NANOCATALYST OF GAS PURIFICATION FROM NITROGEN OXIDES

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Nitric acid production is associated with gas emissions that contain toxic nitrogen oxides. Oxidation of ammonia produces nitric oxide (II), which is oxidized to nitric oxide (IV) by air oxygen. As a result of incompleteness of its absorption in absorber columns NO_2 is released into the atmosphere together with unoxidized NO.

Concentration of NO + NO_2 (NO_x) in after absorption can reach 0.15 % by volume without efficient purification. Therefore level of atmospheric pollution is quite high in areas of chemical plants. The use of catalytic neutralization can significantly reduce the amount of nitrogen oxides emitted by industrial enterprises. An important direction in solving this problem is the development of highly efficient catalysts for the off-gases purification.

Nowadays, catalytic reduction using alumina-vanadium catalysts of the AVK-10 type and their modified analogues is used to purify off-gases from nitrogen oxides at nitric acid plants. The main disadvantage of these catalysts is high hydraulic resistance, which does not allow using them in processes with high space velocity. The development of block catalysts of cell structure which lack these disadvantages has been aroused interest in recent years [1].

The advantages of these catalysts are that they provide low pressure drop before and after the catalytic system at high space velocity. At the same time, metal blocks are easier to produce in comparison with ceramic. They also have high mechanical strength, thermal conductivity and resistance to temperature changes. The use of metal block catalysts allows achieving contact time of several milliseconds. On the other hand simplicity of loading and the absence of dust make them more promising than the catalysts witch are currently used in industry [2].

More and more sensor, adsorption, optical, electrical and catalytic properties of titanium dioxide become a popular object of research [3]. The last can significantly improve the efficiency of technological processes associated with the purification of industrial liquid and gas wastes.

An absence of toxicity, high chemical inertness, and low price allow titanium dioxide to be used in a number of catalytic processes, both as an independent catalyst and as a carrier of a catalytically active substance. However, that modern catalysts based on titanium dioxide powders have limited application in chemical technology due to low activity. In order to increase catalytic properties TiO_2 sometimes is modified by various metals or non-metals. Metallic platinum is one of such component, which historically is a universal catalyst and is used in various chemical processes. But its high price makes researchers to look for alternative options.

A metal nanocatalyst for industrial purification of gases from nitrogen oxides based on platinum deposited on an anodized titanium support was developed at the Department of Technology of Inorganic Substances of Catalysis and Ecology of NTU "KhPI". Nowadays, development of modern nanocatalysis is inextricably linked with the development of nanostructured catalysts in various forms (colloidal solutions, nanodispersed powders, films, etc.), as well as methods for controlling the most important characteristics (particle size and the state of surface). This technology allows producing a catalyst that meets industrial requirements [4].

This catalyst is a MOM system (metal oxide metal) and is a titanium plate of the OT-4 brand, which was coated with a TiO_2 layer by electrochemical anodizing. This layer has a porous structure and is impregnated with platinum salts. The technology of the catalyst also included the temperature treatment of the carrier, both after anodizing, and after its impregnation.

Physico-chemical analysis of the surface layer showed that the oxide coating after anodization has a thickness of 18–20 μm and consists basically in TiO_2 which is in the state of anatase. A part of it turns into rutile after calcination above 773 K.

The morphology of the oxide layer is represented by a fine-grained globular structure with a quite smooth surface relief. The sizes of the globules vary within the limits of 10–30 μm. The specific surface area of the carrier is 150 m^2/g. A calcination at temperature above 773 K leads to a gradual sintering of the anatase particles. After that size of the globules increases from 20 to 100 μm, which leads to their significant decrease in the specific surface area.

Platinum was applied by impregnation of the obtained carrier samples from the $H_2[PtCl_6]$ solution, followed by reduction at a temperature of 773 K. The possibility of modification of the samples with monobasic organic acids, formic and acetic, was also studied [5].

Physico-chemical studies showed that on samples without modification and modified by CH_3COOH have platinum which is in the charge state of Pt^{+2} and Pt^{+4}. Preliminary treatment of the carrier with formic acid leads to increase platinum content in the reduced form of Pt^0 up to 50 %. The particle sizes vary from 2 nm, on samples modified by HCOOH, up to 20 nm – on samples without modification.

Research of morphology of the surface by electron microscopy showed that samples modified by HCOOH have Pt is equally distributed over the surface of the carrier in the form of finely dispersed platinum black The other samples have Pt in the form of conglomerates.

The finished samples were tested in a flow type reactor in laboratory conditions and in industrial conditions at private company “Severodonetsky Azot”. A catalytic activity of the catalyst was about 98 %, which meets industrial purification standards and allows recommending it for application.

References:

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