Journal of Radiation Researches, vol.9, No.1, 2022, Baku
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pp. 64-69

PACS: 61.80.Az,39.30.+w,28.41.Kw

THE INFLUENCE OF IONIZING RADIATION AND TEMPERATURE ON THE STRUCTURAL-GROUP COMPOSITION OF OIL DEPOSITS

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Abstract: The influence of gamma radiation and temperature on the structural-group composition of oil deposits (OD) formed on the surface of an oil pipeline during oil transportation has been studied. As a source of ionizing radiation, and isotopic source of gamma radiation Co^{60} – "MPX - γ -30" was used.

Keywords: gamma radiation, oil deposits, IR spectrum

1. Introduction

In the production, collection, transportation, and storage of oil, one of the problems that cause complications in the operation of technological equipment, containers and pipelines are asphalt and paraffin deposits. The accumulation of oil deposits in the flow path and containers leads to a sharp drop in system performance - and increase in pressure drops and a reduction in useful volumes /1/. The deposition process is quite complex. It depends on the physical and chemical characteristics of the pumped oil, the temperature mode of pumping, speed, temperature changes in the environment, and many other factors. Controlling the process of selecting effective solvents for removing deposits in oilfield and refinery equipment, as well as searching for their qualified use, requires a good knowledge of their physical and chemical properties /2/. Solving the problem of a large number of oil deposits (OD) is an urgent problem for the oil industry, as it will increase the depth of oil refining and reduce the negative impact of waste on the environment. It is also possible to use OD as a raw material for the production of bitumen for the construction of roads and buildings.

2. Research Methods

The influence of temperature on the structural-group composition of oil deposits has been studied. According to the IR spectra of the samples, changes in the composition of OD under the influence of temperature were established. To assess the role of radiation in the processes of cleaning oil pipelines from deposits and to determine the radiation resistance of OD, some patterns of radiation-chemical transformations of oil deposit samples were studied. The studies were carried out in the range of absorbed doses of gamma radiation D=3.4-326.4 kGy at a dose rate of P=0.19 gR/sec on the isotopic source of gamma radiation Co^{60} – "MPX - γ -30". Changes in the molecular structure were determined by IR spectroscopy using a Varian 640-IR Fourier spectrophotometer in the wavelength range of 4000–600 cm^{-1}; absorption bands were assigned according to /3/.

3. Results and discussion

The process of formation of oil deposits in the pipeline is determined by many factors, including changes in the temperature of the oil flow, therefore, it is important to study the effect of temperature on the structural-group composition of oil deposits /4/. A continuous decrease in the flow temperature occurs during transportation through the pipeline due to contact with the cooled metal surface, which leads to the release of crystals of paraffinic hydrocarbons. In this case, the temperature gradient is directed towards the center of the pipe, and in the direction of heat transfer, the formed crystals are deposited on the surface under the action of molecular diffusion. The greater the temperature gradient between the environment and the oil flow, the greater the number of oil deposits formed. Figures 1-2 show the IR spectra of oil deposit filtrates at room and elevated temperatures up to 80°C.

The IR spectra of OD filtrates at room temperature showed absorption bands at 2922, 2852, 2955, and 2925 cm^{-1}, which are responsible for the stretching vibrations of methyl CH_3 and methylene CH_2 groups.

