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THE INFLUENCE OF IONIZING RADIATION ON SOME PROPERTIES OF PETROL AI-92

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Abstract: As a research object it has been used the samples of petrol AI-92 from natural oil of Azerbaijan. Laboratory studies have been conducted on gamma-source Co^{60} at dose rate P=0,18 Gy/s within the absorption dose range D=15-150 kGy. The results of chromatographic, IR-spectroscopic studies have been given. The viscosity and density of the samples have been determined. Concentration, radiation-chemical yields of the obtained gases at different absorption doses of the samples of petrol AI-92 have been determined and their radiation resistance has been evaluated.

Keywords: petrol, fuel, radiolysis

1. Introduction

Petrol is a mixture of hydrocarbons of various structures of C_4-C_{12}. It is flammable liquid with a density of 700-780 kg/m^3, poignant smell, evaporates quickly, does not dissolve in water, burns without a trace. The boiling temperature is from 30^0C to 200^0C. All fuels are organic compounds of different complexity and under the influence of radiation energy there occurs a change in physical and chemical properties of fuels. The influence of radiation exposure on petrol composition, establishment of the links between the requirements for petrol composition and its radiation resistivity are of practical interest. Excited molecules, radicals are formed and gases escape under ionizing radiation influence on hydrocarbons. Chemical transformations are accompained by the changes in physical properties of fuel. While selecting fuel for being used under irradiation it is necessary to find out whether the fuel has sufficient radiation resistance, whether it is possible to increase its stability due to changes in the composition or introduction of special additives. Stability – the ability of fuel to keep its chemical structure under operating conditions within temperature changes, radiation, influence of metals. It is necessary to maintain the thermal stability of jet engine fuel for aircrafts even at low radiation doses. When it is not feasible, new types of fuels with adequate radiation resistance should be developed.

We studied several operational performance of fuel under static conditions in the usual manner before and after irradiation. The results of the experimental studies on radiation resistance of various oil products have been previously conducted in the papers (1,2).

2. Methodology

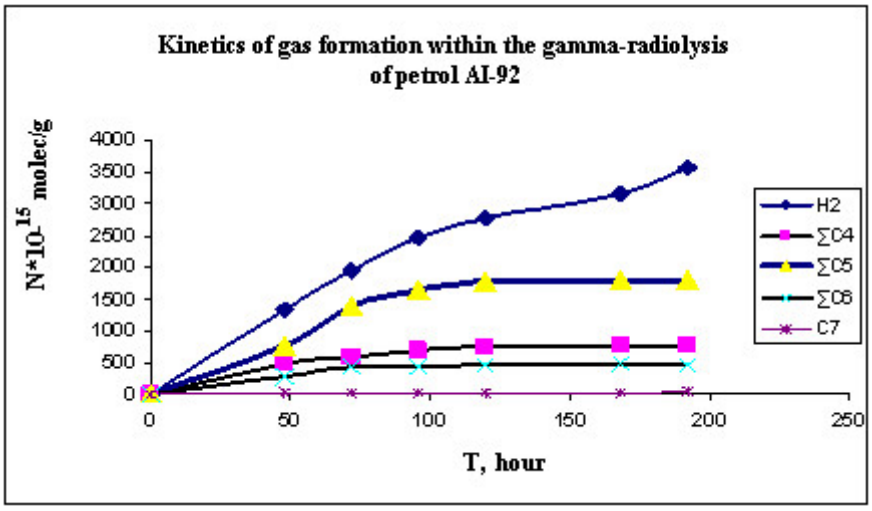
The samples (petrol AI-92 in 2,5 ml) placed in ampoules and sealed in vacuum, were irradiated at room temperature on gamma-source Co^{60} at dose rate P=0,18 Gy/s at different absorption doses: within the range of 15-150 kGy in vacuum so as to trace the kinetics of the current processes. As an ionizing radiation it was used γ-radiation source Co^{60} of type MPX γ-30.

