

SPECTROSCOPIC STUDIES OF THE PRODUCTS OF RADIOLYSIS DOMESTIC WASTEWATER IN THE PRESENCE OF NANO- γ - Al_2O_3 UNDER THE INFLUENCE OF GAMMA RADIATION

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Abstract: This paper presents UV and Fourier - IR spectroscopic studies of radiolysis products of domestic wastewater from an oil refinery in the presence of nano- γ - Al_2O_3 under the action of gamma radiation. The formation of radiolysis products was monitored at different absorbed doses of ionizing radiation. The results on the radiolysis in the present nano oxide obtained indicate the formation of new components, apparently due to their desorption from the nano- γ - Al_2O_3 surface.

Keywords: Radiolysis, nano- γ - Al_2O_3 , domestic wastewater, IR spectroscopy, UV spectroscopy, dose rate

1. Introduction

The use of radiation-chemical technology is one of the promising methods of domestic wastewater treatment. This method makes it possible to achieve a high degree of decomposition of toxic wastewater components and simultaneously carry out microbiological treatment [1–3]. To intensify the process of radiation wastewater treatment, methods of advanced oxidative treatment processes (AOP) are used, based on the combined use of physical factors such as UV radiation, photolysis, Fenton's reagent, ozone, H_2O_2 , etc. In this aspect, it is of interest to study the effect of nanocatalysts on the radiolytic transformation of toxic components of wastewater [4,5].

Several works [5-8] show the positive effect of nanocatalysts on the radiation-chemical processes of wastewater treatment. To analyze the products of radiolytic decomposition of toxic components, various physicochemical methods are used [9-10], such as UV and IR spectroscopy, which is useful for studying the processes of decomposition of components of domestic wastewater - alkanes, alkenes, aromatic hydrocarbons, etc. The possibilities of these methods have made it possible to use them for the analysis of oil and oil components, various hydrocarbons, surfactants, and other toxic components [11-14].

The purpose of this work is to study the effect of nano- γ - Al_2O_3 on the radiolytic decomposition of toxic components of domestic wastewater under the action of gamma radiation by UV and IR spectroscopy.

2. Materials and methods

Nano- γ - Al_2O_3 (d=50 nm, specific surface area $S=262.09 \text{ m}^2/\text{g}$, manufactured by USA Skyspring Nanomaterials) was used in the experiments. Samples of domestic wastewater from the Oil Refinery Plant were used. 0.1 g of nano- γ - Al_2O_3 was added to 70 ml of water, and the

prepared samples were irradiated by irradiation of Co^{60} with a dose rate of 0.1–0.2 Gy/s, in the absorbed dose range of 0.3–55 kGy under static conditions in glass ampoules with a volume of 110 ml.

