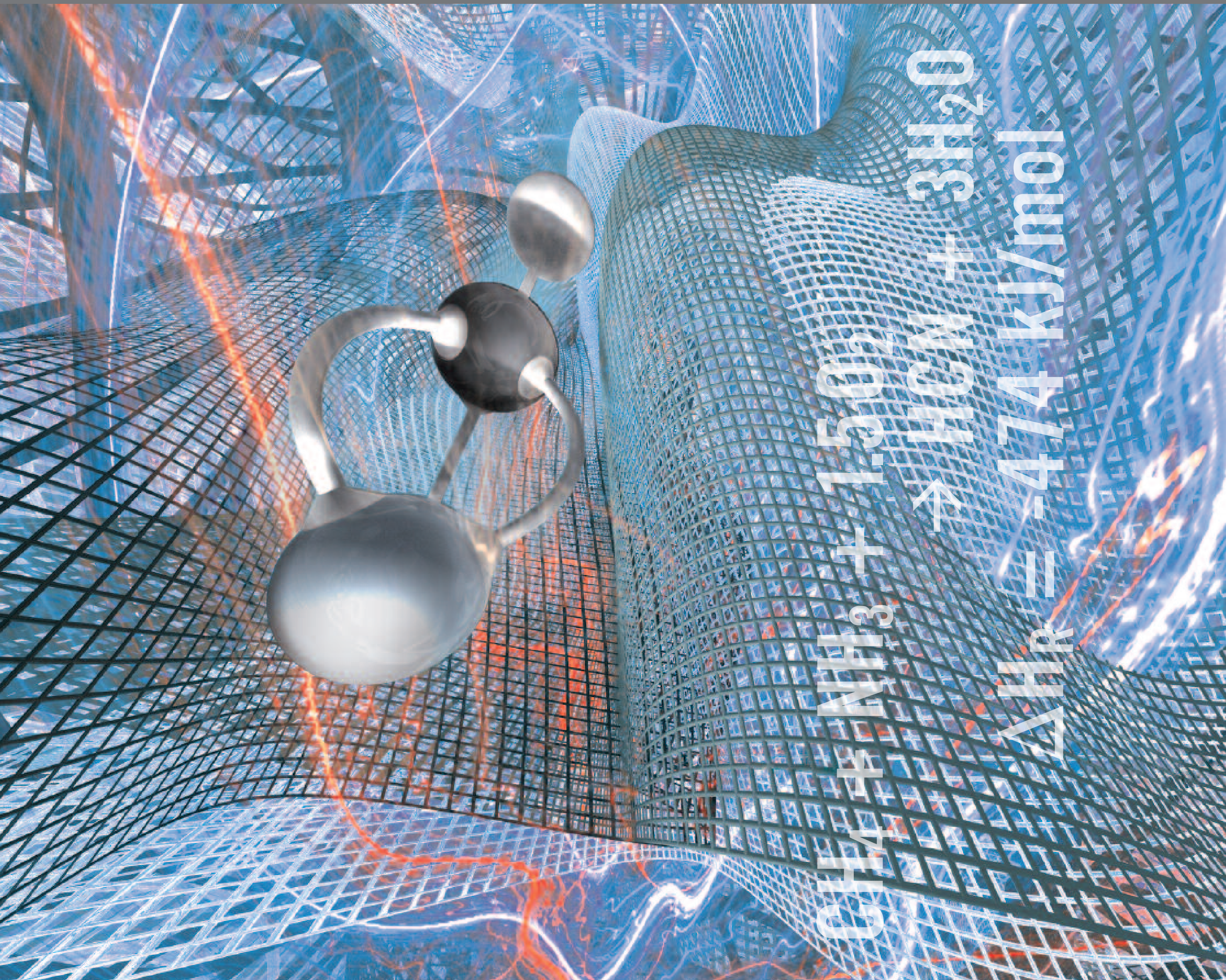
Heraeus



Heraeus Solutions for the Cyanide Industry

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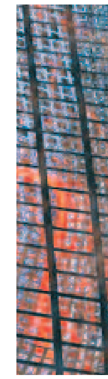


Of all the industrial-scale cyanide production methods, the Andrussow process is the most important and the most frequently used production route. A preheated mixture of ammonia, methane and air is passed through a platinum based gauze catalyst at a temperature of about 1100°C. Although the cyanide synthesis reaction itself is endo-thermic, the air in the feed gas leads to additional oxidation reactions, so that the overall reaction is exothermic and additional heat and energy can be gained from the process.