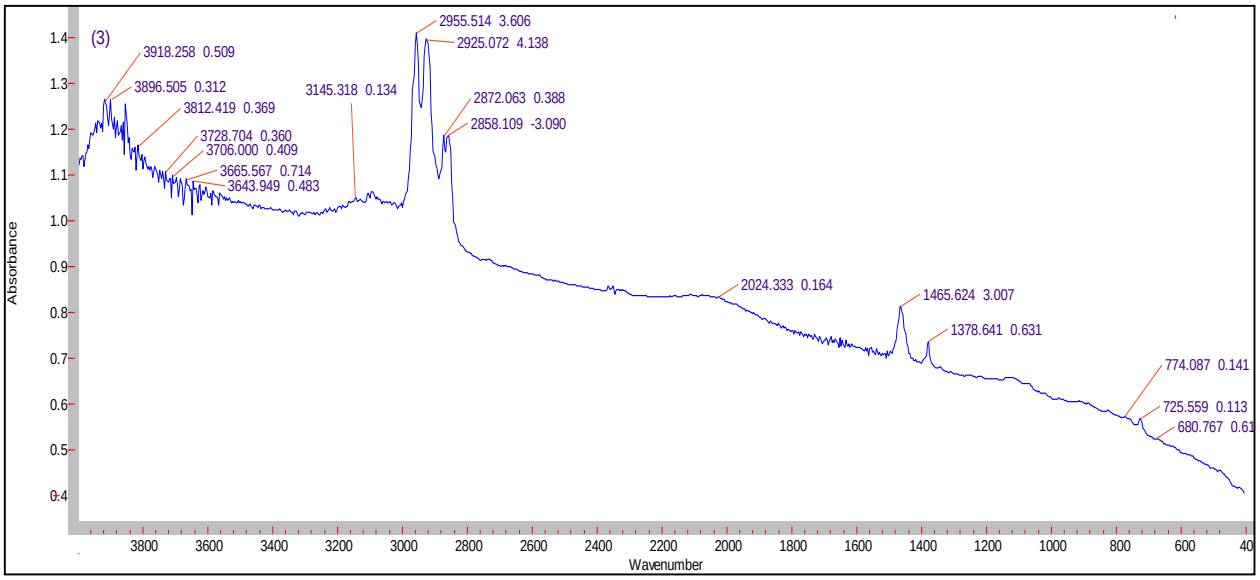

Fig. 1. IR spectrum of OD filtrate at room temperature.

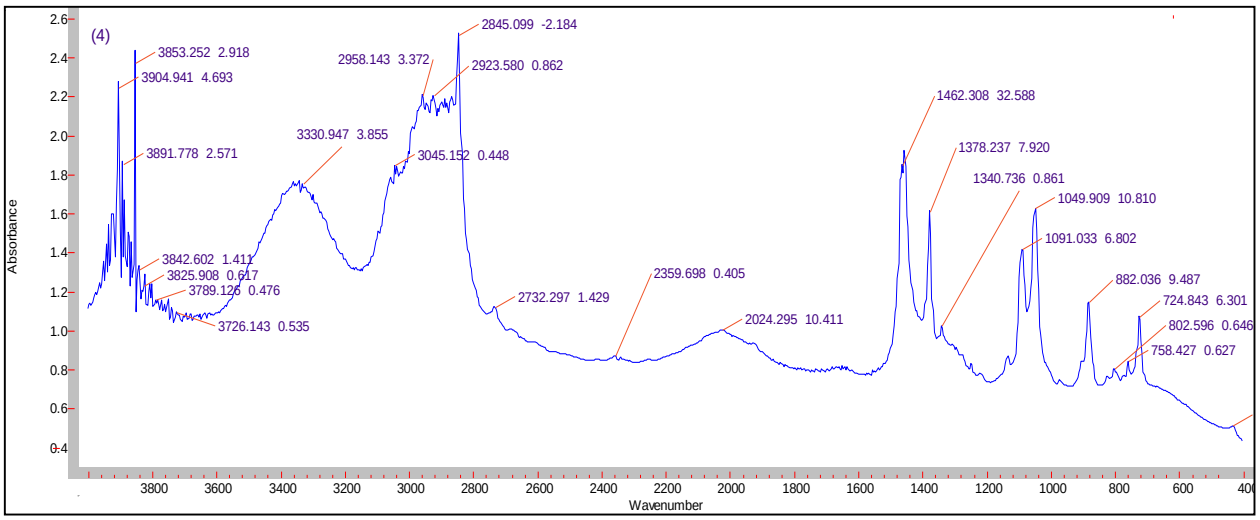

Fig. 2. IR spectrum of OD filtrate at (80°C).