IR-absorption spectra of the studied samples were registered on spectrometer VARIAN 640-IR (VARIAN Company) in the wavelength range (4000-400cm^{-1}). The samples were removed in the form of film with a thickness of d=1. Assignment of the bands of the obtained spectra was carried out as described in [3]. Gas products were analyzed by gas chromatography

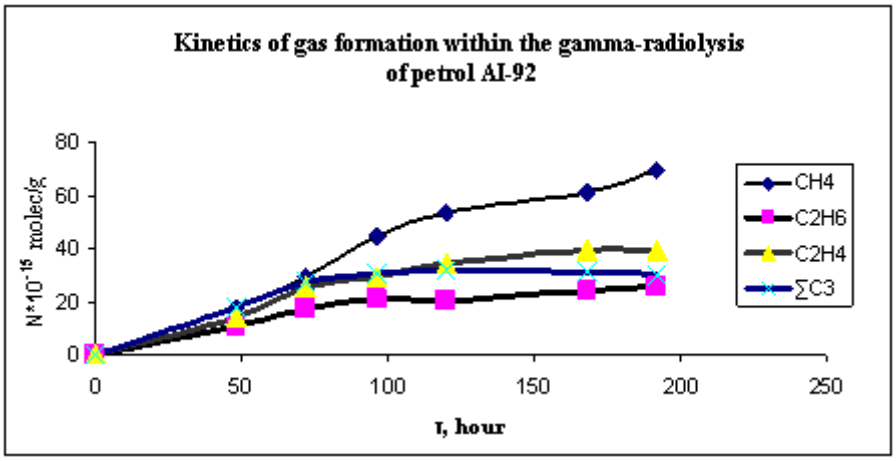
method. The density was determined by a pycnometer according to GOST 3900-85. The viscosity was determined according to GOST 33-66 by a viscometer of ВПЖ-2 type corresponding to GOST 10028-81. The aim of the work is the study of radiation resistance of the petrol AI-92 from Azerbaijan oil.

3. Experiments and results

Below are the kinetic curves of gas accumulation at gamma-radiolysis of the petrol AI-92 from Azerbaijan oil (fig.1).



(a)

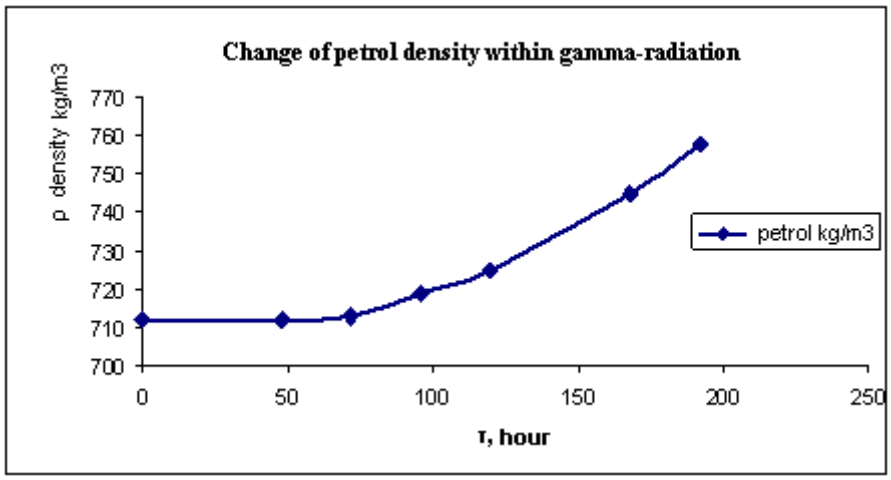


(b)

