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КАТАЛИЗ ЖӘНЕ ЭЛЕКТРОХИМИЯ ИНСТИТУТЫ» АҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

АО «ИНСТИТУТ ТОПЛИВА, КАТАЛИЗА И
ЭЛЕКТРОХИМИИ ИМ. Д.В. СОКОЛЬСКОГО»

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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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INTERACTION OF THE CATALYTIC Fe/γ-Al_2O_3 SYSTEM WITH PROBE MOLECULES II. STUDY OF γ-Al_2O_3 SUPPORT AND Fe/γ-Al_2O_3 SYSTEM AFTER INTERACTION WITH HYDROGEN AND AMMONIA

Abstract. In this work, studies of the Fe/γ-Al_2O_3 system after its interaction with hydrogen and ammonia using X-ray diffractometry, electron microscopy (transmission and scanning), BET on low-temperature nitrogen adsorption and Mössbauer spectroscopy were carried out. The obtained results showed that the Fe/γ-Al_2O_3 system is multiphase.

It contains aluminum and iron oxide, hydroxide phases. In addition, the iron-containing components can be partially reduced to Fe^{2+} and be in two forms, differing in their location relative to the surface.

It was established that in the process of interaction with hydrogen and ammonia, there is a specific surface excursion of the system and its texture. The nature of these changes depends on both the percentage iron phase, and the reagent nature, hydrogen or ammonia.

Key words: heterogeneous catalysis, physicochemical research methods, adsorbed molecules.

Introduction

A unified theory of the selection of catalysts does not currently exist. Many abundantly used catalysts are selected empirically. Theoretical ideas about the catalysis mechanism determine the principles of creating catalysts suitable for individual types of reactions, both in homogeneous and heterogeneous conditions, and / or associated with the type of catalyst (metallic; oxide; metals deposited on an oxide substrate; metals associated with polymeric molecules and others).

The catalytic activity [1 - 6] is determined through various catalyst characteristics: the number of d-electrons per cation orbital (for simple oxides); lattice parameter; electrical conductivity; ion charge and radius; chemical bond energy; acidity; assembly effect (which is determined by the catalyst atoms number which one molecule of the reactant interacts); for structures that can be regarded as periodic, by the energy spectrum nature and the Fermi level position in it, as well as by the periodic localization of particles chemisorbed on the surface and participating in the reaction, affecting the energy spectrum.

In heterogeneous catalysis, the most important stage is adsorption (chemisorption) [1, 4]. When constructing the corresponding models, it is necessary to study the surface state — its structure, adsorption complexes formed by active surface centers and reagent molecules. The active center can combine the adsorption and catalytic centers, for heterogeneous catalysts, they, as a rule, coincide.

The catalyst may contain more than one type of active centers, which allows it to participate in several chemical reactions in parallel. At the same time, a systematic study of various centers on the crystal surfaces of metal-coated oxides, active in the adsorption of various probe molecules, was not carried out.

From this, it follows the relevance of an experimental study of the gases interaction (adsorption) with a heterogeneous catalytic system. This work is a continuation [7] of the Fe/γ-Al_2O_3 catalytic system study with adsorbed molecules and is devoted to the study of the γ-Al_2O_3 support and the Fe/γ-Al_2O_3 system after interaction with hydrogen and ammonia.

As noted in [7], the choice of the Fe/γ-Al_2O_3 system as a model is due to its actual multifunctionality, since it exhibits catalytic activity in many chemical processes [1, 3, 8 - 16].

Experimental

The Fe/γ-Al_2O_3 system with different iron contents was prepared similarly to [7] by the impregnation method [1, 6, 17] of the starting γ-Al_2O_3 oxide with an aqueous iron acetate solution, followed by drying and calcination in air. The interaction of γ-Al_2O_3 oxide and the Fe/γ-Al_2O_3 system with hydrogen and ammonia was carried out at 500 °C.

Due to the difficulty of detecting iron-containing phases in the system with 0.5 weight. %, iron (0.5% Fe/γ-Al_2O_3), due to its low content [7], studies were mainly conducted on systems 3%Fe/γ-Al_2O_3 and 13%Fe/γ-Al_2O_3.

During the research, the same set of physicochemical methods was used as in [7].

X-ray diffractometry. The device X-ray diffractometer Dron-4-07. Cobalt anode tube.

Mode:

- speed 2 deg/min;
- working parameters of the tube: 30 kV, 20 mA

Transmission electron microscopy. The device is an EM 125K, accelerating voltage of 75 kV.

Scanning electron microscopy. Equipment is a scanning low-vacuum electron microscope JSM 6610 LV, JEOL, Japan. Accelerating voltage of 20 kV.

BET method (low-temperature nitrogen adsorption). Equipment is AccuSorb, Micromeritics, USA. Standard technique. Calcination of the sample at 230 - 250 °C for 3 hours with vacuum. The relative error in determining the specific surface area is ± 5%.

Mössbauer spectroscopy. Equipment - MS 1104Em, Russia. The source was cobalt 57 in the chromium matrix, with an activity of 100 mCi. The spectra were processed on a PC using the “least squares” method. The isomeric shifts values are given relative to α-Fe. The spectra were taken in air at a temperature of 23 °C. Shooting mode - "on the light." The error in determining the isomeric shift (IS)

$\Delta IS = \pm$ 0,03 mm / s; quadrupole splitting (QS) $\Delta QS = \pm$ 0,03 mm/s; content ratio (S) $\Delta S = \pm$ 2 %.