The absorption bands at 1465, 1378, and 725 cm^{-1} correspond to bending vibrations of methylene CH_2 groups in paraffinic hydrocarbons. Absorption bands in the low-frequency region, at 750-720 cm^{-1}, are characteristic of long chains of the $(CH_2)_n$-type, where n > 4. In this case, there is an absorption band at 725 cm^{-1}, related to the pendulum vibrations of CH_2 groups of saturated hydrocarbon chains. A comparison of the IR spectra shows that significant changes occur after heating the filtrate. At T=80°C, absorption bands appear at 3330.3045 1340 and 758, 802, and 882 cm^{-1}, corresponding to out-of-plane bending vibrations of the substituted benzene (aromatic) ring. New bands appear in the wavelength range of 1049, 1091 cm^{-1}, responsible for the deformation vibrations of CH_3 and CH_2 groups - branched paraffin and cycloparaffin and low-substituted aromatic structures, and the intensity of the absorption bands at 1462, 1378.2858 - 2958 cm^{-1} increases significantly. These groups are likely redistributed in the OD structure upon heating. It is necessary to note the bands at 750 and 2958 cm^{-1}, which appear after heating to 80°C, indicating the content of methylene groups in five and six-membered saturated rings. Typically, oil deposits mainly consist of paraffin, resins, and asphaltenes (up to 50% wt.), insoluble oils (up to 40% wt.), mechanical impurities, or inorganic substances /5/. The structure of the resin molecule is benzene rings, which form an in-plane condensed polycarboxylic network. Five and six-membered naphthenic and heterocyclic rings may also form part of the formed network. The peripheral part of the condensed system of resins that make up OD is replaced by hydrocarbon radicals (aliphatic, cyclic, and mixed). Probably, when heated, there occurs redistribution of these groups in the structure of the oil deposit, namely, the cyclization of aliphatic groups and the formation of aromatic structures.

The influence of radiation on the structural-group composition of oil deposit samples was studied. Radiation-chemical transformations in the structural-group composition, OD at various absorbed doses of gamma radiation are shown in Fig. 3-6.

A comparison of the OD spectra before and after irradiation shows that after irradiation the spectra of the samples undergo significant changes. Depending on the irradiation time, changes occur in the regions of both stretching and bending vibrations of methyl CH_3 - and methylene CH_2 - groups. The absorption bands at 1440–1465 cm^{-1} and 722 cm^{-1} correspond to the stretching vibrations of the aromatic ring; at irradiation times of 48 h, the spectra of irradiated samples show a significant decrease in the intensity of these bands.

