Methods of Determination Viscosity Index Improvers for Multi-grade Oil of Copolymer Hydrogenated Poly (isoprene-co-styrene)

Ioana Stanciu

University of Bucharest, Faculty of Chemistry, Department of Physical Chemistry, 4-12 Elisabeta Blvd, 030018, Bucharest, Romania

Abstract: To establish the ability of copolymer hydrogenated poly (isoprene-co-styrene) solutions in SAE 10W mineral oil as solvent to perform at low and high temperatures in a vehicle's engine, that is their capacity to improve the oil viscosity index of their 3, 3.5, 4, 4.5 and 5 % solutions were determined two methods. The kinematic viscosities of the concentrated copolymer hydrogenated poly (isoprene-co-styrene) solutions were determined using a set of Schott Ubbelohde-type viscometers selected according to the values of their constants and viscosities of solutions, so that the margins of the uncertainty, inherent in the Hagebach-Couette correction, does not exceed the error allowed for the measurements. Viscosity index is determined using the formula much higher than that determined by the software.Viscosity index of the solution copolymer of 3 % is 67.04 units lower than that, for of 3.5 % is 140.35 units higher than that, for of 4 % is 140.17 units higher than, for of 4.5 % is 139.17 units lower than that and for of 5 % is 140.15 units lower than the one obtained with formula (1) according to ASTM standard.

Keywords: viscosity index improvers, multi-grade oil, copolymer

1. Introduction

With the development of modern technology, manufacturing technology and transmits engine oil would be impossible without the use of a lubricant additive. Industry producing additives for oil lubricants worked in partnership with the automotive industry to enhance durability and performance systems and creating a suitable lubricant engines [1-3]. Additives are synthetic chemicals that added oil based lubricants can improve performance. Some additives give new and useful properties of the lubricant; others can enhance properties already present, while some acts to reduce engine life. The most important types of additives are viscosity index improvers such as viscosity modifiers known [2-5]. Viscosity index is an indicator of viscosity change with temperature. A higher viscosity index indicates that oil viscosity changes very little with increasing temperature. Improvement of viscosity limits change viscosity with temperature. These enhancers have little effect on oil viscosity at low temperatures. However, when these heated oil viscosity improvers allow growth in a limited premise of the type and concentration of the additive. This quality is most evident in the implementation of engine oils several degrees.

Viscosity index depends on oil viscosity and temperature [4-5]. This results in changing the configuration of the polymer in the solvent with increasing temperature. The polymer molecule in solution exists as a coil, which is swollen by a solvent of the lubricating oil.

The volume of this molecule increases the lubricating oil viscosity. At low temperatures, the polymer molecules adopt a spiral configuration, so their effect on viscosity is minimized. At high temperatures, molecules tend to straighten and the interaction of these molecules long oil increases in volume and she produces a thickening effect, which in turn increases the viscosity index of the oil.

An ideal lubricant is possessing the same viscosity at all temperatures and for all purposes [6-9].

Viscosity index modifiers add lubricating oils to make them conform more ideal lubricant. Suitable polymers exert a greater thickening effect (percent increase in oil viscosity based on

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unit weight of polymer) at high temperatures than at low temperatures [10-12] and thus improve the viscosity index of the lubricating oil [13-15].
The purpose of this study was the determination of the viscosity of the solutions in two ways copolymer of styrene-hydrogenated polyisoprene three concentrations, 3.5, 4, 4.5 and 5g/dL.

2. Materials

The copolymer hydrogenated poly (isoprene-co-styrene) is Infineum SV 260 commercialized by Infieum UK Limited. The SAE 10W oil is used so predominantly paraffinic hydrocarbons containing 75 % saturated.
Dissolution of the copolymer hydrogenated poly (isoprene-co-styrene) in the oil SAE 10W was conducted at room temperature with gentle stirring for several weeks. Solutions of concentration 6 g / dL brew was then diluted with mineral oil SAE 10W to achieve concentrations of 3, 3.5, 4, 4.5 and 5g/dL.
The kinematic viscosities of the concentrated copolymer hydrogenated poly (isoprene-co-styrene) solutions 3, 3.5, 4, 4.5 and 5g/ dL were determined using a set of Schott Ubbelohde-type viscometers selected according to the values of their constants and viscosities of solutions, so that the margins of the uncertainty, inherent in the Hagebach-Couette correction, does not exceed the error allowed for the measurements. The measurements were carried out at 40 ± 0.1 and 100 ± 0.1^{o}C, according to the recommandation of ASTM D2270 [15-20]. They were possible only for 3, 3.5, 4, 4.5 and 5 g/dL solutions with the available set of viscometers.

