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MODERN NITRIDE CATALYSTS

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Due to their many valuable physicochemical properties, nitride materials are of great interest to researchers [1-3]. In a recently published review [2], scientists from the University of Virginia (USA) note that catalysts based on transition metal nitrides mark a new era in the production of hydrogen as an environmentally friendly and versatile energy source.

The catalytic systems Pt/TiN and Au/TiN can be used for hydrogen production reactions [3]. The use of titanium nitride TiN in these materials saves expensive metal catalysts, such as platinum and gold. At the same time, complex Pt/TiN and Au/TiN catalysts are characterized by competitive efficiency. For example, they exhibit an extremely promising volcano-like trend between the electrochemical activity of the hydrogen production reaction and the energy of H_2 binding [3].

Another promising catalyst is gallium nitride GaN. Nanowires of this material, with the addition of silver as a co-catalyst, allow the synthesis of urea from carbon dioxide and nitrate. Such a catalyst can be used in solar panels because the high efficiency of urea formation is achieved by exposure to sunlight [4].

Catalysts based on carbon nitride g-CN with Ru and Rh impurities allow both carbon dioxide reduction and hydrogen production [5].

To catalyze the sulfur reduction reaction in lithium-sulfur batteries as next-generation energy storage devices, heterostructures of carbon nitride C_3N_4 and boron nitride BN together with systems of the MeN_4 type, where Me is vanadium, molybdenum, or tungsten, are promising [6].

Photocatalysts with high potential for practical use include the aforementioned C_3N_4 carbon nitride [7-9]. The calculated quantum efficiency of photocatalytic hydrogen generation on optimized C_3N_4 samples using solar radiation is close to 30 %, which is considered to be a very high value [8]. The heterostructure of the composition α-MnO_2@B/Og-C_3N_4/d-Ti_3C_2, formed with the participation of C_3N_4 carbon nitride, is promising for the photocatalytic production of hydrogen peroxide and molecular hydrogen from ethanol solutions [9].

Scientists from the L.V. Pisarzhevskii Institute of Physical Chemistry (Kyiv) and other Ukrainian research institutions make a significant contribution to the study of nitride catalysts [10; 11]. Thus, Korzhak *et al.* found [10] that graphitic carbon nitride (CGCN) has high photocatalytic activity during the chemoselective conversion of furfural to furfuryl alcohol. This process is activated by visible light using the electron-donating substrates methanol–water and ethanol–water. Some co-catalysts, such as

Pd/SiO_2 (to a slightly worse extent) and $PdCl_2$ (to a significantly better extent), allow to increase the rate of chemical conversion. This is due to the formation of an active $CGCN/Pd^0$ composite catalyst in the presence of $PdCl_2$. Instead, in the alternative $CGCN\text{-}Pd/SiO_2$ composite, the photogenerated charges are separated worse. The optimal catalyst is characterized by a high quantum yield of furfural reduction (56 % at 405 nm) [10].

Crystalline graphite-like carbon nitride also allows for the efficient generation of hydrogen from aqueous acetonitrile solutions of benzyl alcohol under the influence of visible light [11]. This process is more active if the electron donating capacity of the substituent in benzyl alcohol is increased. In this case, the substituent must occupy a paraposition in the molecule of the alcohol in question. The quantum yield reaches 22 % at a light wavelength of 405 nm and allows for the highest rate of hydrogen release from 4-methoxybenzyl alcohol in the presence of hydrochloric acid [11].

Thus, the considered nitride catalysts are promising for use in various chemical transformations, in particular for the efficient production of hydrogen fuel.

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СУЧАСНІ НІТРИДНІ КАТАЛІЗАТОРИ

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