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Effect of Surfactant Tween 80 (Polyoxyethylene Sorbitan Mono Oleate) Addition on Viscosity and Activation Energy on Making Asphalt Emulsion

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Abstract. Asphalt emulsion is a mixture of asphalt (55% - 65%), water (35% - 45%) and emulsifier material (1% - 2%). This research studied the effect of adding surfactant tween 80 (polyoxyethylene sorbitan mono-oleate) on the viscosity and activation energy. The research data was obtained by mixing asphalt, surfactant tween 80, and water and then heated at a certain temperature and viscosity values were measured using a Brookfield Viscosimetre at 500 rpm. The results show that the viscosity and the activation energy increase with the addition of surfactant tween 80: η = -49,82380 cp end Ea = 9,18452154 kJ/mol

Keywords: Asphalt emulsion, activation energy, surfactant tween 80, viscosity

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1 Introduction

Nowadays, highway infrastructure in Indonesia is still a big problem due to some of these highways need rejuvenation or repair every year and this requires a lot of funds from the state budget (APBN) every year. Therefore, it is necessary to find solutions to be able to reduce these expenses. One way is very possible to avoid state losses is to assess the durability of durable and quality asphalt. Based on the strength or resistance of the highway was made quickly damaged, of course, many factors cause it. It might the weakness of chemical interaction between the asphalt and its aggregates (Tamrin, 2011).

Asphalt is known as a material that is viscous or solid, black or brown, which has adhesion (adhesive), containing the main parts of hydrocarbons produced from petroleum or natural occurrence (natural asphalt) and dissolved in carbon disulfide. Asphalt is produced from selected crude oil through the petroleum distillation process. The distillation process is done by

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heating to 350°C under atmospheric pressure to separate light fractions, such as gasoline, kerosene, and gas oil (Wignall, 2003).

Asphalt has several disadvantages such as deformation (change shape) permanently caused by heavy pressure by excessive truck loads, cracks caused by heat, and also damage caused by moisture. It happens in all asphalt mixtures (Brown, 1990).

Various studies have been conducted such as Ahmed M. Al-sabagh (2001) on the relevance of HLB of surfactants on the stability of emulsion asphalt, also Marketa Cervinkova (2006) studied emulsion asphalt using waste modification as a reinforcing material from a mixture of ionic and cationic surfactants which concluded that the addition of ionic and cationic surfactants and addition of reinforcing had produced the high adhesion asphalt emulsions.

Therefore, it is necessary to research to make the high adhesion asphalt emulsion based on the addition of surfactant Tween 80 (Polyoxytilen Sorbitan Mono oleate) that can increase the viscosity and activation energy of the asphalt emulsion produced.

2. Material and Methods

2.1 Materials

Bitumen type grade 60/70, was collected from Iran. Tween 80 surfactants and distilled water were purchased from Merck (Darmstadt, Germany).

2.2 Preparation of Asphalt

Asphalt was weighed with the variations of 55 g, 60 g, 65 g, 70 g, and 75 g and heated at temperature variations of 80°C, 90°C, 100°C, 110°C, and 120°C. Then, as much as 10 g of distilled water was prepared for each of the variations. Tween 80 surfactants were weighed with variations of 35 g, 30 g, 25 g, 20 g, and 15 g.

2.3 Fabrication of Asphalt Emulsion

As much as 55 g of asphalt was heated at 80°C while stirring. and then slowly added 35 g Tween 80 into the asphalt. As much as 10 g was slowly added. The asphalt, distilled water, and surfactant mixture were stirred at 500 rpm with a mechanical stirrer to ensure that it was well combined. The same experiments were carried out with a variation of 10 g of water and the ratio of asphalt to surfactant (w/w): (55:35); (60:30); (65:25); (70:20) and (75:15) at 90°C, 100°C, 110°C and 120°C.

2.4 Viscosity Test

Firstly, the temperature controller was set up from 80°C to 120°C. Then, the test tube was filled with asphalt according to the spindle used. The clamp was utilized to insert the tube containing

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the test object into the water bath. Next, placed the viscosimeter directly above the water bath. The spindle was assembled then to the viscosimeter and the viscosimeter was dismounted in order for the spindle can enter into the test object. The asphalt was then allowed to reach 80°C to 120°C. The viscosimeter Brookfield was operated at 500 rpm and recorded 3 readings every 60 seconds of each temperature test, then the viscosity was measured.

3 RESULT AND DISCUSSION

Viscosity test results for asphalt: surfactant: and water were conducted in the PT. SMART, Tbk Lab, Medan are shown in Tables 1, 2, 3, and 5.