Results and Discussion

A study of γ-Al_2O_3 oxide and Fe/γ-Al_2O_3 system after their interaction with hydrogen and ammonia was carried out.

X-ray diffractometry

From the obtained results after the interaction of γ-Al_2O_3 with hydrogen and ammonia, it follows that the oxide structure does not change and the obtained diffractograms coincide with the diffractogram of the original γ-Al_2O_3, which is given in [7].

In fig. 1 shows the diffraction patterns of the systems 3%Fe/γ-Al_2O_3, 13%Fe/γ-Al_2O_3 after their interaction with hydrogen and ammonia.

Processing of diffractograms gave the following results:

3%Fe/γ-Al_2O_3 system

- after interaction with hydrogen

Reflexes 4.1817; 2.6971; 2.4503 Å - phase O(OH) (goethite) (ASTM 29 - 713)
Reflexes 4.5681; 2.8046; 2.3856; 2.2863; 1.9781; 1.5261; 1.3985 Å - γ-Al_2O_3 phase (ASTM 10-424);
Reflexes 4.8569; 4.3088; 2.4503; 2.3856; 1.9781 Å - gibbsite phase $Al(OH)_3$ (ASTM 33-18);
Reflexes 3.6768; 2.6971; 2.5154; 2.2863 Å - α-Fe_2O_3 phase (maghemite) (ASTM 33-664);
Reflexes; 2.5154; 2.4903; 2.1518; 1.5261 Å - FeO phase (wustite) (ASTM 6-615)

- after interaction with ammonia

Reflexes 4.1750; 2.6997,4449 Å - α-FeO(OH) phase (ASTM 29 - 713)
Reflexes 4.5641; 2.8090; 2.3754; 2.2910; 1.9788; 1.5261; 1.3985 Å - γ-Al_2O_3 phase (ASTM 10-424);
Reflexes 4.8569; 4.3158; 3.1854 2.4449; 2.3754; 1.9788 Å - $Al(OH)_3$ phase(ASTM 33-18);
Reflexes 3.6794; 2.6997; 2.5282; 2.2910 Å - α-Fe_2O_3 phase(ASTM 33-664);
Reflexes 2.4903; 2.1592; 1.5261 Å - FeO phase(ASTM 6-615)

13%Fe/γ-Al_2O_3 system

- after interaction with hydrogen

Reflexes 4.1784; 2.7001; 2.4514 Å - α-FeO(OH) phase(ASTM 29 - 713)

Reflexes 4.5602; 2.7988; 2.3754; 2.2986; 1.9863; 1.5280; 1.3982 Å - γ-Al_2O_3 phase(ASTM 10-424);

Reflexes 4.8569; 4.3265; 2.4514; 2.3754; 1.9863 Å - $Al(OH)_3$ phase(ASTM 33-18);

Reflexes 3.6615; 2.7001; 2.5178; 2.2986 Å - α-Fe_2O_3 phase(ASTM 33-664);

reflexes: 2.5178; 2.1452; 1.5280 Å - FeO (ASTM 6-615)