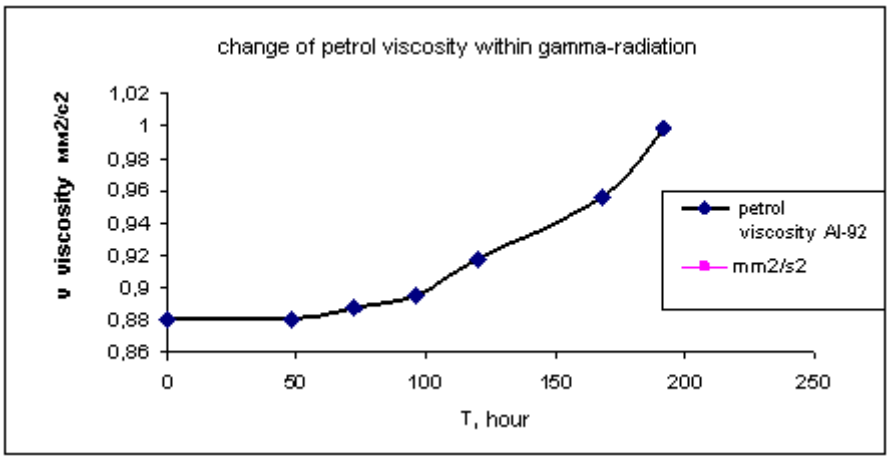
Fig. 1. (a,b) Kinetic curves of gas accumulation at gamma-radiolysis of the petrol AI-92 from Azerbaijan oil

The changes in viscosity and density of the initial petrol and after radiation exposure at different absorption doses are given below in fig. 2(a,b)

The viscosity of the initial petrol is 0,88 cSt(mm^2/c^2). The density of the initial petrol is 710 kg/m^3.



(a)



(b)

Fig. 2. (a,b) Changes in viscosity and density of petrol before and after radiation exposure.

Total radiation-chemical yields of gases of petrol AI-92 within absorbed dose range of 15-150 kGy have been presented in the table 1.

Table 1. Radiation-chemical yields of gases of petrol AI-92 within absorbed dose range of 15-150 kGy

Radiation-chemical yields of gases of petrol AI-92 within absorbed dose range of 15-150 kGy									
gases	H_2	CH_4	C_2H_6	C_2H_4	ΣC_3	ΣC_4	ΣC_5	ΣC_6	ΣC_7
Petrol AI-92	0,446	0,0074	0,0040	0,0057	0,0053	0,132	0,322	0,091	0,006

Results of IR - spectroscopic studies of petrol AI-92 samples have been shown below.

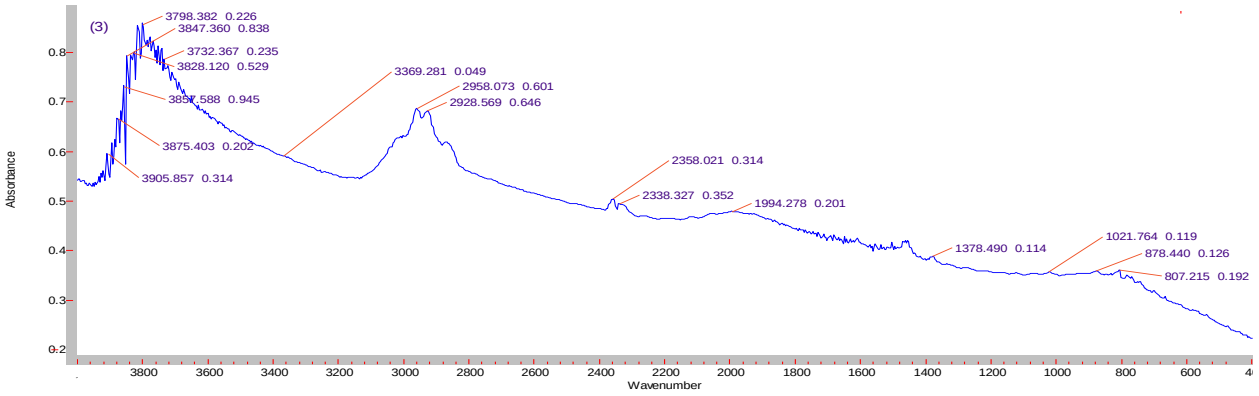
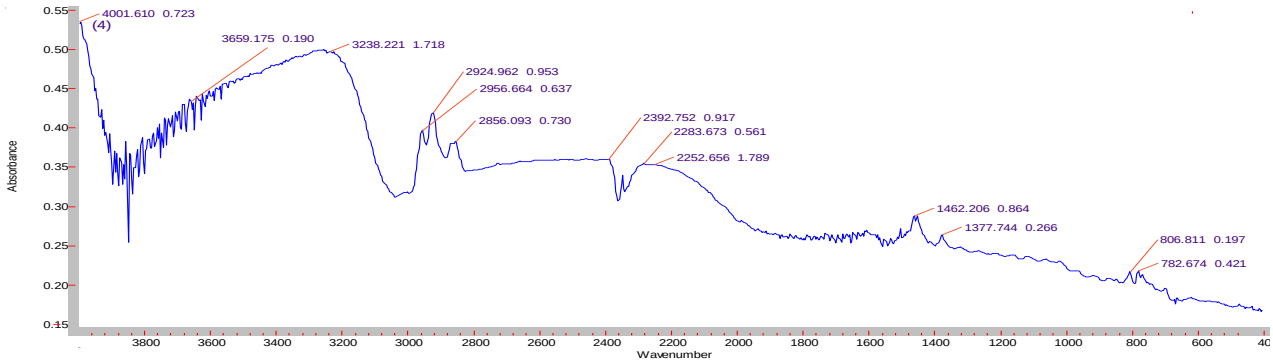


