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Study of the Effect of Adding A Blend of (Ethylene Vinyl Acetate: Styrene Butadiene Rubber) on the Rheological Properties of Asphaltic Materials

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Abstract

Obtaining asphalt with rheological properties is suitable for different uses, especially the field of paving that has become a concern of researchers. Thus, many researchers have been keen on modifying asphalt by various additives, particularly polymeric additives. In our study, We modified the rheological properties of the Iraqi al-dura asphalt using a polymeric mixture of ethylene vinyl acetate (EVA) with styrene-butadiene rubber (SBR).

The above polymeric mixture is used with different weights of both polymers, so that the sum of both polymers is equal to one. Then, we added the polymeric mixture to the asphalt with different percentages in the presence of (0.5%) by weight of anhydrous aluminum chloride as a catalyst for this process at a constant temperature of (150) ° C for one hour .

We made many measurements made on the modified samples in addition to the original asphalt, including the Ductility, Penetration and Softening Point as well as calculating the penetration index and the percentage of the separated asphaltens . The modified pathway produced many samples with excellent rheological properties.

The selected samples that have a good rheological properties are suitable for climates in our country (Iraq) . If obtained Marshall values for modified asphalt are better than the original asphalt, this indicates greater stability and resistance to rattan as well as higher resistance to acid rain.

Keywords: Asphalt, Rheological properties, Ethylene vinyl acetate, styrene-butadiene rubber.

1. Introduction

Asphalt, is known as Bitumen, is highly viscous liquid or semi-solid, black in color, and sticky that originated from petroleum. Bitumen is a widely used as a thermoplastic adhesive for the paving, mastic and in the flattening. The main use of asphalt is about 70% is road construction as binder with particles to create asphalt concrete. Bitumen as a word is used instead of Asphalt which is restricted to asphalt concrete.[1, 2] Society development leads to development of new bitumen-related technology and measurements and its service performances and level have been significantly improved.[3-5]. Understanding the effects of modifiers on the performance of asphalt binders can help engineers to select the appropriate modifiers to achieve the desired

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properties.[6] However, it is worth noting that there are yet many problems in the field of asphalt which need to be solved urgently. Bituminous material has a significant feature that its properties are strongly influenced by its service temperature [7, 8]. The resulting damage will reduce the service performance of bituminous flexible materials, such as rutting, cracks, and other damage phenomena. [9, 10]. The new technology of bitumen is very close with rheological properties. The asphalt aging properties are normally connected by measuring physical and rheological properties (e.g. softening point, penetration, viscosity and complex modulus) before and after artificial aging in the laboratory. Rheological properties of asphalt includes study of deformation resistance, elastic/viscous response, rutting resistance, and resistance to fatigue cracking etc. [11].

So, to overcome the damage phenomena that occur in asphalt is characterized by use a quality binder as one of the requirements for the satisfactory pavement performance. On the other hand, effect of a styrene butadiene styrene copolymer (SBS) was studied[12] on the physical and rheological properties of asphalt, and conducted a thin film furnace (TFOT) test to find out the resistance of the modified asphalt to the aging conditions[13] (Figure 1).