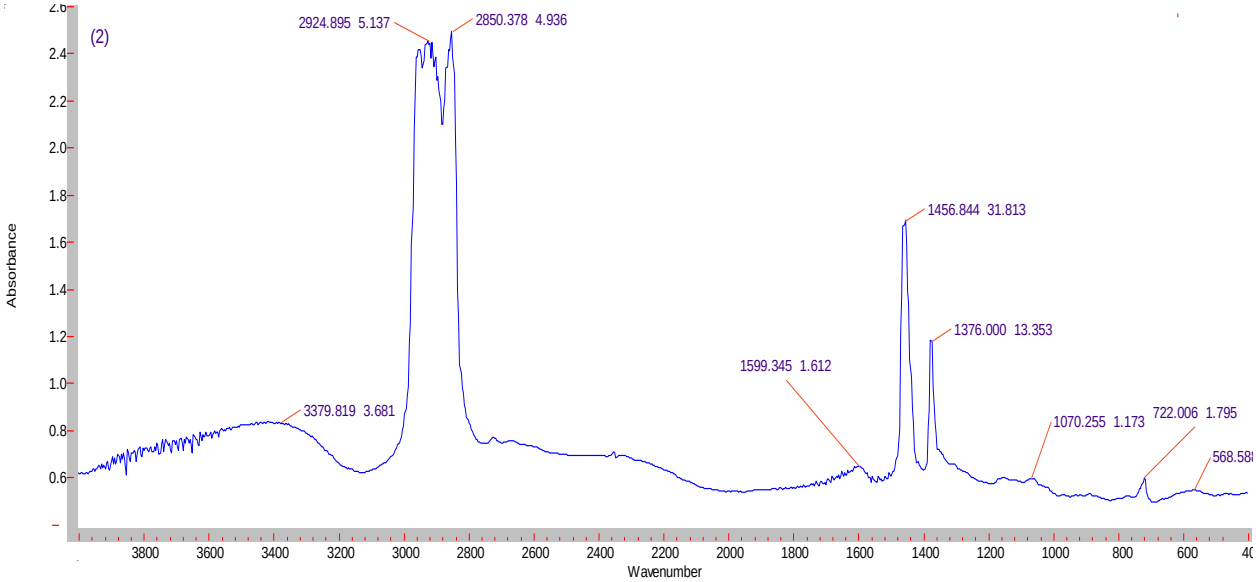

Fig. 3. IR spectrum of the OD sample before irradiation (D=0).

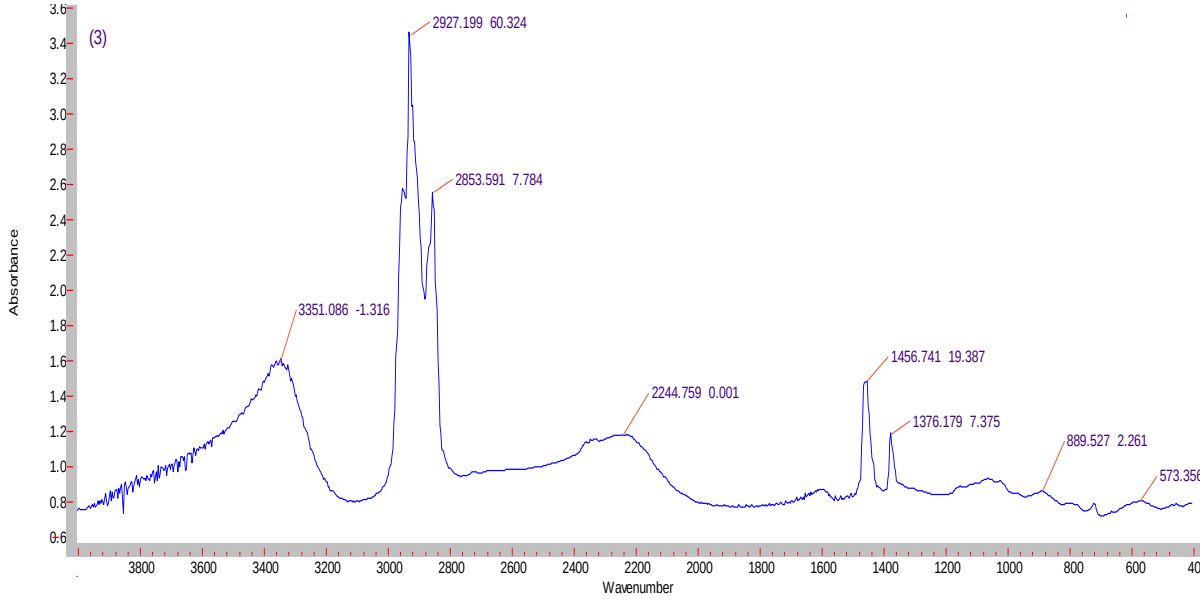

Fig. 4. IR spectrum of the OD sample at D=3.4 kGy.