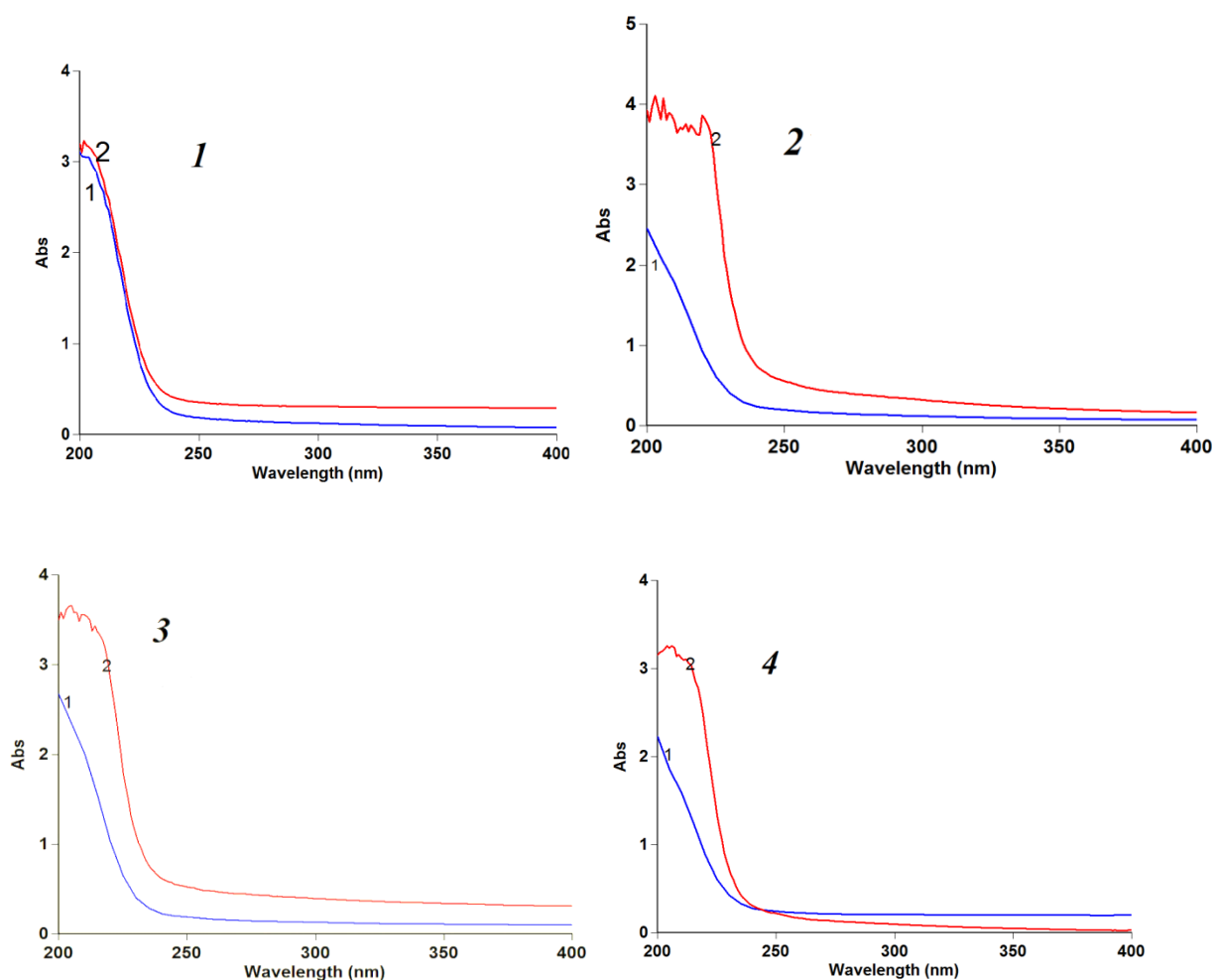
Liquid phase samples were analyzed in a VARIAN SCAN-50 UV spectrophotometer (UV-Visible Spectrophotometer) in a 4 ml cuvette, 1 cm thick.

To separate nano- $\gamma\text{-Al}_2\text{O}_3$ from the liquid phase, a «Centrifuge 5804 R» centrifuge from «Eppendorf» was used. For this purpose, a 1 ml sample of domestic wastewater was placed in a cylindrical cell and subjected to rotation at a speed of 5000 cycles/min for 5 minutes.

IR spectroscopic studies were carried out after the separation of the liquid and solid phases (nano oxide) using a centrifuge. A part of the obtained solid mass of the nano- $\gamma\text{-Al}_2\text{O}_3$ sample was mixed in KBr according to the standard procedure. IR spectra were taken on a Fourier-IR spectrophotometer VARIAN-640 in the range $\nu=3600\text{-}400\text{ cm}^{-1}$.

3. Results and discussion

Figure 1 shows the UV absorption spectra of the initial and irradiated samples in the liquid phase at different absorbed doses.



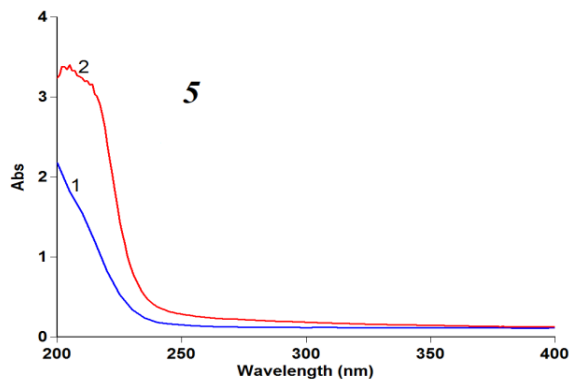


Fig. 1. UV absorption spectra of domestic wastewater before and after passing from the centrifuge. 1- before passing, 2- after passing through the centrifuge 1-initial; 2-0.3 kGy; 3-0.8 kGy; 4-5.5 kGy; 5-55.4 kGy

As can be seen from fig.1, with an increase in the irradiation dose in the range of 0.3÷55.4 kGy Abs decrease from 3.2 to 2.1 at 201 nm. Abs values in the spectra of samples before and after centrifugation are shown in table 1.