3. Results and discussion

Multi-grade oils which have a viscosity index greater than 100 and viscosity index occur equation parameters U and H, and N, where U is the viscosity of the multi-grade oil at a temperature of 40^{o}C.
The IV is defined by a new parameter N, calculated from H and Y rather than H and L:

$$IV = 100 + 140((antilog\ N) - 1 \quad (1)$$

$$N = (log\ H - log\ U)/log\ Y \quad (2)$$

All logarithms are to base 10. Y is the value of kinematic viscosity multi-grade oil at 100 ^{o}C. Values of L and H for higher viscosities are calculated from two equations:

$$L = 0.8385Y^2 + 14.67Y - 216 \quad (3)$$

$$H = 0.1684Y^2 + 11.85Y - 97 \quad (4)$$

For Y >70.
The viscosity index for solutions copolymer hydrogenated poly (isoprene-co-styrene) of 3, 3.5, 4, 4.5 and 5 % concentrations calculation was performed with a computer program developed by INCERP SA, created in Visual Basic using kinematics viscosity at 40^{o}C and 100^{o}C [9].
The kinematic viscosities of 3, 3.5, 4, 4.5 and 5 g/dL copolymer solutions Infineum SV 260 in SAE 10W as solvent were measured at 40 and 100^{o}C, according to ASTM D2270 [15], and the viscosity indices were determined using the ASTM D-341 diagrams, shown in Figures 1, 2, 3, 4 and 5.

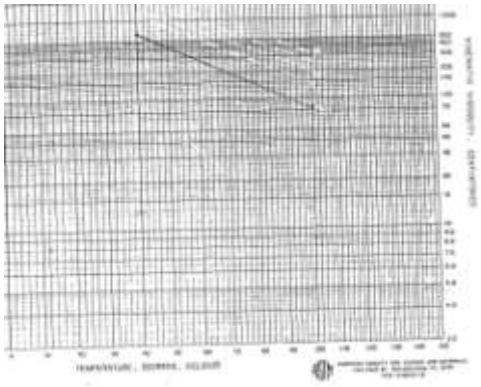

Fig. 1. ASTM D-341diagram for determination of viscosity indices of SAE 10W oil and concentrated copolymer Infineum SV 260 solution 3 %

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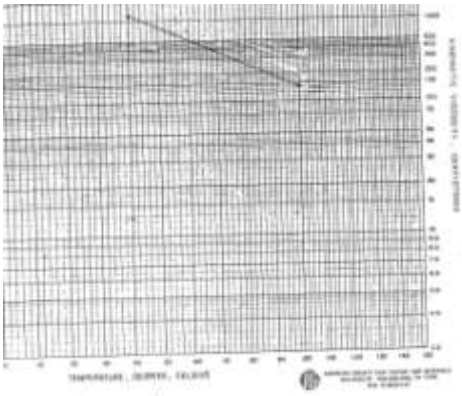

Fig. 2. ASTM D-341diagram for determination of viscosity indices of SAE 10W oil and concentrated copolymer Infineum SV 260 solution 3.5 %

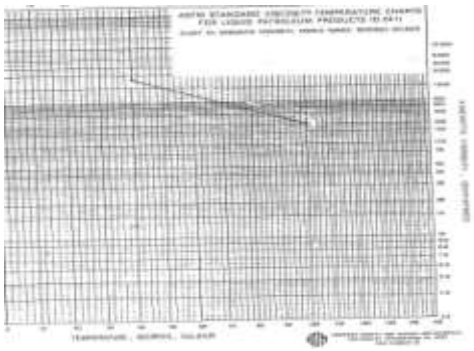

Fig. 3. ASTM D-341diagram for determination of viscosity indices of SAE 10W oil and concentrated copolymer Infineum SV 260 solution 4 %

