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CATALYTIC CONVERSION OF A MIXTURE OF GASES CONSISTING OF METHANE AND CARBON DIOXIDE INTO A MIXTURE OF CARBON DIOXIDE AND HYDROGEN IN THE GAS PHASE USING ABSORBED NICKEL CATALYSTS

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Abstract
Studies have shown that less coke is produced in the presence of catalysts supported on nickel-based carriers [12; pp. 359-372, 13; pp. 22]. If the metal is supported on a carrier with a high Lewis basicity, the production of char decreases.

Introduction

Al_2O_3 Further additions are made to carriers such as . Thus, the formation of carbonates, which are not very stable, facilitates their interaction with carbon. Of particular interest is the work on the catalytic conversion of methane into a mixture of carbon dioxide and hydrogen in the gas phase on nickel catalysts operated by Japanese companies. At a pressure of 1-2 MPa, coal is taken and the catalyst is activated The addition of SaO significantly reduces char formation in this case (in the absence of SaO in the catalyst $330 \cdot 10^{-3}$г/г дан то CaO when added $9{,}5 \cdot 10^{-3}$ г/г up to).

In the articles [14; 220-227-p.]. [15; 534-545-p.], it was shown that concentrated (13-20% mass Ni) solid solutions of Ni, MgO were converted into a mixture of carbon dioxide and hydrogen in the gas phase under catalytic conditions, after which the same concentration of Ni and MgO was converted into a mixture of carbon dioxide and hydrogen. NiO/Al_2O_3 ва NiO/SiO_2 much more active and stable compared to systems.

Nickel catalysts doped with intermediate metals

CeO_2, CuO, Cr_2O_3, MnO_2 was with additions Ni/MgO-Cr_2O_3 most active output: composition 6% Ni-1%Cr_2O_3-MgO when it is a catalytic transformation in the presence of catalysts close to equilibrium -700°C provides at (Figure 6). It can be seen from the laws presented in Figure 6, Ni ва Cr_2O_3 оз provides at (Figure 6). It can be seen from the laws presented in Figure 6 Catalytic conversion of a gas mixture consisting of methane and carbon dioxide into a mixture of carbon monoxide and hydrogen in the gas phase α-Al_2O_3, γ-Al_2O_3, α-Al_2O_3 SiO_2, ZrO_2, MgO was studied on catalysts doped with nickel; also on catalysts modified with intermediate metals and alkaline promoters [1] Ni/α-Al_2O_3 catalytic activity Ni/γ-Al_2O_3 Close to where. Ni-

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Coking resistance range for catalysts was obtained:Ni/α-Al_2O_3 > Ni/γ-Al_2O_3> SiO_2 > Ni/α-Al_2O_3-SiO_2> ZrO_2, MgO.

Intermediate metals Ni/α-Al_2O_3 effect on Ni-Co, Ni>Ni-Cu>>Ni-Fe on alkaline additives Ni>Ni-Na>Ni-R,

The addition of metals reduces nickel recovery, but increases dispersibility. After 12 hours of work 700°C да nickel-catalyst completely lost its catalytic activity [9]; at the same time Ni-Cr- The catalyst activity increased significantly, and no coke was formed at all.

Under the conditions of catalysis, the mineral structure consisting of a mixture of mixed oxides is destroyed, but in the mineral composition consisting of a mixture of oxides $x<0,5$ catalysts can be regenerated by heating. The high dispersity of nickel results in high catalyst activity and coke resistance, with reduced char formation partly due to the presence of active metals. The mobile carbon in the crystal lattice of the mineral, which is a mixture of oxides, also causes the loss of coal. Slowing (or stopping) the formation of coal was active in the catalytic conversion of methane in the presence of dry catalysts.

The addition of Ru to the Ni catalyst significantly increases its activity due to the formation of a bimetallic nickel-ruthenium homogeneous set of objects. This results in highly dispersed nickel and, consequently, in the formation of rapidly reactive carbon. [23; 341-344-б].

Won to different carriers Ti-, Rh-, Pt- ва Ru- studies of catalysts have shown Ni/SiO_2 and Rh/Al_2O_3 are the most active [28].

Catalytic conversion of methane at low and medium temperatures (400-800°C) in the presence of carbonic anhydride catalysts SiO_2 and Al_2O_3 lost to carriers Co, Ni, Ru, Rh, Ir and Pt- was conducted on catalysts [29]. Summarizing the above-mentioned works, it can be noted that nickel is of great importance as an active component in the creation of a catalyst with high catalytic activity, productivity, and selectivity for the catalytic conversion of a gas mixture consisting of methane and carbon dioxide into a mixture of carbon dioxide and hydrogen in the gas phase. Researchers are trying to find a way to reduce coke formation on nickel surfaces, and positive results can be achieved by increasing its dispersion and using basic carriers or metal promoters that reduce carbon solubility.

