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VISCOSITY IMPROVERS FOR COPOLYMER POLYETHYLENE - POLYPROPYLENE SOLUTIONS

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Abstract. *In this article we presented viscosity indices for poly (ethylene-co-propylene) copolymer solutions in rapeseed oil using three methods. Viscosity indices are calculated from the measured viscosity at 40 and 100 ºC according to ASTM D 2270, using program VI and graphical method from ASTM D 341. The viscosity-temperature coefficients for poly (ethylene-co-propylene) copolymer solutions in rapeseed oil were calculated from the measured viscosity at 40 and 100 ºC.*

Keywords: *oils, viscosity index, rapeseed oil, solutions.*

1. INTRODUCTION

As the uppermost herbaceous edible oil crop in Romania, rape (Brassica Napus) has been planted for thousands of years. The rapeseed oil extracted from the rape seed is top-quality edible oil, which contains rich fact acids, fast-soluble vitamins, phospholipids and pigments but lacks cholesterol [1]. The color of rapeseed is deep yellow. The characteristic of large viscosity, least saponification value among semi-drying oils and high-content erucic acid can be used to distinguish rapeseed oil from other vegetable oils [2, 3]. Viscosity index, or VI, is a means of expressing the variation of viscosity with temperature. VI is also widely used as a rough measure of the paraffinic or naphthenic hydrocarbon character of oil. The decrease in viscosity with temperature in commercial lubricant products is described by the so called viscosity index, VI. This is an empirical number indicating the rate of change in viscosity of oil within a given temperature range [4]: high numbers indicate a low change, while low numbers a relatively large change. These numbers can only be compared within a viscosity range. Ideal oil for most purposes is one that maintains a constant viscosity throughout the temperature changes [5]. The importance of the VI can be shown by considering automotive lubricants: oil having high VI resists excessive thickening when the motor is cold, promoting rapid starting and prompt circulation, and resists excessive thinning when the engine is hot, providing full lubrication and preventing excessive oil consumption.

The object of the present paper is the determination of viscosity index for concentrated solutions rapeseed oil and poly (ethylene-co-propylene). Copolymer ethylene-propylene is an excellent viscosity index improver.

2. MATERIALS AND METHODS

Vegetable oil used in this work is provided by a company in Bucharest, Romania. The copolymer used as viscosity improver is poly (ethylene-co-propylene). Dissolution of polymer in rapeseed oil was realized at room temperature with gentle shaking now and then.

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Solutions of concentrations 1, 2, 3, 4 and 5 g/dL were prepared by dissolving the copolymer at room temperature and stirring continued.

The kinematic viscosities of the mineral oil and concentrated copolymer 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. The measurements were carried out at 40 ± 0.1 and 100 ± 0.1 ºC, according to the recommandation of ASTM D2270 [6].

3. RESULTS AND DISCUSSION

Viscosity is a measure of an oil thickness and ability to flow at certain temperatures, while viscosity index is a lubricating oil quality indicator, an arbitrary measure for the change of its kinematics viscosity with temperature providing an insight into the oil's ability to perform at high and low temperatures [7]. The viscosity-temperature relationship represents the manner in which the viscosity of a given fluid varies inversely with temperature. Given the mathematical relation existing between these two quantities, it is possible to predict graphically the viscosity of a petroleum fluid at any temperature within a limited range if the viscosities at two other temperatures are determined.