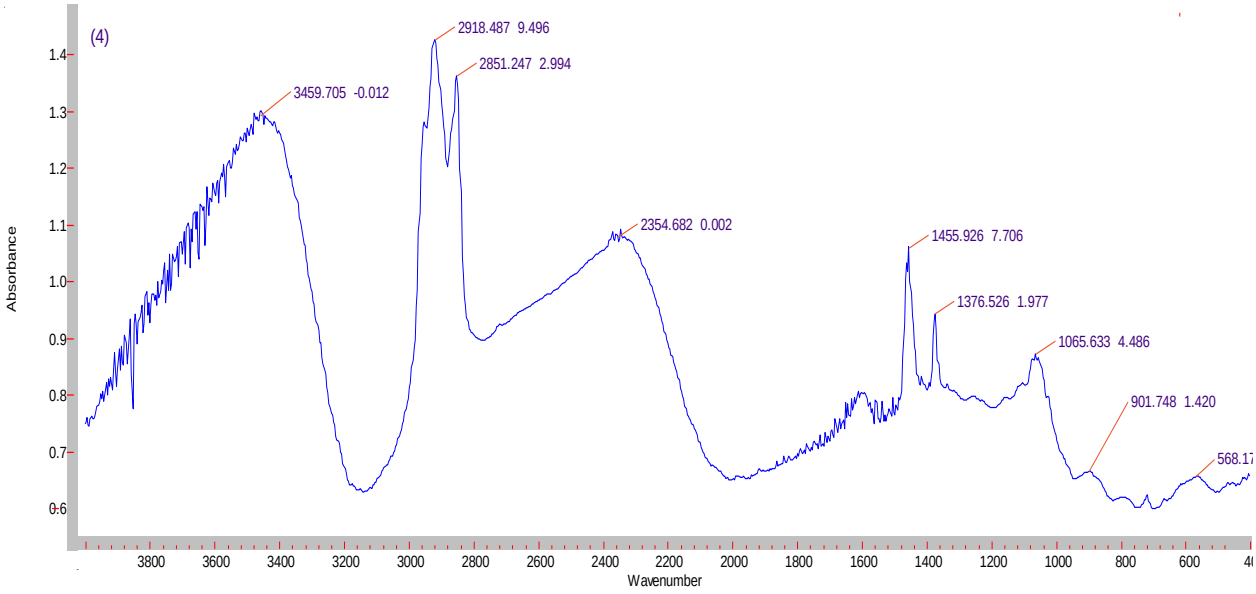

Fig. 5. IR spectrum of OD sample at D = 32.6 kGy.