Tabel 1. Viscosity test results (55: 35: 10)

T (K)	1/T (K)	η (cp)	1/η (cp)	ln 1/η (cp)
353	0,00283286.	25000	0,0000400000	-10,1266
363	0,00275482	23000	0,0000434783	-10,0432
373	0,00268097	21000	0,0000476190	-9,95228
383	0,00261097	20000	0,0000500000	-9,90349
393	0,00254453	18000	0,0000555556	-9,79813
	0,01342414	107000	0,0002366530	-49,82380

Tabel 2. Viscosity test results (60: 30: 10)

T (K)	1/T (K)	η (cp)	1/η (cp)	ln 1/η (cp)
353	0,00283286	27800	0,0000359712	-10,2328
363	0,00275482	26000	0,0000384615	-10,1659
373	0,00268097	24000	0,0000416667	-10,0858
383	0,00261097	23000	0,0000434783	-10,0432
393	0,00254453	21500	0,0000465116	-9,7581
	0,01342414	122300	0,0002060890	-50,5035

Tabel 3. Viscosity test results (65: 25: 10)

T (K)	1/T (K)	η (cp)	1/η (cp)	ln 1/η (cp)
353	0,00283286	35000	0,0000285714	-10,4631
363	0,00275482	34000	0,0000294118	-10,4341
373	0,00268097	32300	0,0000309598	-10,3828
383	0,00261097	30000	0,0000333333	-10,309

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393	0,00254453	29500	0,0000338983	-10,2921
	0,01342414	160800	0,0001561750	-51,8811

Tabel 4. Viscosity test results (70: 20: 10)

T (K)	1/T (K)	η (cp)	1/η (cp)	ln 1/η (cp)
353	0,00283286	39000	0,0000256410	-10,5713
363	0,00275482	37000	0,0000270270	-10,5187
373	0,00268097	36000	0,0000277778	-10,4913
383	0,00261097	35000	0,0000285714	-10,4631
393	0,00254453	34000	0,0000294118	-10,4341
	0,01342414	181000	0,0001384290	-52,4785

Tabel 5. Viscosity test results (75: 15: 10)

T (K)	1/T (K)	η (cp)	1/η (cp)	ln 1/η (cp)
353	0,00283286	31000	0,0000322581	-10,3417
363	0,00275482	29000	0,0000344828	-10,2751
373	0,00268097	27500	0,0000363636	-10,2219
383	0,00261097	26000	0,0000384615	-10,1659
393	0,00254453	25000	0.0000400000	-10,1266
	0,01342414	138500	0,0001815660	-51,1312

3.1 Effect of Temperature on Viscosity

From the calculation results obtained the ln 1/η value and 1 / T value, then made a graph of the relationship between 1/η and 1/T.

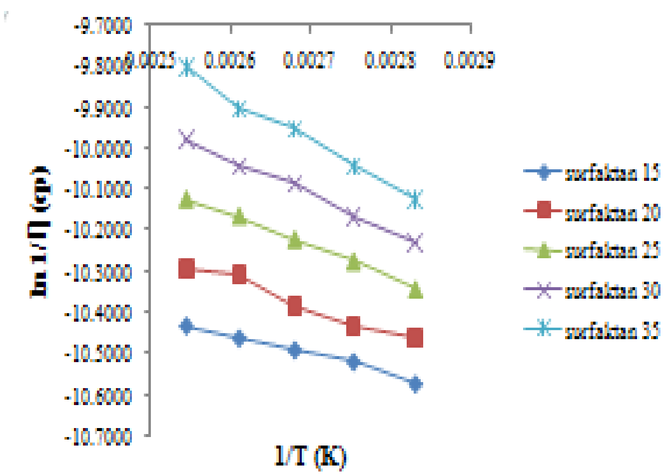

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Figure 1. Graph of relationship between 1/η and 1/T

The relationship between the 1/η and 1/T graphs indicated in figure 1 shows that the viscosity value in the fabrication of asphalt emulsion was decreasing with an increase in temperature which the temperature increased by 10°C. As depicted in figure 1 can be seen that at 353 K obtained the viscosity value of -10.12660 cp while -9.79813 cp was obtained at 393 K. It proved that the temperature was very significant in the heating process. According to the literature study with the Arrhenius equation which stated that the higher temperature of the molecules present in the compound will change rapidly, so the compounds were more easily melt in the sample. This is made possible by the presence of higher collisions in molecules.

In Tabel 2, 3, 4, and 5 the similar cases were happened that the viscosity value decreased with the higher temperature. Finally, it can be concluded that increasing temperature inversed with decreasing the viscosity value result.