Table

Abs values in the spectra of samples after centrifugation at different absorbed doses

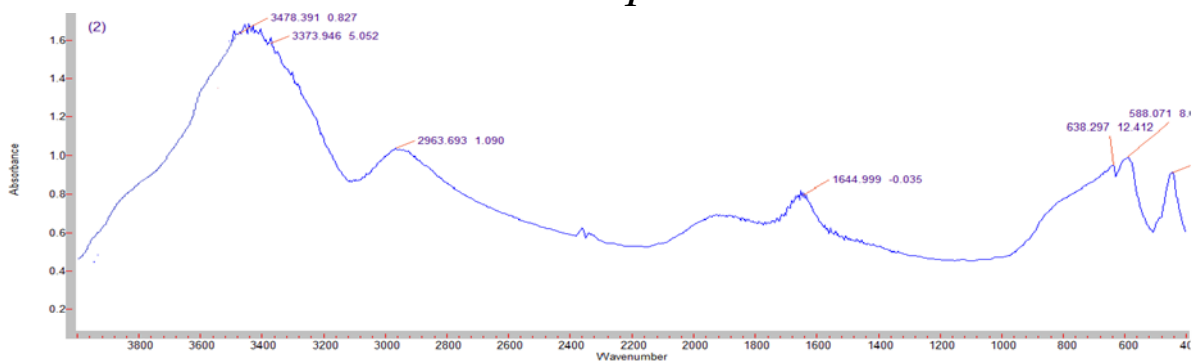
<i>0,3 kGy</i>		<i>0,8 kGy</i>		<i>5,4 kGy</i>		<i>55,4 kGy</i>	
λ , nm	<i>Abs</i>	λ , nm	<i>Abs</i>	λ , nm	<i>Abs</i>	λ , nm	<i>Abs</i>
203	4,1	201	3,5	204	3,2	201	3,4
206	4	205	3,6	206	3,2	205	3,4
208	3,8	209	3,6	209	3,1	439	0,14
212	3,7	214	3,4	667	0,02	627	0,13
214	3,7	440	0,3	-	-	-	-
216	3,7	599	0,3	-	-	-	-
220	3,8	-	-	-	-	-	-

At higher doses, there is also a mixing of absorption in the region of lower wavelengths (hypsochromic shift). A more complex picture is observed in the UV spectra of the samples after passing through the centrifuge (Fig. 1. (curve 2)). As can be seen from the figure, in this spectrum at low doses, several absorption peaks are observed, and the composition of the peaks expands to a dose of 5.5 kGy and gradually decreases to 55.4 kGy.

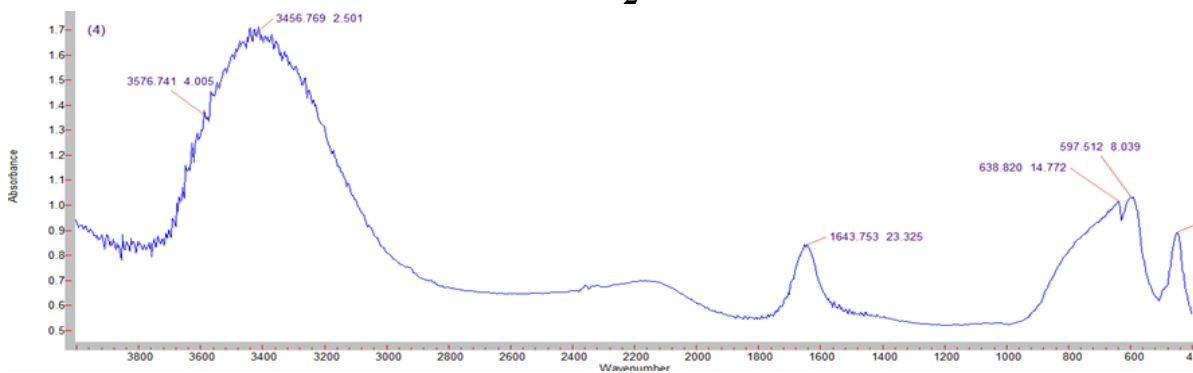
The decrease of absorption at high absorbed doses (55.4 kGy) can be explained by the decomposition of organic matter in domestic wastewater samples. In all cases, centrifuged samples have a hypochromic effect, i.e. the peaks are shifted to the left.

Centrifuged nano- γ - Al_2O_3 samples were analyzed by Fourier IR spectroscopy using KBr. The spectra of the corresponding samples at different absorbed doses are shown in Fig. 2.