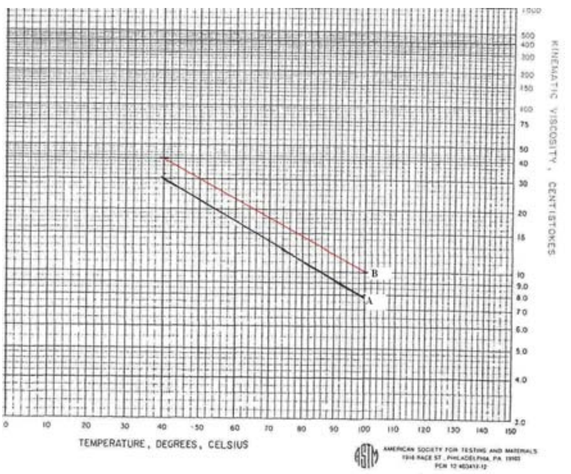

Fig. 1. ASTM D 341 diagram for determination of viscosity index: A - rapeseed oil; B – rapeseed oil and poly (ethylene-co-propylene) 1%.

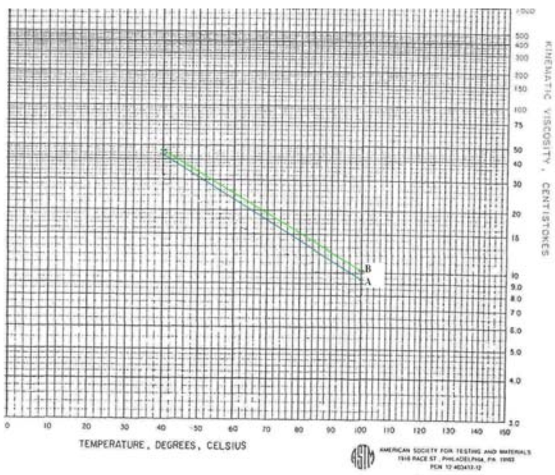

Fig. 2. ASTM D 341 diagram for determination of viscosity index: A - rapeseed oil and poly (ethylene-co-propylene) 2%, B- rapeseed oil and poly (ethylene-co-propylene) 3%.

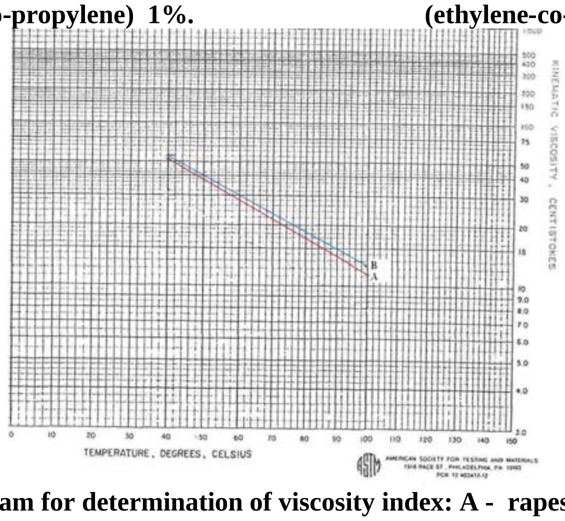

Fig. 3. ASTM D 341 diagram for determination of viscosity index: A - rapeseed oil and poly (ethylene-co-propylene) 4%, B- rapeseed oil poly (ethylene-co-propylene) 5%.

For this purpose the ASTM Standard Viscosity-Temperature Charts for Liquid Petroleum Products, available in 6 ranges, are used [8]: the two known viscosity-temperature points are located on the chart and a straight line is drawn through them. The other viscosity-temperature values of the given fluid will fall on this line.

Multi-grade oils typically begin as base oils. Then special oil-soluble organic polymers, called viscosity index improvers, are added in an effort to bring the difference in viscosities closer together. The viscosity still varies logarithmically with temperature, but the slope representing the change is lessened [9-11]. This slope, which represents the change in viscosity with temperature, depends on the nature and amount of the additives to the base oil.

The kinematic viscosities of poly (ethylene-co-propylene) solutions of (1, 2, 3, 4 and 5g/dL) concentrations decrease with temperature after Andrade equation [12].

The kinematic viscosities of 1, 2, 3, 4, and 5 g/dL copolymer solutions in rapeseed oil as solvent were measured at 40 and 100 ^{o}C, according to ASTM D 2270 [6], and the viscosity indices were determined using the ASTM 2270-10 diagram, shown in Figures 1-3.