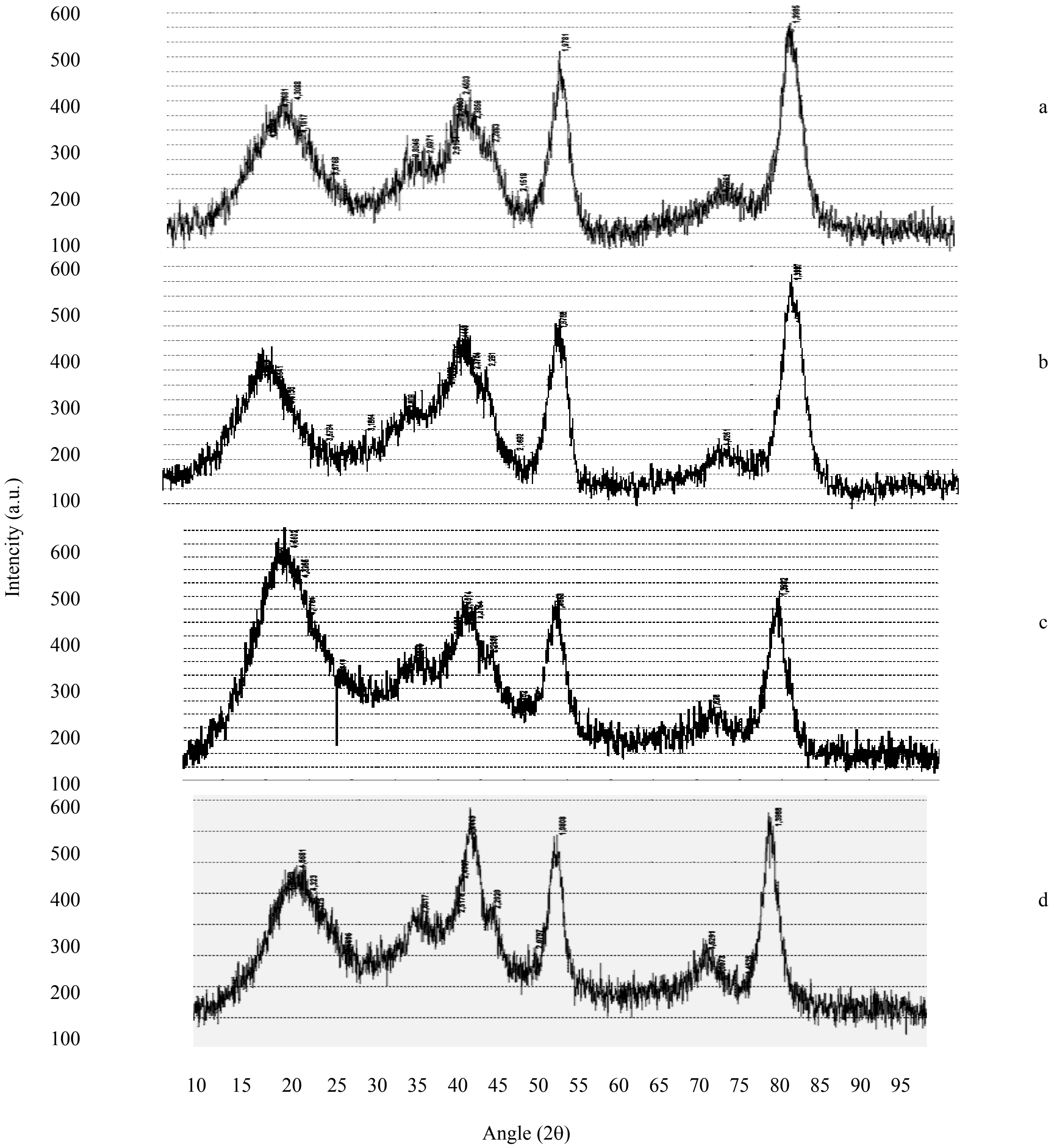


Figure 1 - Diffraction patterns of systems 3%Fe/γ-Al_2O_3 and 13%Fe/γ-Al_2O_3 after their interaction with hydrogen and ammonia a, b - 3%Fe/γ-Al_2O_3 system; c, d 13%Fe/γ-Al_2O_3 system; a, c - after interaction with hydrogen; b, d- after interaction with ammonia

Processing of diffractograms gave the following results:

3%Fe/γ-Al_2O_3 system

- after interaction with ammonia

Reflexes 4.1750; 2.7001; 2.4514 Å - phase α-FeO(OH) phase(ASTM 29 - 713)

Reflexes 4.5681; 2.8017; 2.2929; 1.9808; 1.5291; 1.3988 Å –γ-Al_2O_3 phase(ASTM 10-424);

Reflexes 4.8569; 4.3230; 2.4449; 1.9808 Å - $Al(OH)_3$ phase(ASTM 33-18);

Reflexes 3.6896; 2.7101; 2.5178; 2.2929 Å - α-Fe_2O_3 phase(ASTM 33-664);

Reflexes: 2.5178; 2.4937; 2.0797; 1.5291; 1.5073; 1.4550 Å – phase mixture

FeO (ASTM 6-615) and $Fe_{0,98}O$ (ASTM39-1088)/

The obtained data show the presence of Fe/γ-Al_2O_3 oxide γ-Al_2O_3, $Al(OH)_3$ hydroxide (gibbsite) and several iron-containing phases, including iron, reduced to the state of Fe^{2+} in the system.

Transmission electron microscopy

In fig. 2 shows micrographs of the Fe/γ-Al_2O_3 system with different iron content after interaction with hydrogen and ammonia, obtained using transmission electron microscopy.

3%Fe/Al_2O_3 system

- after hydrogen interaction

In fig. 2a, (magnification of 24,000 times) aggregates of particles up to 10 nm in size, which are located at the edges of large, dense particles of micron size. Microdiffraction gives a set of symmetric and separate reflexes and can be attributed to γ-Al_2O_3 (JCPDS, 10-425).

In fig. 2b (magnification of 50,000 times) a large particle of the plate type is shown, on which seals from 5 to 40 nm are observed. Microdiffraction shows a set of symmetric, separate intense and weak reflections, which can be attributed to a mixture of phases of aluminum oxides with a predominance of γ-Al_2O_3 (JCPDS, 10-425) and iron hydroxides α-FeO (OH) - getit (JCPDS, 29-713) , Fe $(OH)_2$ (JCPDS, 13-89).

In fig. 2c (magnification of 50,000 times), the edges of the aggregates composed of their fine, dense particles 5 to 10 nm in size. Microdiffraction gives a small set of weak diffuse rings, which can be attributed to a mixture of phases Al $(OH)_3$ - gibbsite (JCPDS, 7-324) and Fe_2O_3 (JCPDS, 32-469).

- after ammonia interaction

In fig. 2d (magnification of 24,000 times) is an aggregate of translucent particles ranging in size from 150 to 300 nm. Microdiffraction gives symmetrical reflexes, which can be attributed to the phase of FeO - wustite (JCPDS, 6-615).

In fig. 2e (magnification of 24,000 times), a dense aggregate is shown, with translucent particles ranging in size from 150 to 200 nm along its edge. Microdiffraction shows symmetrical reflexes that can respond to Fe_2O_3 (JCPDS, 32-469).

In fig. 2f there is a small aggregate, on the edge of which there are semitransparent particles with a size of 20-40 nm. Microdiffraction gives symmetric reflections, they can be attributed to a mixture of phases γ-Al_2O_3 (JCPDS, 10-425), Al $(OH)_3$ (JCPDS, 7-324).