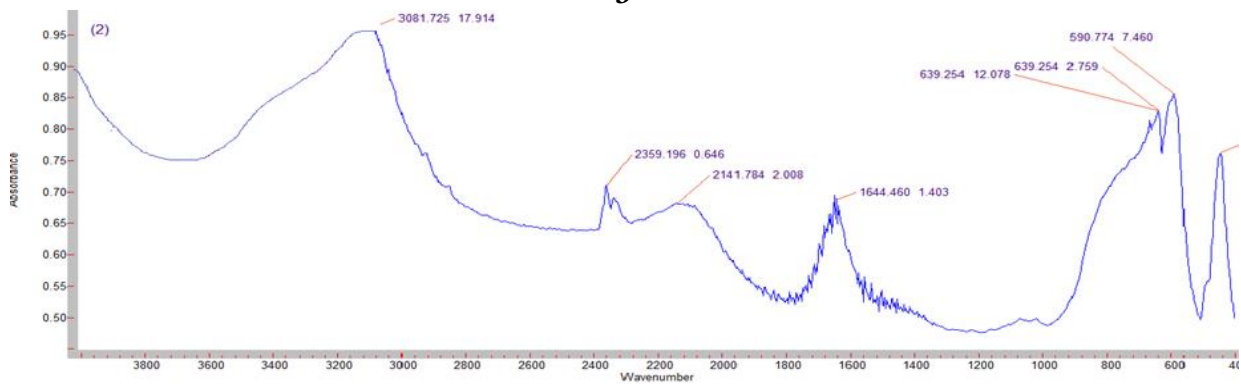
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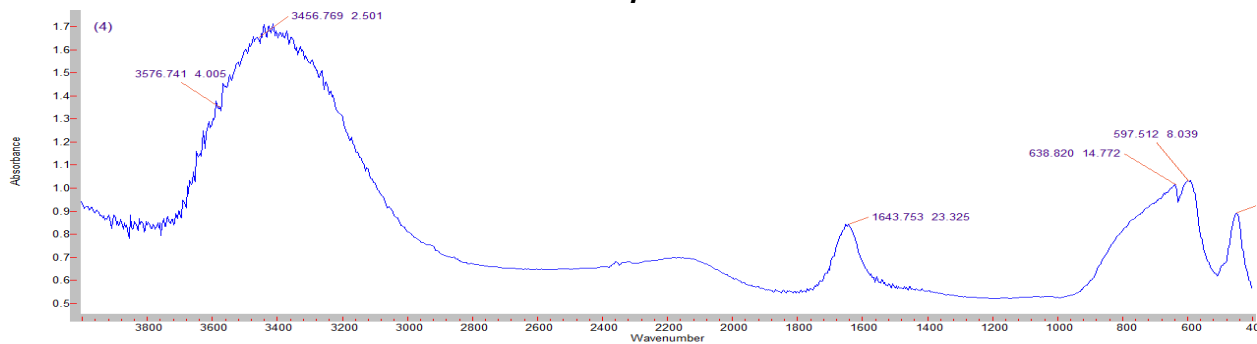
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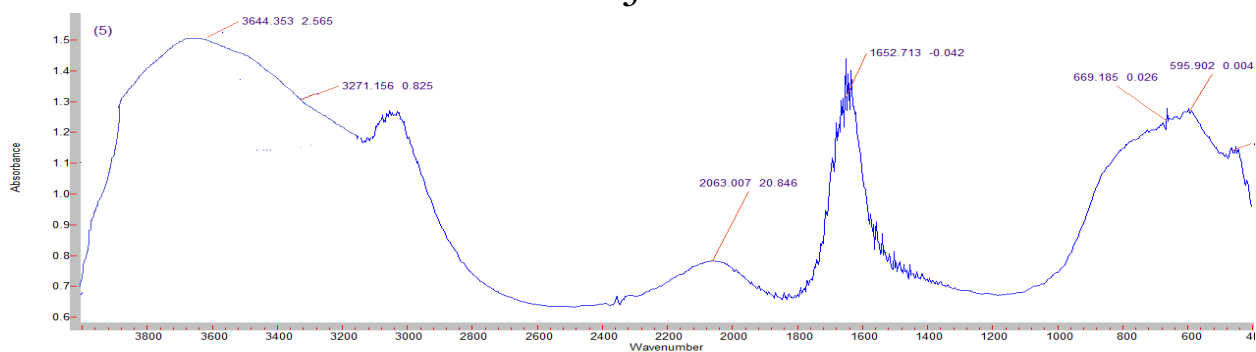


Fig. 2. Fourier-IR absorption spectra of the solid phase obtained after centrifugation of household waste samples in the presence of nano- γ - Al_2O_3 at different absorbed doses

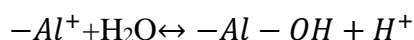
As can be seen from Fig. 2, the following absorption bands are observed in the spectra [15]:

- 3400-3600 cm^{-1} - intermolecular hydrogen bond
- 2961 cm^{-1} - This region includes C-H stretching vibrations of aromatic, heteroaromatic, small cycles, halogenated alkyl groups, C-H bond vibrations in alkanes
- 1926 cm^{-1} - Deformation vibrations of C-H bonds in alkenes and types of substitution at double bonds
- 1645 cm^{-1} - Stretching vibrations of C=C bonds in alkenes, terminal vinyl group, Terminal methylene group, 1,2- and 1,4-quinones, Stretching vibrations of the carbonyl group.
- 400-800 cm^{-1} Active bands in this region can be explained by Al-O bonds.