To whatever product the cyanide is later converted (methyl-methacrylate, polyamide, methionine, sodium cyanide, etc.), Heraeus catalyst gauzes are always the best choice to run the cyanide synthesis with the highest possible yield.

Reaction Mechanism

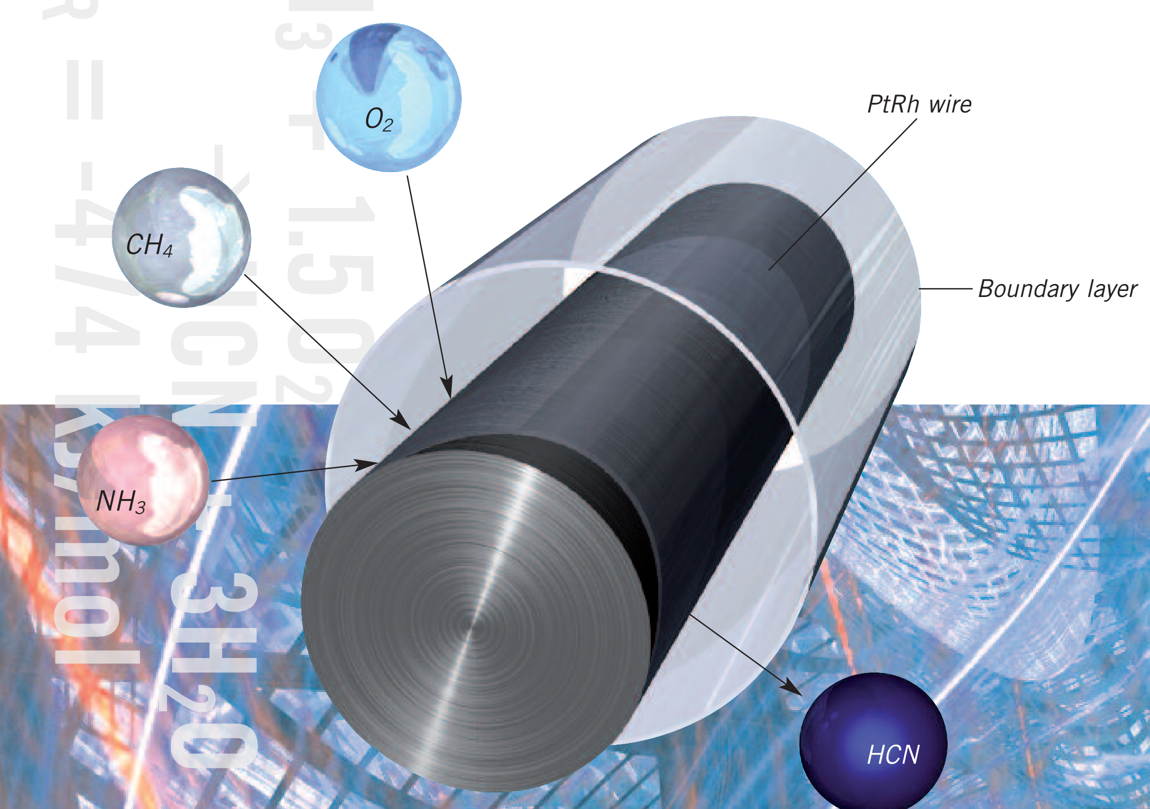
Once the reactants have reached the catalyst surface, the HCN synthesis reaction is extremely rapid. The speed of the overall reaction is therefore only limited by the mass transfer of the reactants through the boundary layer that is surrounding each wire.