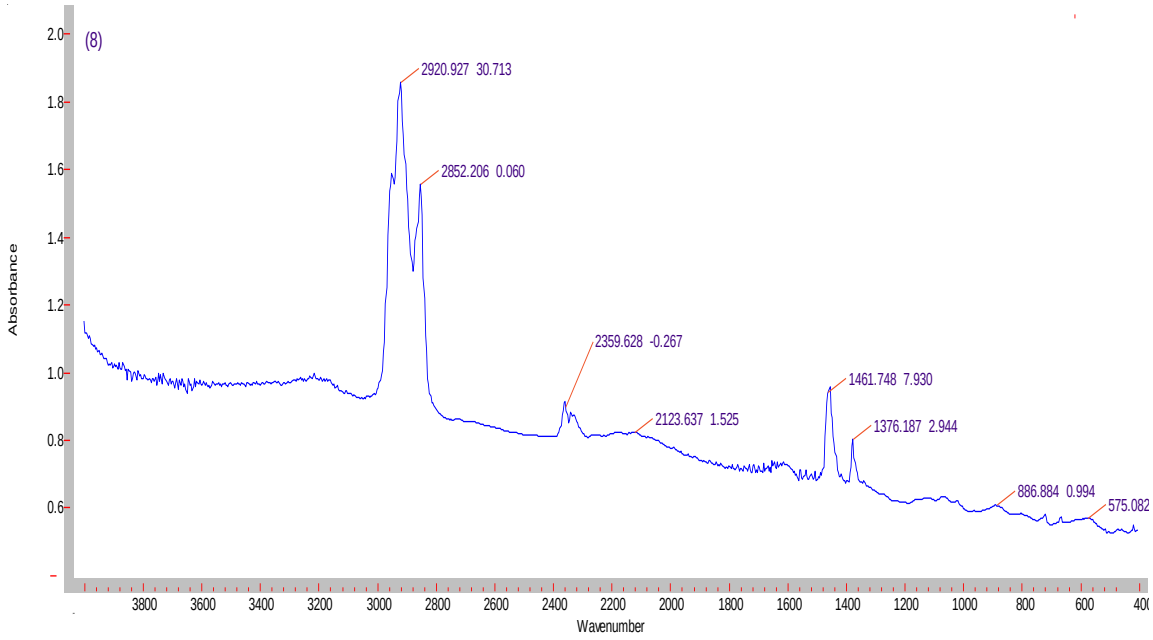

Fig. 6. IR spectrum of OD sample at D=326.4 kGy.

Further irradiation for 240 h. and 480 h. (163 and 326 kGy) leads to a partial restoration of the intensities of the absorption bands, which may indicate that at low doses of radiation, effective decomposition of aromatic compounds occurs, and a further increase in the dose of radiation leads to polycondensation processes.

The spectra of irradiated samples show a clear appearance of an absorption band at wavelengths of 2366 -2215 cm^{-1}, characterizing the cumulated double bonds =C=C, =C=X. These can be both aliphatic and aromatic groups in the composition of OD, the appearance of which is observed upon irradiation. When irradiated for 48 hours and 120 hours, new absorption bands at 1065 cm^{-1} appear, which characterize monosubstituted in-plane bending vibrations of C-H bonds of the aromatic ring, and bands at wavelengths of 3459–3324 cm^{-1}, corresponding to vibrations of OD hydroxyl groups, the bands disappear at 163 and 326 kGy irradiation. Increasing the dose leads to the loss of aromatic (polycyclic) structures, which is explained by the fact that large doses of radiation contribute to the destruction of the conjugation system, i.e. a significant part of the excitation energy is spent on breaking the C=C bond.

Thus, comparative studies of the IR spectra of the samples before and after OD irradiation showed that structural changes in the composition of oil deposits occur depending on the irradiation time and flow temperature. To choose the most appropriate method of dealing with deposits and, accordingly, chemical reagents, it is necessary to have an idea about their composition and properties.

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ВОЗДЕЙСТВИЕ ИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ И ТЕМПЕРАТУРЫ НА СТРУКТУРНО – ГРУППОВОЙ СОСТАВ НЕФТЯНЫХ ОТЛОЖЕНИЙ

Н.К. Гулиева, Ф. Чичек, С.З. Меликова, С.М. Мамедова

Резюме. Изучено влияние гамма-излучения и температурного режима на структурно-групповой состав нефтяных отложений (НО), образовавшихся на поверхности нефтепровода при транспортировке нефти. В качестве источника ионизирующего излучения использован изотопный источник гамма-излучения Co^{60} – «МРХ – γ -30».

Ключевые слова: гамма-излучения, нефтяные отложения, ИК-спектр

İONLAŞDIRICI ŞUALARIN VƏ TEMPERATURUN NEFT ÇÖKÜNTÜLƏRİNİN STRUKTUR-QRUP TƏRKİBİNƏ TƏSİRİ

N.K. Quliyeva, F. Çiçək, S.Z. Məlikova, S.M. Məmmədova

Xülasə: Neft nəqli zamanı neft kəmərinin səthində əmələ gələn neft çöküntülərinin (NQ) struktur-qrup tərkibinə qamma şüalanma və temperatur şəraitinin təsiri tədqiq edilmişdir. İonlaşdırıcı şüalanma mənbəyi kimi izotopik mənbə Co^{60}-"MPX - γ -30"-dən istifadə edilmişdir.

Açar sözlər: qamma şüalanma, neft çöküntüləri, İQ-spektr.