In the calculation of VI, for each viscosity at 100 ^{o}C (called Y), the ASTM Method D 2270 gives the value of two parameters, called L and H. L is the 40 ºC viscosity of oil having the same 100 ºC viscosity as the test oil, but a VI of zero. H is the 40 ºC viscosity of second oil, also with the same 100 ºC viscosity, but with a VI of 100:

$$IV = 100 \times (L - U)/(L - H) \quad (1)$$

The values obtained for the viscosity indices of 1, 2, 3, 4 and 5% poly (ethylene-co-propylene) solutions are given in Table 1, together with their kinematic viscosities at 40 and 100 ºC, viscosity index from relationship (1), from program and viscosity-temperature coefficients calculated with eq. (2). The viscosity index calculation was performed with a computer program developed by INCERP SA, created in Visual Basic.

Table 1. Values of kinematic viscosities at 40 and 100 ºC, viscosity index calculated with eq. (1) and computer program, viscosity-temperature coefficients.

Fluid	ν, cSt		Viscosity index calculated with eq. (1)	Viscosity index from program VI	Viscosity-temperature coefficient calc.with eq. (2)
	40 ºC	100 ºC			
Rapeseed oil	34.26	7.51	156	195.79	0.7807
1% solution	38.42	9.90	162	258.42	0.7668
2% solution	43.23	9.25	202	204.08	0.7772
3% solution	45.24	10.12	217	219.98	0.7788
4% solution	50.25	11.15	231	222.38	0. 7819
5% solution	53.13	12.03	245	230.78	0.7820

Viscosity index of the solution of 1% concentration obtained with equation (1) is 96.42 units lower than that obtained with the software but is still at the standard ASTM 2270. To 2% solution, the viscosity index is 2.08 units higher than that obtained with formula (1). The 3% concentration solution has viscosity index of 2.98 units higher than that obtained with the formula. For 4% solution, the viscosity index is 8.62 units lower than the one obtained with formula (1) according to ASTM standard.

For 5% concentration solution was obtained at higher viscosity index. The chart shows that by introducing the additive in rapeseed oil 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. The dependences of viscosity indices on concentration of copolymer are shown in Fig. 4.

Another indication of the change in kinematics viscosity with temperature, which is less arbitrary than the viscosity index, is the viscosity-temperature coefficient, VTC, defined by the relationship [13, 14]:

$$VTC = (A - B)/A \qquad (2)$$

where A is the viscosity (cSt) at 40 ºC and B – viscosity at 100 ºC. The calculated values of VTC are given also in Table 1. They are in accordance with the values of VI and the previously published results on the efficiency of the copolymer as viscosity improver obtained using the dynamic viscosities [5].

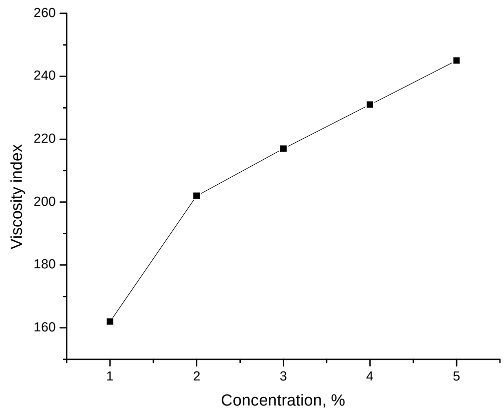

Fig. 4 Dependence of viscosity index on copolymer concentration.

4. CONCLUSIONS

The introduction of the polymer in rapeseed oil significantly increases the value of the viscosity, the more so as its concentration is higher.

Viscosity indices obtained with the computer program are, generally, a few units higher than those obtained by the graphical method and with equation (1). Viscosity index of rapeseed oil solutions with polymer poly (ethylene-co-propylene) is significantly higher than those of rapeseed oil.

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