As conditions of thermodynamic equilibrium are not achieved in the HCN synthesis, the selectivity of the reaction is completely governed by kinetics. The secret of a good catalyst gauze with high selectivity lies in the chemistry of the alloy and the gauze structure.

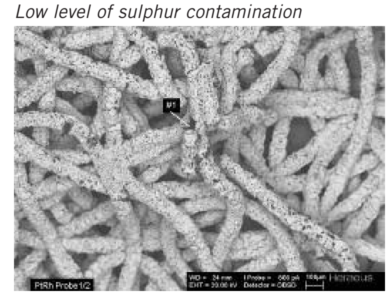
The microstructure of the catalyst gauze needs to be designed in a way that allows fast mass transfer through the boundary layer. In addition to that a homogeneous density over the complete reaction area is extremely important to allow an even gas distribution throughout the reaction zone.

Contamination

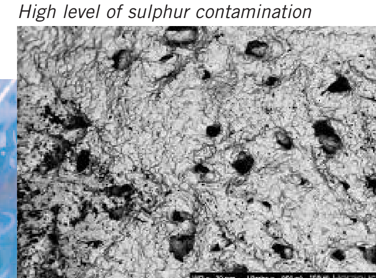
There are three possible sources of catalyst contamination. The process gases, the reactor construction materials and the purity of the catalyst itself. During our production process, we pay particular attention to the purity of materials used in the catalyst gauzes. This ensures that the process gases flow from day one through only high purity material. The process gases themselves are responsible for the vast majority of contamination problems.

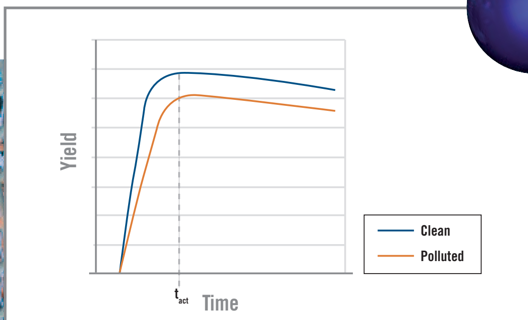


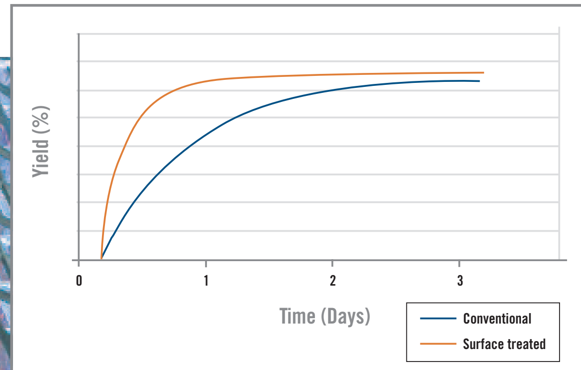
Low level of sulphur contamination



High level of sulphur contamination



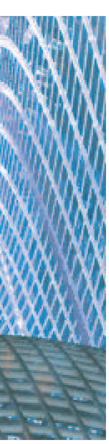




Consequences of contamination are mechanical degradation of the catalyst structure, deactivation due to shadowing effects and a loss in selectivity.

Iron is the most significant impurity in HCN production. It is present in the ammonia in the form of submicron particles transported by the process gas. Iron causes cracking of ammonia and disproportionation of CO, which leads to a loss of the expensive feedstock (ammonia and natural gas), higher NOx emissions and carbon formation on the gauzes.

Heavy hydrocarbons have a severe impact on catalyst performance. The resulting increased rate of carbon deposition limits the mass transfer efficiency on the catalyst surface. The higher the molecular weight of the hydrocarbons the greater is the tendency for hydrocarbon cracking to occur, resulting in further carbon formation. The carbon can diffuse into the alloy where it creates a solid solution. This leads to alloy embrittlement, wire cracking and increased mechanical losses.