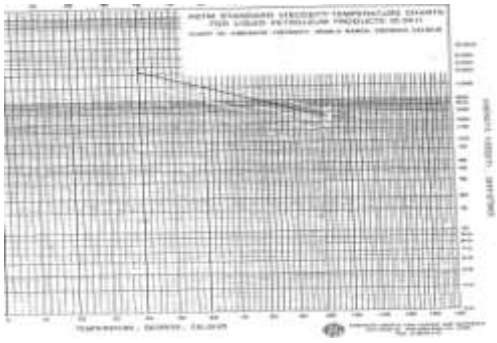

Fig. 4. ASTM D-341diagram for determination of viscosity indices of SAE 10W oil and concentrated copolymer Infineum SV 260 solution 4.5 %

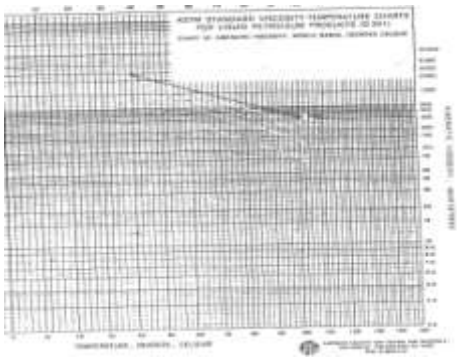

Fig. 5. ASTM D-341diagram for determination of viscosity indices of SAE 10W oil and concentrated copolymer Infineum SV 260 solution 5 %

As can be seen in the slope of the lines 5 graphics solution decreases with increasing concentration. The slope has the lowest concentration solution 5 % and the largest concentration of 3 % solution. Table 1 shows the kinematic viscosity of the copolymer solutions determined at 40 and 100^{o}C, viscosity indices determined using equation (1) and viscosity indices determined with cun computer software solutions styrene-hydrogenated polyisoprene copolymer concentrations 3, 3.5, 4 4.5 and 5 %.

Viscosity index of the solution copolymer hydrogenated poly (isoprene-co-styrene) of 3 % concentration obtained with equation (1) is 67.04 units lower than that obtained with the software but is still at the standard ASTM 2270. To 3.5 % solution copolymer hydrogenated poly (isoprene-co-styrene), the viscosity index is 140.35 units higher than that obtained with formula (1). The 4 % concentration solution copolymer hydrogenated poly (isoprene-co-styrene) has viscosity index of 140.17 units higher than that obtained with the formula (1). For 4.5 % solution copolymer hydrogenated poly (isoprene-co-styrene), the viscosity index is 139.17 units lower than the one obtained with formula (1) according to ASTM standard.

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Table.1. Values of kinematic viscosities at 40 and 100°C, viscosity index improvers for solution copolymer hydrogenated poly (isoprene-co-styrene)

Fluid	ν, cSt		Viscosity index equation (1)	Viscosity index program VI
	40°C	100°C		
Infineum SV 260				
3% solution	600	78.5	282.04	215
3.5% solution	1083	138.2	379.35	239
4% solution	1564	198.4	398.17	258
4.5% solution	2053	258.5	411.37	272
5% solution	2536	318.3	424.15	284

Viscosity index of the solution copolymer hydrogenated poly (isoprene-co-styrene) of 3 % concentration obtained with equation (1) is 67.04 units lower than that obtained with the software but is still at the standard ASTM 2270. To 3.5 % solution copolymer hydrogenated poly (isoprene-co-styrene), the viscosity index is 140.35 units higher than that obtained with formula (1). The 4 % concentration solution copolymer hydrogenated poly (isoprene-co-styrene) has viscosity index of 140.17 units higher than that obtained with the formula (1). For 4.5 % solution copolymer hydrogenated poly (isoprene-co-styrene), the viscosity index is 139.17 units lower than the one obtained with formula (1) according to ASTM standard.

For 5 % concentration solution copolymer hydrogenated poly (isoprene-co-styrene), the viscosity index is 140.15 units lower than the one obtained with formula (1) according to ASTM standard.

The chart shows that by introducing the additive in oil SAE 10W viscosity index increase is significant, especially since the concentration is higher, but as the solution concentration increases (the amount of additive is greater), viscosity indices tend to a limit.

4. Conclusion

The viscosity indices of 3, 3.5, 4, 4.5 and 5 % solutions of copolymer hydrogenated poly (isoprene-co-styrene), recommended as viscosity index improvers, in SAE 10W mineral oil as solvent were determined using the ASTM 2270-93 diagram and two methods according to the recommandation of ASTM D2270.

