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**Abstract**

**Full Text**

## **CHEMISTRY**

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### **VISCOSITY PROPERTIES OF ALKYLAROMATIC HYDROCARBONS AND THEIR HYDROGENATED ANALOGS**

A study of the viscosity properties of aromatic hydrocarbons containing isolated benzene rings and of their hydrogenated analogs (Table 1) showed that the change in the viscosity of hydrocarbons as a result of hydrogenation depends to a great extent on the structure of the hydrocarbons. It was established that hydrogenation of certain structures leads to an unusual decrease in viscosity.

The aromatic hydrocarbons of composition  $C_{24}^*$  studied by us can be divided into two groups. The first group includes hydrocarbons that do not contain substituents in the ring (hydrocarbons Nos. 1-5, Table 1); the second, hydrocarbons containing methyl groups in the ring (Nos. 6-8, Table 1). For the first group of hydrocarbons, in all cases hydrogenation—i.e., the transition from aromatic hydrocarbons to naphthenic ones—causes an increase in viscosity and a worsening of the temperature dependence of viscosity (a greater increase in viscosity with decreasing temperature).

An increase in viscosity upon hydrogenation of aromatic hydrocarbons, mono- and polycyclic, has been noted in the literature. The data obtained by us indicate that this rule can also be extended to polycyclic aromatic hydrocarbons with isolated benzene rings that do not contain alkyl-group substituents in the ring.

Upon hydrogenation of bicyclic aromatic hydrocarbons containing methyl groups in the benzene ring (Nos. 6-8, Table 1), naphthenic hydrocarbons were obtained whose viscosity is considerably lower than the viscosity of the initial aromatic hydrocarbons. For the hydrocarbons studied, the greatest decrease in viscosity occurred upon hydrogenation of the aromatic hydrocarbon containing two methyl groups in the ring. Thus, a dependence was observed opposite to that described above for aromatic hydrocarbons that do not contain substituents in the ring. For clarity, Table 2 gives comparative viscosity data for both types of hydrocarbons, methylated and nonmethylated.

As is seen from Table 2, the viscosity of 1,3-di-(2,5-dimethylphenyl)-2-

amylpropane (No. 8) upon hydrogenation to 1,3-di-(2,5-dimethylcyclohexyl)-2-amylpropane (No. 16) decreased, when viscosity was measured at temperatures of 50, 0, and  $-20^{\circ}$ , by factors of 1.6, 14, and 12.6, respectively. Correspondingly, a considerable improvement in the temperature dependence of viscosity was observed: the ratio  $\eta_{0^{\circ}}/\eta_{50^{\circ}}$  for the aromatic hydrocarbon was 95.7, and for its hydrogenated analog 37.7.

As already noted above, and as is seen from the data in Table 2, the viscosity level of hydrocarbons methylated in the ring, especially aromatic ones, is considerably higher than the viscosity level of nonmethylated hydro-

\* The synthesis and properties of the hydrocarbons have been partly described (<sup>4</sup>).

**Table 1**

**Structure of the investigated aromatic hydrocarbons and their hydrogenated analogs**

1. [[chemical structural formula diagram; biphenyl-type structure with substituent $C_{11}$ ]]	6. [[chemical structural formula diagram; methyl-substituted aromatic rings connected through an aliphatic chain, with substituent $C_7$ ]]	11. [[chemical structural formula diagram; two phenyl rings connected by an aliphatic chain, with substituent $C_7$ ]]
2. [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure, with substituents $C$ , $C$ , and $C_8$ ]]	7. [[chemical structural formula diagram; substituted aromatic rings connected through an aliphatic chain, with substituent $C_7$ ]]	12. [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure with a cyclopentyl substituent]]
3. [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure, with substituent $C_7$ ]]	8. [[chemical structural formula diagram; dimethyl-substituted aromatic rings connected through an aliphatic chain, with substituent $C_6$ ]]	13. [[chemical structural formula diagram; three phenyl/cycloalkyl aromatic groups connected by an aliphatic chain]]
4. [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure with a cyclopentyl substituent]]	9. [[chemical structural formula diagram; biphenyl-type structure with substituent $C_{11}$ ]]	14. [[chemical structural formula diagram; methyl-substituted phenyl-aliphatic-phenyl structure, with substituent $C_7$ ]]