13% Fe/Al_2O_3 system

- after hydrogen interaction

In fig. 2g (magnification of 24,000 times) aggregate of large particles ranging in size from 70 to 200 nm. Microdiffraction shows a large set of reflections and can be attributed to the mixture of phases of hydroxides Fe $(OH)_2$ (JCPDS, 13-89) and α-FeO (OH) (JCPDS, 29-713).

In fig. 2h (magnification of 24,000 times) is an aggregate of large dense particles ranging in size from 70 to 500 nm and translucent rectangular crystals, reaching 150 to 200 nm in diameter. Microdiffraction gives a large set of reflexes. They can be attributed to the mixture of phases FeOOH (JCPDS, 26-792), γ-FeO (OH) (JCPDS, 8-98), Fe_2O_3 (JCPDS, 32-469), α-FeO (OH) (JCPDS, 29- 713).

- after ammonia interaction

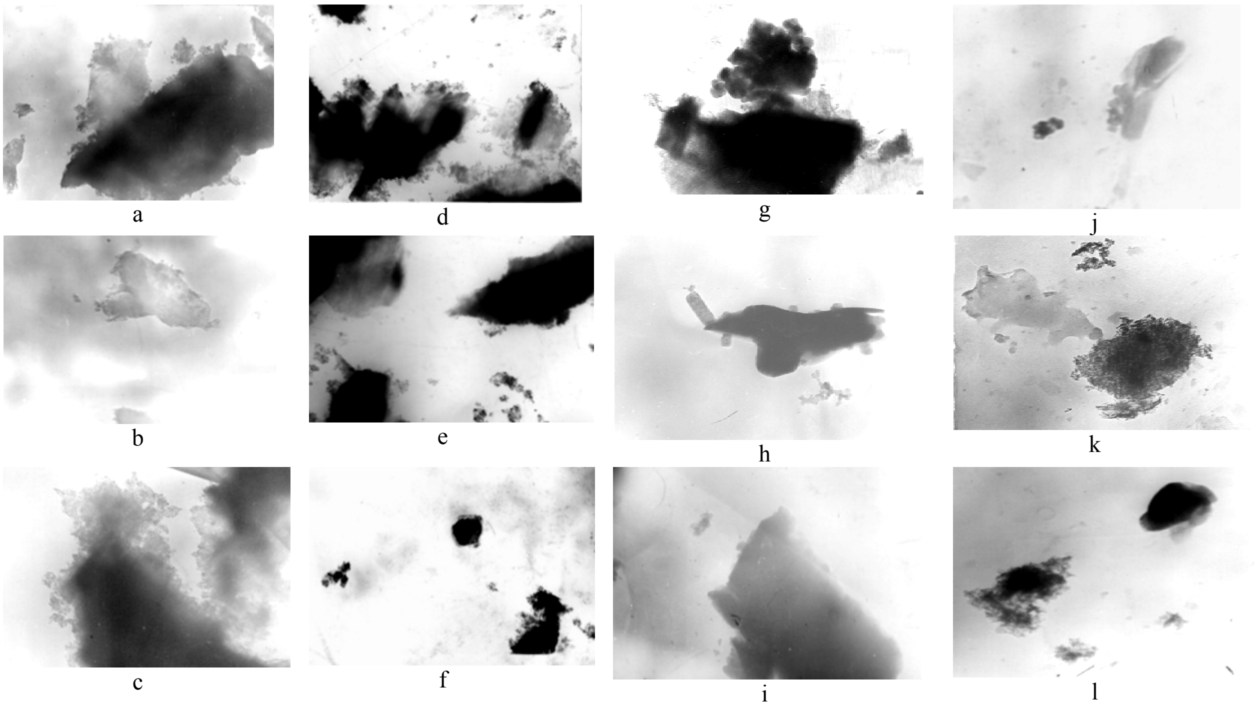


Figure 2 - Micrographs of the Fe/γ-Al_2O_3 system with different iron content after interaction with hydrogen and ammonia
(a, b, c, d, e, f) - 3%Fe/Al_2O_3; (g, h, i, j, k, l) - 13%Fe/Al_2O_3;
(a, b, c, g, h, i) - after hydrogen interaction; (d, e, f, g, h, i) - after ammonia interaction

In fig. 2i (magnification of 50,000 times) a small aggregate of dense particles 40–60 nm in size is shown. Microdiffraction gives a small set of reflexes that can be attributed to Fe_2O_3 (JCPDS, 32-469).

In fig. 2j (an increase of 24,000 times) an aggregate of translucent particles of plate-like type with a size of 100–200 nm and small aggregates with a size of up to 10 nm. Microdiffraction gives a large set of reflections that can be attributed to a mixture of phases $Fe(OH)_2$ (JCPDS, 13-89), δ -FeOOH (JCPDS, 13-87), $Al(OH)_3$ (JCPDS, 29-41) and FeO (JCPDS, 6-615)

In fig. 2k aggregate of particles with a size of 70 - 100 nm. Microdiffraction shows a large set of reflections that can be attributed to a mixture of Fe_2O_3 (JCPDS, 32-469), γ – FeO (OH) (JCPDS, 8-98), Al $(OH)_3$ (JCPDS, 7-324), γ- Al_2O_3 (JCPDS, 10-425).