Carbides CH+CO_2 The change in the environment can occur via the oxidation-reduction mechanism:

$Mo_2C + 5CO_2 = 2MoO_2 + 6CO$

$2MoO_2 + 5CH_4 = Mo_2C + 4CO + 10H_2$

Or

$CO_2 = CO + O_L$ $WC + O_L = W + CO$

$W + O_L = WO_3$, $WO + C = WC + O_L$

In the works of the Institute of Chemical Physics and the Institute of Petrochemical Processes (Baku) (see review [30:175-193-b]), it was shown that oxide catalysts can also be catalysts in the catalytic conversion of methane in the presence of carbon dioxide catalysts. Experiment carried out in the laboratory of M.I. Temkin [31]. The kinetics of the catalytic conversion of a mixture of gases consisting of methane and carbon dioxide into a mixture of carbon dioxide and hydrogen in the gas phase in the presence of catalytic catalysts was the first work to be carried out. Based on the following scheme [32;6908-6919-б].

$CH_4 + Z \rightarrow CH_2 - Z + H_2$
$CO_2 + Z \leftrightarrow CO + O - Z$
$O - Z + H_2 \leftrightarrow H_2O + Z$ (11)
$CH_2 - Z + H_2O \leftrightarrow CO - Z + H_2$
$CO - Z \leftrightarrow CO + Z$

They showed that when the process was carried out at 800-900°C in the presence of nickel, the reaction obeyed the kinetic equations obtained for the steam catalytic transformation (1) on this catalyst..

$$r = \frac{kP_{CH_4}}{1 + \alpha P_{H_2O} / P_{H_2} + bP_{CO}} \quad (12)$$

Here к1, α ва б- constants; $P_{CH_4}, P_{H_2O}, P_{H_2}, va \ P_{CO}$ - partial pressures of methane, water, hydrogen, and SOs, respectively.

Later, other equations were also found. The catalytic conversion of a mixture of gases consisting of methane and carbon dioxide into a mixture of carbon dioxide and hydrogen in the gas phase in the presence of catalytic catalysts (3) and the steam catalytic conversion of CO (6):

$CH_4 + 2CO_2 \ H_2 + H_2O + CO$ (13)

Together Ni/C, Ni/SiO_2, Ni/TiO_2 ва Ni/MgO and absorbed Pt-catalysts [14; 220-227-b]. [33; 96-24-b] for reaction

$$r = \frac{k_1 P_{CH_4} P_{H_2O}}{P_{H_2}^{(4-x)/2} P_{CO}} \quad (14)$$

The equation was found. According to the authors, this equation corresponds to the following scheme:

$CH_4 + Z \leftrightarrow Z - CH_x + [(14-x)/2H_2]$
$2CO_2 + 2Z \leftrightarrow 2Z - CO_2$
$H_2 + 2Z - 2Z - H$
$2Z - CO_2 + 2Z - H \leftrightarrow 2Z - CO + 2Z - OH$ (15)
$Z - OH + Z - H \leftrightarrow H_2O + 2Z$
$Z - CH_x + Z - OH \leftrightarrow Z - O - CHx + Z - H$
$Z - O - Ch_x \rightarrow Z - CO + (1/2)H_2$
$3Z - CO \leftrightarrow 3CO + 3Z$

Ni/Al_2O_3 the following equation is obtained for the catalyst process:

$$r = kp^{1/2}$$

Data (taken from more than 60 articles) on the kinetics of the catalytic conversion of a gas mixture consisting of methane and carbon dioxide into a mixture of carbon dioxide and

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hydrogen in the gas phase in the presence of catalytic catalysts are given in the review [32].

The following series was obtained for the recovered nickel catalysts: $TiO_2 > Al_2O_3 \approx SiO_2 \approx MgO$ [34; 2015] бу The result is consistent with the data of [11]. It has been proven in many studies that the rate of catalytic transformation of a mixture of gases consisting of methane and carbon dioxide into a mixture of carbon dioxide and hydrogen in the gas phase in the presence of catalytic catalysts is proportional to the first degree of methane pressure..

Ni/Al_2O_3 ва Ni/La_2O_3 KPE value increases as the temperature increases in the reactions Ni/La_2O_3 да КПЕ. Ni/Al_2O_3 much higher than the process in [36:652-684-б.]

According to the data, the kinetics of the catalytic conversion of methane in the gas phase to a mixture of carbon dioxide and hydrogen in the presence of catalysts is strongly dependent on the reverse reaction - the hydrogenation of CO:

$$r_n = r_n^1 - KP_{H_2}^{1,6-2,0} P_{CO}^{0,5} \qquad (17)$$

Summary

Data (taken from more than 60 articles) on the kinetics of the catalytic conversion of a gas mixture consisting of methane and carbon dioxide into a mixture of carbon dioxide and hydrogen in the gas phase in the presence of catalytic catalysts are given in the review. According to the data, the kinetics of the catalytic conversion of methane in the gas phase to a mixture of carbon dioxide and hydrogen in the presence of catalysts is strongly dependent on the reverse reaction - the hydrogenation of CO

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