3.2 Effect of Surfactant Addition on Viscosity

From the calculation test results obtained viscosity value shown in Tabel 5 and figure 2 as follows:

Table 6. Effect of surfactant on viscosity

Surfactant (g)	**ln 1/ η (cp)**
35	-49,82380
30	-50,50350
25	-51,13120
20	-51,88110
15	-52,47850

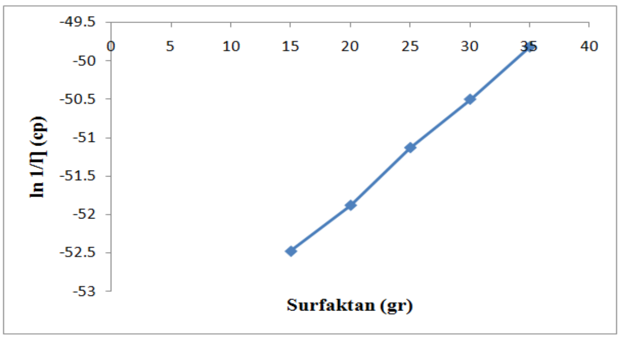

Figure 2. Graph of relationship between surfactant with viscosity value

From figure 2, the relationship between surfactant with viscosity value could be seen that the addition of more surfactant accordingly higher the viscosity value. It showed that the greater concentration of surfactants added inflicted the greater viscosity value of asphalt and water. It

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was caused due to the surfactant molecules added would interact with the molecules of asphalt and water, thus changing the arrangement of non-polar and polar phase molecules. On the other hand, the changes in the arrangement of water and asphalt molecules will cause the viscosity of the system to change. In contrast, the factors that affect the viscosity of an emulsion are the viscosity of the dispersion medium, the percentage volume of the dispersion medium, the size of the dispersed phase particles, and the type and concentration of the emulsifier/stabilizer used. The higher viscosity and the percentage of the dispersion medium, so the higher viscosity of the emulsion. Thus, the smaller particle size of an emulsion accordingly the higher viscosity and the higher concentration of the emulsifier/stabilizer used.

Theoretically, the addition of surfactant concentration will retard the flow time of the asphalt-water system because surfactants can increase the viscosity of asphalt water.

3.3 Effect of Surfactant Addition on Activation Energy

From the results of the calculation, the activation energy value obtained is indicated in Tabel 7 and 3 as follows :

Table 7. Effect of surfactant addition on activation energy

Surfactant (g)	ln 1/ η (cp)
35	9.18452154
30	7.34929625
25	6.23411128
20	5.38391700
15	3.81833694

Then a graph was made of the relationship between surfactants with the activation energy value.

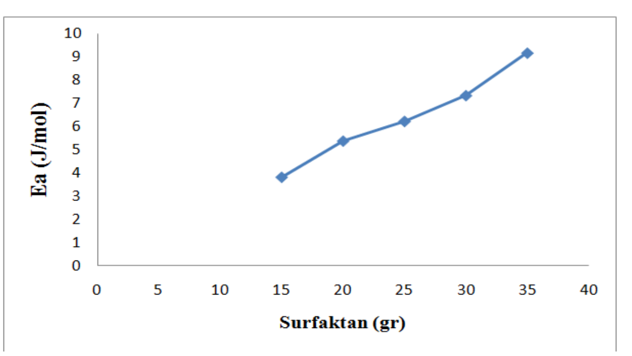

Figure 3. Relationship between surfactant and activation energy

From figure 3, of the relationship between surfactant with the activation energy value, could be seen that the addition of more surfactant accordingly higher the activation energy value. It showed that the greater concentration of surfactants added inflicted the greater activation energy value of asphalt and water. M. Al-sabagh (2001) has reported the addition of the molecular weight of surfactants used will increase the activation energy and accordingly can change the asphalt and pores values investigated. Associated with Hydrophyle Lypophyle Balance (HLB) surfactant and also concluded that the increase of molecular weight of surfactants will give a large impact on activation energy value, and also concluded that the high activation energy has a binding force with its aggregates. This statement was also supported by Marketa Cervinkova (2009) who has studied the emulsion asphalt.

Based on the theory that it is explained, the addition of Tween 80 surfactant caused increasing in activation energy value with an increasing average of about 100 points as increased surfactant. Due to surfactants have a hydrophilic group and a lipophilic group that can unite a mixture of oil and water.

4 Conclusion

The emulsion asphalt produced in this study is based on the Arrhenius equation. From the results obtained asphalt emulsion which had the optimum result was in the ratio of asphalt: surfactant: water (55: 35: 10) with the value of viscosity (ln 1/η) of -49.82380 cp and activation energy value was 9.18452154 kJ/mol.

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