Thus, the results obtained using transmission electron microscopy in diffraction mode show that the system Fe/Al_2O_3, after interaction with hydrogen and ammonia, has a complex composition. It contains oxide and hydroxide phases of aluminum, as well as iron, including phases containing Fe^{2+}. This result is in good agreement with the X-ray diffractometry data.

Scanning electron microscopy

In fig. 3 shows micrographs of the Fe/γ-Al_2O_3 system with different iron contents after interaction with hydrogen and ammonia, obtained using scanning electron microscopy.

A comparison of the microphotographs of the initial Fe/γ-Al_2O_3 system [7] with the microphotographs in fig. 3 shows that after interaction with hydrogen and ammonia, the surface relief of the system becomes smoother, with the most significant in the case of ammonia, which is especially noticeable for 3%Fe/γ-Al_2O_3. Perhaps this effect is associated with the formation of some surface compounds, with the result that the iron-containing component is more evenly distributed over the support surface.

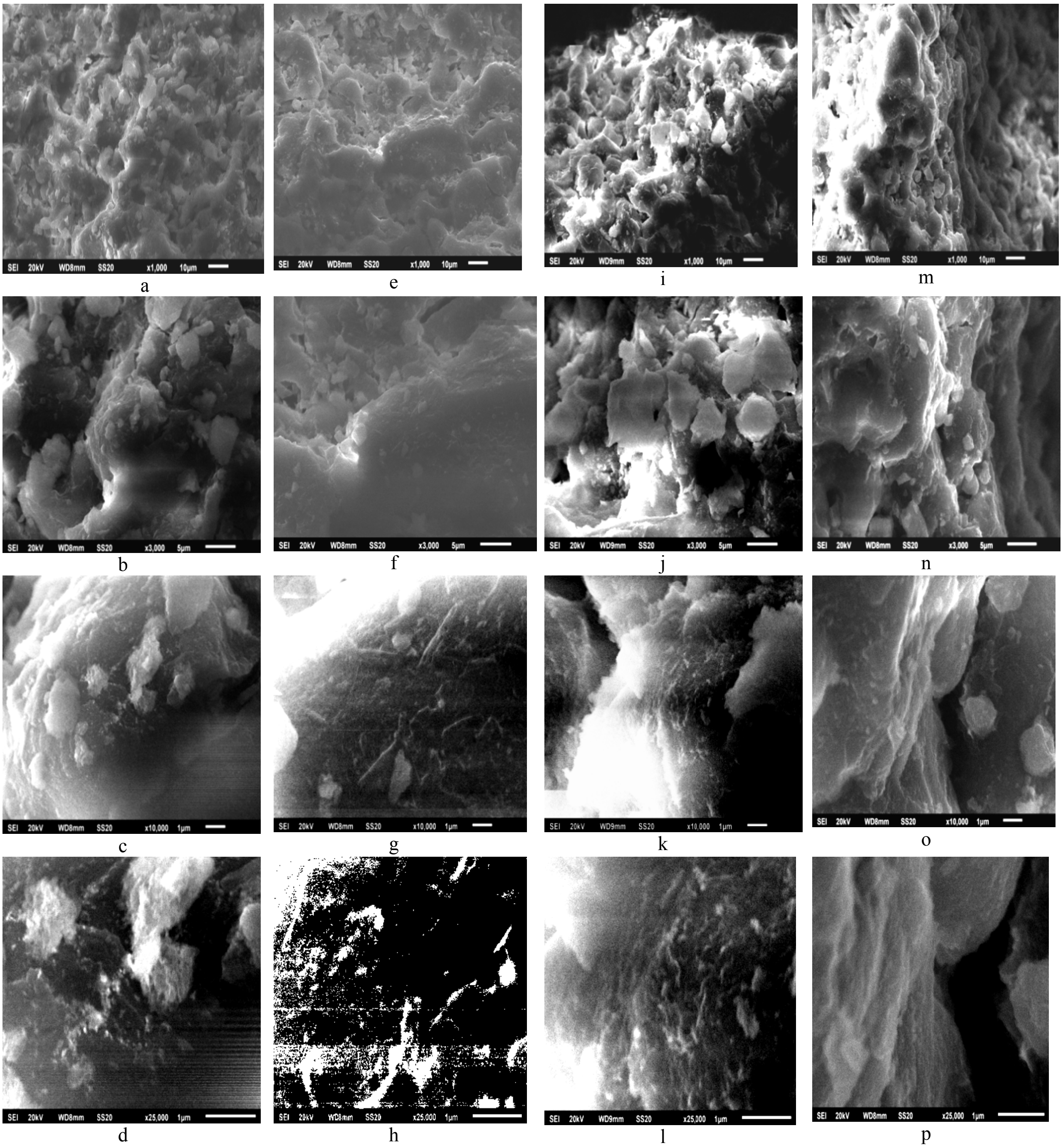


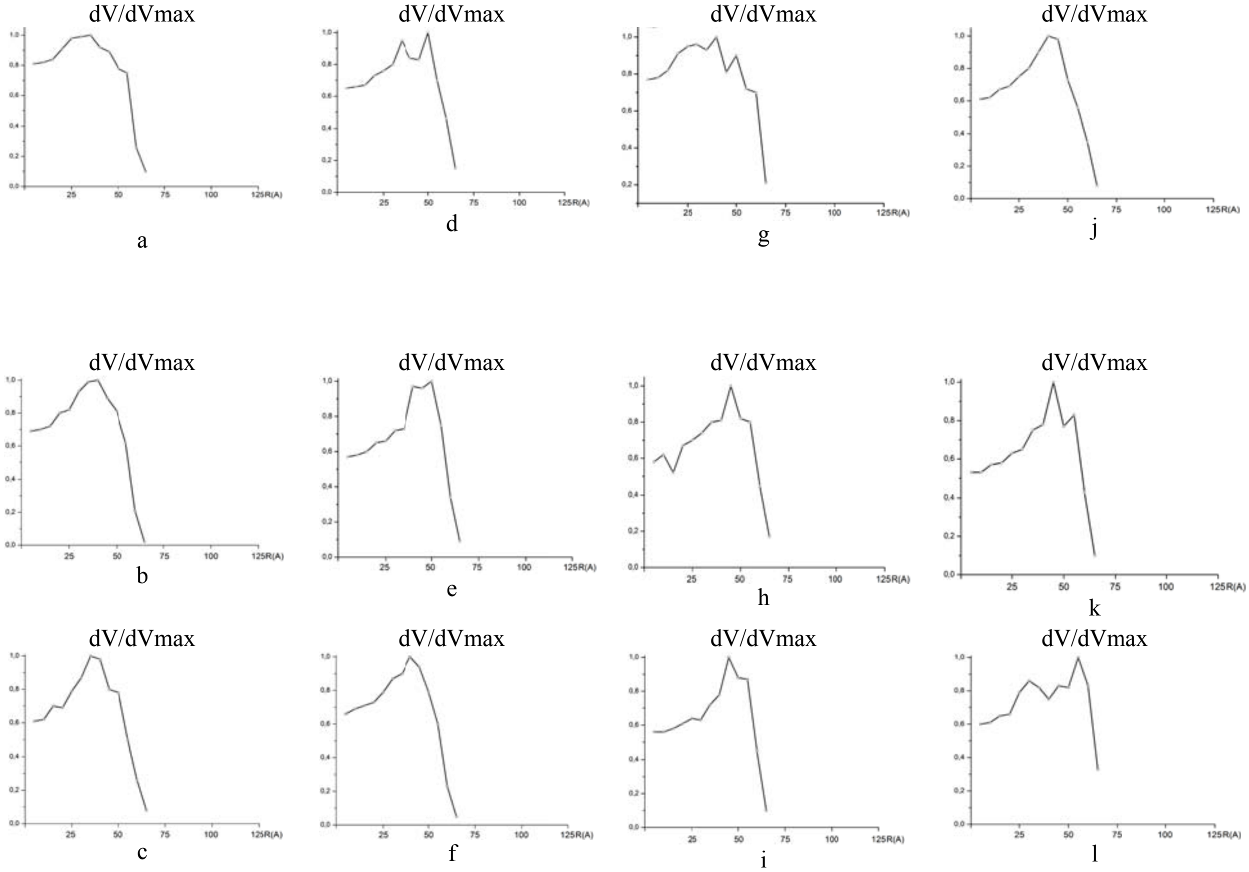
Figure 3 - Microphotographs of the system Fe/γ-Al_2O_3, obtained using scanning electron microscopy, with different iron content after hydrogen and ammonia interaction (a, b, c, d, e, f, g, h) - 3% Fe/Al_2O_3; (i, j, k, l, m, n, o, p) - 13% Fe/Al_2O_3; (a, b, c, d, i, j, k, l) - after hydrogen interaction; (d, f, g, h, m, n, o, p - after ammonia interaction; magnification: (a, e, i, m) - 1000 times; (b, f, j, n) - 3000 times; (c, g, k, o) - 10000 times; (d, h, l, p) - 25000 times