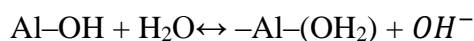
As can be seen from the spectra, the absorption (Abs) band corresponding to $\nu=1645\text{ cm}^{-1}$ increases with the absorbed dose. When the dose is increased to 55.4 kGy, Abs increases from 0.7 to 1.58, and the absorption band corresponding to $\nu=2961\text{ cm}^{-1}$ disappears at higher doses.

The observed patterns of radiolysis of wastewater in the presence of nano- γ -gamma- Al_2O_3 are associated with the additional formation of active centers when exposed to gamma radiation with oxide.

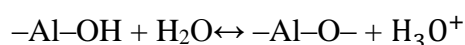
It is known that aluminum-oxygen bonds are hydrolyzed as follows:



As a result of further hydrolysis, the Al_2O_3 surface can acquire a weak excess positive charge:



Or a weak excess negative charge:



Thus, there are many acidic and basic sites on the oxide surface, and each site is capable of adding or removing only one hydrogen, hydroxide, or other singly charged ions [14].

4. Conclusion

1. The absorption band corresponding to $\nu=1645 \text{ cm}^{-1}$ increases with the absorbed dose. When the dose is increased to 55.4 kGy, Abs increases from 0.7 to 1.58, and the absorption band corresponding to $\nu=2961 \text{ cm}^{-1}$ disappears at higher doses.
2. The results obtained indicate the formation of new components by apparent desorption from the surface of nano- $\gamma\text{-Al}_2\text{O}_3$. In addition, a significant decrease in the composition of products at a wavelength of 200-210 nm indicates the decomposition of the components adsorbed on the surface of nano- $\gamma\text{-Al}_2\text{O}_3$. In all cases, centrifuged samples have a hypochromic effect, i.e. the peaks are shifted to the left.

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СПЕКТРОСКОПИЧЕСКИЕ ИССЛЕДОВАНИЯ ПРОДУКТОВ РАДИОЛИЗА БЫТОВЫХ СТОЧНЫХ ВОД В ПРИСУТСТВИИ НАНО- γ - Al_2O_3 ПОД ДЕЙСТВИЕМ ГАММА ИЗЛУЧЕНИЯ

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Резюме: В данной работе приведены УФ- и Фурье - ИК спектроскопические исследования продуктов радиолитического разложения бытовых сточных вод нефтеперерабатывающего завода в присутствии наночастиц γ - Al_2O_3 под действием гамма-излучения. Следили за образованием продуктов радиолитического разложения при различных поглощенных дозах ионизирующего излучения. Полученные результаты свидетельствуют об образовании новых компонентов, по видимому за счет их десорбции из поверхности наночастиц γ - Al_2O_3 .

Ключевые слова: Радиолитическое разложение, наночастицы γ - Al_2O_3 , бытовые сточные воды, ИК- спектроскопия, УФ- спектроскопия, мощность дозы

QAMMA ŞUALARIN TƏSİRİ ALTINDA NANO- γ - Al_2O_3 İŞTİRAKINDA MƏİŞƏT TULLANTI SULARININ RADİOLİZ MƏHSULLARININ SPEKTROSKOPİK TƏDQIQI

N.T. Məmmədova, Z.İ. İskəndərova, S.Z. Məlikova, M.Ə. Qurbanov

Xülasə: Bu məqalədə qamma şüalarının təsiri altında nano- γ - Al_2O_3 iştirakında neft emalı zavodunun məişət tullantı sularının radioliz məhsullarının UB və Furiye - İQ spektroskopik tədqiqatları öyrənilmişdir. İonlaşdırıcı şüalanmanın təsiri altında udulma dozasının müxtəlif qiymətlərində radioliz məhsullarının əmələ gəlməsi müşahidə edilmişdir. Nəticələrə əsasən demək olar ki, əmələ gələn məhsulların nano- γ - Al_2O_3 səthində desorbsiya olunması sistemdə yeni komponentlərin əmələ gəldiyini göstərir.

Açar sözlər: Radioliz, nano- γ - Al_2O_3 , məişət tullantı suları, IQ spektroskopiyası, UB spektroskopiyası, doza gücü