Fig. 3. IR - spectra of original petrol AI-92 (without irradiation)

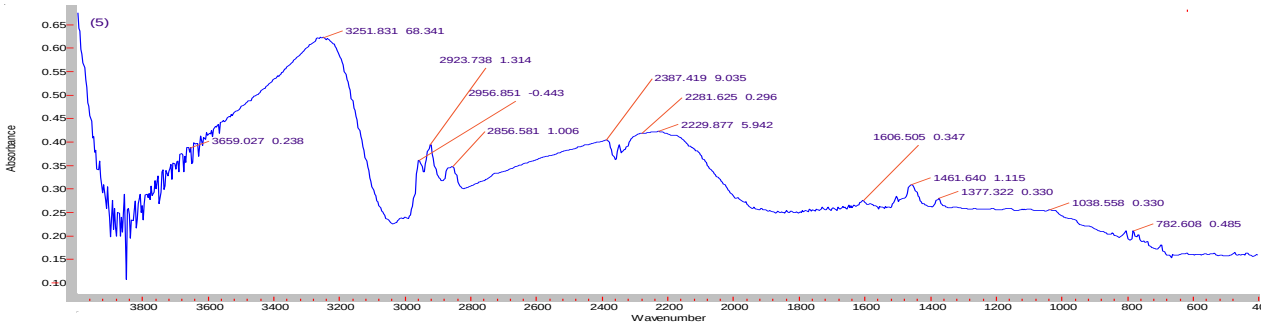
Out of plane deformation oscillations of C-H group in the field of 1000-650 cm^{-1}, 1021 cm^{-1}-condensed heterocycles.

(1380-1370) cm^{-1}- deformation oscillations of $-CH_3$- group. (2500-2300) cm^{-1}- amine salts $R_2C=NH^+$, (2975-2950) cm^{-1}- oscillations of bonds C-H in alkane, (3300-2500) cm^{-1}- oscillations of hydroxyl group and C-O bonds.



(a) IR - spectra of petrol after 120 hours irradiation (76 kGy) – AI-92

After 120 hours irradiation, twice decrease in (1000-650) cm^{-1}- intensity of out of plane deformation oscillations C-H, as well as decrease in deformation oscillation of $-CH_3$- groups (1370-1380 cm^{-1}) are observed. (1440-1480) cm^{-1}- deformation oscillation of CH_2-group is formed. 2252, 2283, 2392-(2860-2960 cm^{-1}) - valence oscillation of CH_3-group and 2940-2915 cm^{-1}- oscillation of $-CH_2$ bonds in alkanes decrease. There appears (3200-3400) cm^{-1} imines C=NH.