BET method

The specific surface area and its texture (porosity) for the Fe/γ-Al_2O_3 system with different iron content after interaction with hydrogen and ammonia are determined. The results are shown in table 1 and shown in figure 4.

Table 1 - The specific surface of the Fe/γ-Al_2O_3 system after hydrogen and ammonia interaction

Sample	Parameter		
	SW, m^2/g	V_{ADSmax}., mL/g	V_{true}, mL/g
γ-Al_2O_3*	214	180	0,28
γ-Al_2O_3 - hydrogen interaction	168	236	0,37
γ-Al_2O_3 - ammonia interaction	171	249	0,39
0,5%Fe/γ-Al_2O_3*	211	196	0,31
0,5%Fe/γ-Al_2O_3 - hydrogen interaction	202	253	0,39
0,5%Fe/γ-Al_2O_3 - ammonia interaction	209	268	0,42
3%Fe/γ-Al_2O_3*	190	115	0,18
3%Fe/γ-Al_2O_3 - hydrogen interaction	186	225	0,35
3%Fe/γ-Al_2O_3 - ammonia interaction	188	233	0,36
13%Fe/γ-Al_2O_3*	173	101	0,16
13%Fe/γ-Al_2O_3 - - hydrogen interaction	158	189	0,29
13%Fe/γ-Al_2O_3 - ammonia interaction	139	194	0,39
Note: SW - specific surface area, m^2 / g; V_{ADSmax} - total pore volume with gas filling, mL / g; V_{true} - total true pore volume, mL / g * - data from work [7]			



a d g j

b e h k

c f i l

Figure 4 - The distribution of pore sizes in γ-Al_2O_3 and in Fe/γ-Al_2O_3 after hydrogen and ammonia interaction (a*, b, c) - γ-Al_2O_3; (d*, e, f) - 0,5%Fe/γ-Al_2O_3; (g*, h, i) - 3%Fe/γ-Al_2O_3; (j*, k, l) - 13%Fe/γ-Al_2O_3; (a, b, g, j) – initial states; (b, e, g, k) – after hydrogen interaction; (c, f, i, l) – after ammonia interaction; * - data from work [7]; R(A) – pore radius in angstroms (Å); dV/dVmax the ratio of the pore volume of a given radius to the maximum volume