Sulphur is a common impurity in natural gas. It drastically affects the catalyst structure, because sulphur lowers the melting point of the alloy and leads to fusing of the wires and reduction in active surface area. The images on the left show the effects of medium and high sulphur contamination.

The impact of contamination depends on surface concentration and not on bulk concentration. For fully soluble contaminants such as iron, the impact on catalytic properties depends on the balance between the rate of surface deposition and the rate of diffusion into the bulk. Special attention has to be paid preventing pollution during the start-up period. A contamination during start-up hinders the important crystal structure development in the first days of operation and leads to lower process yield throughout the remainder of the campaign. (See chart above left)

Activation

Heraeus offers a special surface activation process for the catalyst gauzes which improves the recrystallisation of the gauze surface in the reactor. Gauzes will thus reach their maximum efficiency in a shorter time, thus increasing general efficiency and reducing the production costs per ton of acid produced. (See chart above right)

Analysis

Reasons for unexpectedly low process yields are often extremely complex. Heraeus offers diverse analysis techniques which allow us to zero in on the specific problem areas. Customers can provide us with a representative sample of the used catalyst pack. In case you would like Heraeus to carry out an analysis, please contact us for instructions on how to take samples.

We offer the following analysis methods:

- Optical Microscopy
- Scanning Electron Microscopy (SEM)
- Energy-Dispersive and Wavelength-Dispersive X-Ray Analysis (EDX and WDX) for local chemical analysis
- Auger Electron Spectrometry (AES), Secondary-Ion Mass-Spectrometry (SIMS) for surface specific chemical analysis
- Hot-Gas Extraction for determination of C, O, H, N and S
- X-Ray Fluorescence (XRF), Glow Discharge Luminescence (GDL), Spark-Assisted Optical Emission Spectrometry (S-OES) of solids chemical analysis
- Inductive Coupled Plasma Optical Emission Spectrometry (ICP-OES) for trace chemical analysis of liquids

Heraeus Catalyst Gauzes for Cyanide Production

All Heraeus gauze catalysts for cyanide synthesis are manufactured using extremely fine wires of a platinum group alloy. Due to the very high operating temperature in the process the rhodium content must be sufficient to ensure adequate mechanical strength. Other alloying elements such as iridium that would give high strength at elevated temperatures are not acceptable, as unwanted side reactions would be favoured which lead to lower process yields.

Today warp knitted catalyst gauzes have almost completely replaced the traditional woven gauzes. Knitted gauzes offer improved mechanical flexibility compared to the more rigid and crack susceptible woven gauzes. Knitted gauzes also have a more open structure that offers lower shadowing of the wire surface and a lower tendency to fuse.

Warp knitted catalyst gauze

Warp knitted structure

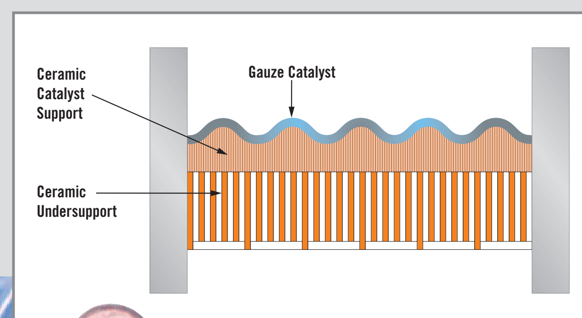
Low Fusion and Wafer Packs

Heraeus has developed low fusion packs, specially for the cyanide process. These packs are constructed specifically to hinder the fusion of individual wires, which can occur by unusually high process temperatures or in the presence of gas impurities. This type of pack is becoming ever more widely used in the cyanide industry.

Corrugated Packs

A major leap forward is the Heraeus development of corrugation and profiling technology, offering the following advantages:

- Up to 40 % reduction in specific load per unit area
- Considerably extended campaign durations



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