(b) IR – spectra of petrol after 240 hours irradiation (150kGy)

Fig.3. (a,b). IR-spectra of irradiated petrol a) (120 hours irradiation), b) (240 hours irradiation)

Out of plane deformation oscillation of C-H group in the range of 1000-650 cm^{-1}. There appears (1020-1075) cm^{-1}- aromatic and vinyl =C-O-C- group, (1410-1310) cm^{-1}- tertiary alcohols, oscillation of bonds of C-O-H groups, (1480-1400) cm^{-1}- deformation oscillation of - CH_2- group. After 240 hours irradiation, (1600-1440) cm^{-1}- valence oscillation of = CH bonds is formed, 1650-1580 cm^{-1} pyridines and quinolines appear, the intensity of the bands of 2300-2230cm^{-1} - azo compound and (3310-3200) cm^{-1}- the absorption band of alkyne and triple bonds increase. Intensity of band of CH_3 group attached to heteroatoms (2860- 2975) cm^{-1} decreases.

4. Discussion of the results

Under the influence of radioactive radiation in fuels, there occurs ionization of medium, formation of free radicals. Under these conditions, simultaneously with the low molecular compounds, dimers and polymers are formed in fuel, as the products of recombination of radicals as a result of cracking, dehydrogenation, isomerization and polymerization of hydrocarbons. These processes are intensified and acquire oxidative character in the presence of oxygen. Simultaneously joining linear molecules and their splitting occur within the radiation. Splitting occurs always, since the gas is released from organic substances during radiolysis. Gas phase consists of hydrogen and low molecular hydrocarbons. Under the influence of radiolysis, secondary, tertiary and quaternary C-C bond and secondary C-H bond break down. Yields of gaseous products and hydrogen decrease under the irradiation of alkenes. Physical structuring appears in liquids in the change of viscosity and density. At high altitude, the hydrocarbon fuel in the aircraft can be under the influence of high-energy cosmic particles. However, the processes arising due to the radiolysis can grow after termination of irradiation, which leads to a change in the fuel composition. This is especially true for the oxidation processes accompanying with formation of peroxides. As a result of radiolysis operating properties of oil fuel deteriorate (4-5).

5. Results

Chemical processes, changes in density and viscosity occur in petrol within absorbed dose range 15-150 kGy. The effect of radiation influence on hydrocarbons of fuel depends on chemical structure, fuel composition. When the formation of radicals slow down at low temperatures, small amount of seal products are formed in hydrocarbon medium as a result of radiation. But operational performance of oil fuels deteriorate and compress sprayer even in a slight resin formation at the temperature of ambient air. In the future, it will be necessary to select such composition of oil fuel, which will withstand the effect of irradiation by changing hydrocarbon composition of oil products due to minor changes in the composition and introduction of additives.

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ВОЗДЕЙСТВИЕ ИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ НА НЕКОТОРЫЕ ХАРАКТЕРИСТИКИ БЕНЗИНА АИ-92

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Резюме: В качестве объекта исследования использовались образцы бензина АИ-92 из нефти Азербайджана. Лабораторные исследования проводились на гамма-источнике Co^{60} при мощности дозы P=0,18 Гр/с в пределах поглощенных доз D=15-150 кГр. Представлены результаты хроматографического, ИК-спектроскопического исследований. Определены вязкости и плотности образцов. Определены концентрации, радиационно-химические выходы полученных газов при различных поглощенных дозах образцов бензина АИ-92 и оценена их радиационная стойкость.

Ключевые слова: бензин, топливо**,** радиолиз.

BENZİN Aİ-92 BƏZİ XÜSUSİYYƏTLƏRİNƏ İONLAŞDIRICI ŞÜANIN TƏSİRİ

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Xülasə: Tədqiqat obyekti olaraq Azərbaycan neftindən alınmış Aİ-92 benzinindən istifadə olunmuşdur. Laboratoriya tədqiqatları Co^{60} qamma şüalanma mənbəyində udulan dozanın D=15-150 kQr intervalında və doza gücünün P=0.18 Qr/s qiymətində aparılmışdır. Nümunələrin özlülük və sıxlığı müəyyən edilmişdir. Xromatoqrafiya nəticələri və İQ -spektrləri təyin edilmişdir. Benzin Aİ-92 nümunələrinin müxtəlif udulmuş dozalarda alınan qazların qatılığı, radiasiya-kimyəvi çıxımı müəyyən edilmiş və onların radiasiyaya davamlılığı qiymətləndirilmişdir.

Açar sözlər: benzin, yanacaq, radioliz