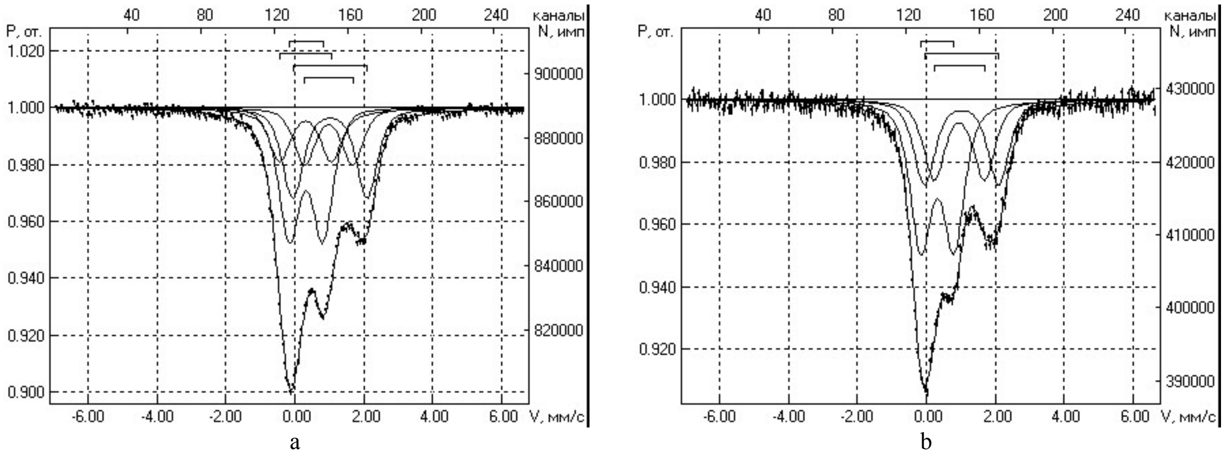
From the results of table 1, it follows that the interaction of the γ-Al_2O_3 oxide, of the Fe/γ-Al_2O_3 system with hydrogen and ammonia leads to a decrease in the specific surface area and an increase in the total pore volume. It should be noted that it is possible there is a tendency for a larger increase in the value of the total pore volume in the case of interaction with ammonia.

The data presented in fig. 4 shows that the interaction of γ-Al_2O_3 oxide of the Fe/γ-Al_2O_3 system with hydrogen and ammonia leads to a change in the size distribution of the pores. For oxide γ-Al_2O_3, the relative content of pores with a diameter of up to 25 Å decreases (fig. 4 (a, b, c)).

In the case of a 00,5% Fe/γ-Al_2O_3system, the relative content of pores with a diameter in the range of 27–40 Å decreases and there is an extremum in the graphs in the range of 40–50 Å (fig. 4 (d, e, f). The situation is similar for 3% Fe/γ-Al_2O_3, but with the formation of a “sharp” maximum at a distribution in the region of ~ 45 Å (fig. 4 (f, h, i). In the case of a system of 13% Al_2O_3 during its interaction with hydrogen, a “sharp” maximum is also observed at ~ 45 Å. When interacting with ammonia, the relative intensity of this maximum decreases and the other two appear with a center of distribution at ~ 28–30 and 55 Å (fig. 4 (k, l, m).

Mössbauer spectroscopy

In fig. 5 shows the Mössbauer spectra of the 3%Fe/γ-Al_2O_3 system after hydrogen and ammonia interaction.



a b

Figure 5 - Mössbauer spectra of the system 3%Fe/γ-Al_2O_3 after interaction with hydrogen (a) and ammonia (b)

The processing of the spectra showed that the system, based on the values of the Mössbauer parameters, contains various forms of Fe^{3+} and Fe^{2+} in the paramagnetic state [18].

The following iron forms are present in the 3%Fe/γ-Al_2O_3 system:
- after interaction with hydrogen
Fe_1^{3+} form - IS = 0,33 mm•s^{-1}; QS = 0,97 mm•s^{-1}; S = 39%
Fe_2^{3+} form - IS = 0,32 mm•s^{-1}; QS = 1,51 mm•s^{-1}; S = 16%
Form
Fe_1^{2+} form - IS = 1,02 mm•s^{-1}; QS = 2,15 mm•s^{-1}; S = 28%
Fe_2^{2+} form - IS = 0,98 mm•s^{-1}; QS = 1,40 mm•s^{-1}; S = 17%
- after ammonia interaction
Fe_1^{3+} form - IS = 0,32 mm•s^{-1}; QS = 0,96 mm•s^{-1}; S = 47%
Fe_1^{2+} form - IS = 1,02 mm•s^{-1}; QS = 2,15 mm•s^{-1}; S = 27%
Fe_2^{2+} form - IS = 0,95 mm•s^{-1}; QS = 1,46 mm•s^{-1}; S = 26%

The forms Fe_1^{3+} and Fe_2^{3+}after the interaction of the system with hydrogen have almost identical IS values, at the same time, they differ significantly in QS. In [7], based on the data of [19-21], the form Fe_2^{3+} with a large QS value was attributed to iron on the support surface, and the form Fe_1^{3+} with a smaller QS to the more deeply located one. It should be noted that after interaction with ammonia, only one form of Fe_1^{3+} is present in the system.