Viscosity index of the solution copolymer hydrogenated poly (isoprene-co-styrene) of 3 % is 67.04 units lower than that, for of 3.5 % is 140.35 units higher than that, for of 4 % is 140.17 units higher than, for of 4.5 % is 139.17 units lower than that and for of 5 % is 140.15 units lower than the one obtained with formula (1) according to ASTM standard.

References

1. Smeeth M, Spikes H, & Gunsel S. Boundary film formation by viscosity index improvers. Tribology transactions 1996;39(3):726-734.
2. Horne WV. Polymethacrylates as viscosity index improvers and pour point depressants. Industrial & Engineering Chemistry. 1949;41(5):952-959.
3. Eckert RJA & Covey DF. Developments in the field of hydrogenated diene copolymers as viscosity index improvers. Lubrication Science.1998;1(1): 65-80.
4. Mueller HG. Mechanism of action of viscosity index improvers. TRIBOLOGY international. 1978;11(3):189-192.
5. Jukic A, Vidovic E & Janovic Z. Alkyl methacrylate and styrene terpolymers as lubricating oil viscosity index improvers. Chemistry and Technology of Fuels and Oils. 2007;43(5):386-394.
6. Stanciu I, Rheological behaviour of mineral oil. Journal of Science and Arts. 2011; 4(17):487-490.
7. Horowitz HH. Predicting Effects of Temperature and Shear Rate on Viscosity of Viscosity Index–Improved Lubricants. Industrial & Engineering Chemistry. 1958;50(7):1089-1094.

(doi:1444-8939.2018/5-4/MRR.47)

8. Fan J, Müller M, Stöhr T, & Spikes HA. Reduction of friction by functionalised viscosity index improvers. Tribology Letters.2007;28(3):287-298.
9. Smeeth M, Spikes H & Gunsel S. Performance of viscosity index improvers in lubricated contacts. Langmuir.1996;12(19): 4594-4598.
10. Azim AA, Nasser AM, Ahmed NS, El Kafrawy AF, & Kamal RS. Multifunctional additives viscosity index improvers, pour point depressants and dispersants for lube oil. Petroleum Science and Technology. 2009;27(1):20-32.
11. Jordan EF, Smith S, Koos RE, Parker WE, Artymyshyn B, & Wrigley AN. Viscosity index. I. Evaluation of selected copolymers incorporating n-octadecyl acrylate as viscosity index improvers. Journal of Applied Polymer Science 1978;22(6):1509-1528.
12. Stanciu I. Methods for calculating the viscosity index hydaulic oil. Journal of Science and Arts. 2012;2(19):189-192.
13. Stambaugh RL. Viscosity index improvers and thickeners. In Chemistry and technology of lubricants (pp. 124-159). Springer US. 1994.
14. Mohamed MM, El Naga A, Hamdi H, & El Meneir MF. Multifunctional viscosity index improvers. Journal of Chemical Technology and Biotechnology. 1994;60(3):283-289.
15. Nassar AM & Ahmed NS. Synthesis and evaluation of ethoxylated polyesters as viscosity index improvers and pour point depressants for lube oil.International Journal of Polymeric Materials.2003; 52(9):821-832.
16. Stanciu I. Viscosity index improvers for multi-grade oil of copolymers polyethylene-propylene and hydrogenated poly (isoprene-co-styrene). Journal of Science and Arts. 2017;4(41):771-778.
17. Morgan S, Ye Z, Subramanian R, & Zhu S. Higher-molecular-weight hyperbranched polyethylenes containing crosslinking structures as lubricant viscosity index improvers. Polymer Engineering & Science 2010;50(5),911-918.
18. Lariviere D, Asfour AFA, Hage A, & Gao J Z. Viscometric properties of viscosity index improvers in lubricant base oil over a wide temperature range. Part I: group II base oil. Lubrication Science. 2000;12(2),133-143.
19. Stanciu I. Determination viscosity index improvers for multi-grade oil of copolymer polyethylene-propylene Journal of Science and Arts. 2018;1(42), 197-202.
20. Stanciu I. Viscosity index for soybean oil. MAGNT Research Report 2018;5(3),447-449.

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