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<b>5.</b> [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure with a cyclopentyl substituent]]	<b>10.</b> [[chemical structural formula diagram; phenyl-aliphatic-phenyl structure, with substituents $C_7$ , $C_7$ , and $C_8$ ]]	<b>15.</b> [[chemical structural formula diagram; substituted phenyl-aliphatic-phenyl structure, with substituent $C_7$ ]]
		<b>16.</b> [[chemical structural formula diagram; methyl-substituted phenyl-aliphatic-phenyl structure, with substituent $C_5$ ]]

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hydrocarbons of similar structure. The sharp increase in the viscosity of the hydrocarbon observed upon methylation of its benzene rings is apparently connected with the unusual ratio of the viscosities of the methylated aromatic hydrocarbon and its hydrogenated analog—the naphthenic hydrocarbon.

The phenomenon observed by us is of exceptional interest for solving general questions concerning the dependence of the viscosity of hydrocarbons on their structure and, at the same time, makes it possible to interpret in a new way certain results of the investigation of petroleum aromatic fractions by the hydrogenation method.

Studies by other authors have shown that hydrogenation of synthetic polycyclic aromatic hydrocarbons consisting of condensed benzene rings leads to a decrease in viscosity and an increas-

**Table 2**

**Effect of hydrogenation on the viscosity properties of bicyclic aromatic hydrocarbons of composition  $C_{24}$  containing methyl groups in the ring**

No. of aromatic hydrocarbon	Formula	Viscosity (centipoise) at 50°	Viscosity (centipoise) at 0°	Viscosity (centipoise) at -20°	$\eta_{0^\circ}/\eta_{50^\circ}$
3	benzene ring-C-C-C(C <sub>7</sub> )-C-C-benzene ring	7.10	65.3	361	9.2
11	cyclohexane ring-C-C-C(C <sub>7</sub> )-C-C-cyclohexane ring	15.2	239	1778	15.7
8	dimethylbenzene ring-C-C-C(C <sub>5</sub> )-dimethylbenzene ring	27.8	2660	146000	95.7
16	dimethylcyclohexane ring-C-C-C(C <sub>5</sub> )-dimethylcyclohexane ring	17.3	646	11590	37.3

to a decrease in the viscosity index, whereas hydrogenation of aromatic hydrocarbons consisting of isolated benzene rings, on the contrary, leads to an increase in viscosity and a decrease in the viscosity index (<sup>1, 2</sup>). At the same time, as was established ((<sup>1</sup>), p. 326), hydrogenation of narrow oil fractions of petroleum consisting of polycyclic aromatic hydrocarbons leads to a considerable decrease in viscosity, the greater the more aromatic rings are contained in the hydrocarbons. By analogy with the hydrogenation of synthetic hydrocarbons, these data were regarded as substantial confirmation that the polycyclic aromatic hydrocarbons of petroleum oil fractions practically all belong to various kinds of condensed

systems.

Such indeed “exceptional types” of polycyclic aromatic hydrocarbons, upon hydrogenation of which a decrease in viscosity is observed, include, for example, alkylated derivatives of anthracene, phenanthrene, and naphthacene (<sup>2</sup>, <sup>3</sup>).

The results obtained by us make it possible to believe that the decrease in viscosity upon hydrogenation of the higher petroleum fractions may also result from the presence in them of polycyclic aromatic hydrocarbons with isolated benzene rings containing alkyl (methyl) groups in the ring. The cause of the unusual change in viscosity of certain types of aromatic hydrocarbons upon hydrogenation is unknown. Apparently, this phenomenon, as we have shown, is connected with the unusually high viscosity of the aromatic hydrocarbons themselves.

The task for the near future is to investigate new non-condensed aromatic structures possessing the peculiar viscosity properties described above.

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*Note: Figure translations are in progress. See original paper for figures.*

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