The corresponding reduced forms of iron (Fe_1^{2+} and Fe_2^{2+}), after interaction with hydrogen and ammonia, have close Mössbauer parameters. It should be noted that in the case of ammonia, the total relative content of the forms of Fe_2^{2+} in the system is noticeably higher, in addition, there is no form of Fe_2^{3+}, which, presumably, is located closer to the surface, and therefore must be restored first. Regarding the forms Fe_1^{2+} and Fe_2^{2+}, it can be assumed that each of them has a corresponding form of Fe^{3+} as its predecessor.

Conclusion

Studies of $Fe/\gamma\text{-}Al_2O_3$ system after its hydrogen and ammonia interaction using X-ray diffractometry, electron microscopy (transmission and scanning), BET on low-temperature nitrogen adsorption, and Mössbauer spectroscopy were carried out. The results showed that the system $Fe/\gamma\text{-}Al_2O_3$ is multiphase. It contains oxide, hydroxide phases of aluminum and iron. In addition, the iron-containing components can be partially reduced to Fe^{2+} and can be in two forms, differing by their location relative to the surface.

It was established that in the process of interaction with hydrogen and ammonia, there is a change in the value of the specific surface of the system and its texture. The nature of these changes depends on both the percentage of the iron-containing phase and the nature of the reagent, hydrogen or ammonia.

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МОЛЕКУЛА ЗОНДЫ БАР Fe/γ-Al_2O_3 КАТАЛИЗДІҚ ЖҮЙЕНІҢ ӘРЕКЕТТЕСТІГІ II. СУТЕГІ МЕН АММИАКПЕН ӘРЕКЕТТЕСУІНЕН КЕЙІНГІ γ-Al_2O_3 ТАСУШЫ МЕН Fe/γ-Al_2O_3 ЖҮЙЕНІҢ ЗЕРТТЕУІ

Аннотация. Бұл жұмыста Fe/γ-Al_2O_3 жүйенің оның сутегі мен аммиакпен әрекеттесуінен кейінгі рентгендік дифрактометрия, электронды микроскопия (жарықтық және сканерлеуші), төменгі температуралы азоттың адсорбциясы арқылы БЭТ пен мессбауэрлік спектроскопия әдістерінің зерттеулері көрсетілген. Алынған нәтижелер Fe/γ-Al_2O_3 жүйенің көпфазалы екенін анықтады. Бұл фаза алюминий мен темірдің оксидті, гидроксидті фазасынан тұрады. Одан басқа, темірқұрамды компоненттер Fe^{2+} дейін жартылай тотықсызданады және беттік қабатының орналасуының айырмашылығымен екі түрде орналасуы мүмкін.

Сутегі мен аммиакпен әрекеттесуі кезінде жүйенің және оның текстурасының меншікті бет шамасының өзгеруі болатыны анықталды. Бұл өзгерістердің ерекшелігі темірқұрамды фазаның пайыздық құрамы мен реагент табиғатына да – сутегі мен аммиак тәуелді.

Түйін сөздер: гетерогенді катализ, зерттеудің физикалық-химиялық әдістері, адсорбталған молекулалар

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ВЗАИМОДЕЙСТВИЕ КАТАЛИТИЧЕСКОЙ СИСТЕМЫ Fe/γ-Al_2O_3 С МОЛЕКУЛАМИ-ЗОНДАМИ II. ИССЛЕДОВАНИЕ НОСИТЕЛЯ γ-Al_2O_3 И СИСТЕМЫ Fe/γ-Al_2O_3 ПОСЛЕ ВЗАИМОДЕЙСТВИЯ С ВОДОРОДОМ И АММИАКОМ

Аннотация. В работе проведены исследования системы Fe/γ-Al_2O_3 после её взаимодействия с водородом и аммиаком методами рентгеновской дифрактометрии, электронной микроскопии (просвечивающей и сканирующей), БЭТ по низкотемпературной адсорбции азота и мессбауэровской спектроскопии. Полученные результаты показали, что система Fe/γ-Al_2O_3 является многофазной. Она содержит оксидные, гидроксидные фазы алюминия и железа. Кроме того, железосодержащие компоненты могут частично восстанавливаться до Fe^{2+} и находиться в двух формах, различаясь расположением относительно поверхности.

Установлено, что в процессе взаимодействия с водородом и аммиаком, происходит изменение величины удельной поверхности системы и её текстуры. Характер этих изменений зависит как от процентного содержания железосодержащей фазы, так и от природы реагента - водорода или аммиака.

Ключевые слова: гетерогенный катализ, физико-химические методы исследования, адсорбированные молекулы

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