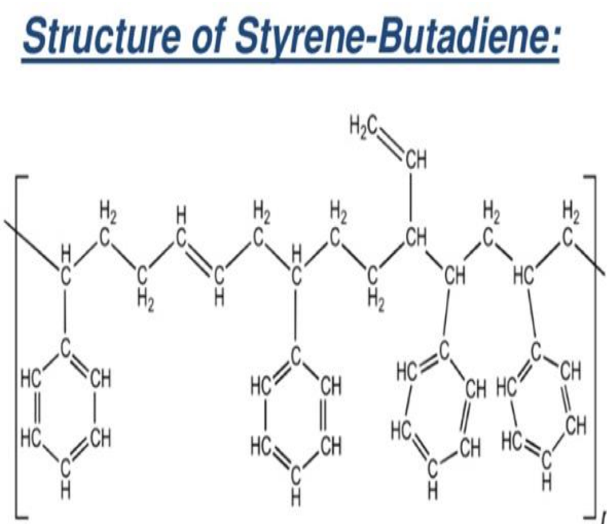


Figure 1: Styrene Butadiene Styrene Copolymer Asphalt Modifier Material Pellet

There are many studies that focused on the effect of a styrene butadiene styrene copolymer (SBS) on the physical and rheological properties of asphalt such as Li et al.[14] that conducted a thin film furnace (TFOT) test to find out the resistance of the modified asphalt to the aging conditions, Leng et al. studied the effect of adding (PET) to asphalt pavement [15] and also many laboratory investigations including dynamic shear gauge, bending beam meter, moisture ductility, infrared spectroscopy and fluorescence microscopy tests. [16-21] These studies indicated that the samples containing the additives derived from RAP and PET provided better overall performance compared to the conventional binders, resulting in an increase in crack resistance by at least 15% and resistance to cracking fatigue by 60%. Singh et al. [22] conducted a laboratory study of modified asphalt with recycled acrylonitrile butadiene styrene (ABS) polymer. ABS was mixed into bitumen in different percentages .The Penetration, softening point, viscosity and dynamic sheer scale (DSR) test were performed. The results indicated an increase in softening point and dynamic viscosity and decrease in penetration. The best rheological properties of the modified asphalt were obtained with the addition of 4% ABS. Yeganeh et al.[23] used styrene-butadiene rubber (SBR) and polybutadiene rubber (PBR), as bitumen modifiers. The results obtained indicated that the two polymers (SBR and PBR) have completely different effects on fluidity, meanwhile, these polymers have similar effects in terms of resistance to permanent deformation.

According to above survey and I continues to our work in laboratory, we aim to study the effect of adding a blender of both ethylene vinyl acetate and styrene butadiene rubber (EVA:SBR) on the rheological properties of asphalt.

2. Experimental

A certain weight of asphalt with the specifications was taken and placed in the asphalt treatment device. A different percentages from the blend of EVA:SBR were added and (0.5%) by weight from anhydrous aluminum chloride was used as a catalyst for this process.

(Table1) The rheological properties of al-Dora Asphalt

Specifications	Laboratory value
Ductility(cm.25 °C)	>150
Softening Point(°C)	50
Penetration (100gm.5sec.25°C)	45.3
Penetration Index	-1.413
Asphalt percentage	19.2

After determining the optimum percentage of the catalyst, the materials were mixed at 150 centigrade for one hour. The rheological properties of modified and original asphalt were conducted and this including Ductility, Softening Point, Penetration and penetration index, separated asphalt, chemical immersion, Marshal test and aging test.

3. Results and discussion

Modifying asphalt (one of the main components of the asphalt paving mixture) has the ability to improve the rheological properties of asphalt through the use of different additives, which makes it suitable for various uses, especially in the field of paving. Therefore, researchers are keen on modifying the asphalt using different polymeric additives. In our study, a polymeric blend of ethylene vinyl acetate (EVA) with SBR was used. The reason for our use of this mixture is that we had used polyethylene vinyl estate as an additive to the asphalt and it gave more than wonderful results along with the air oxidation process [18]. At the same time, we had some experiments using SBR (Styrene-Butadiene Rubber) and in the form of a solution that was obtained from the local market. Our experiments did not give any encouraging results. Based on these data, we decided to use a mixture of both materials above, without the air oxidation process. The asphalt was treated with different percentages of the above mixture in the presence of (0.5%) anhydrous aluminum chloride as a catalyst for this process. Table (2) and Figure (1) show the results obtained from treating asphalt material with a mixture (0.9 grams of EVA: 0.1 grams of SBR) in different percentages .

Table (2): Rheological properties of asphalt treated with different percentages of (EVA: SBR) blend [0.9gm: 0.1gm] with (0.5%) of anhydrous aluminum chloride at 150 ° C for one hour .

Samples no.	Add %	Ductility cm. 25C₀	Softening point C₀	Penetration 100gm. 5sec.25 C₀	Penetration index (PI)	Asphaltenes %
As0	0	>150	50	45.3	-1.413	19.2
As1	1	>150	54	43.7	-0.476	23.7
As2	2	>150	55	42.9	-0.377	25.8
As3	3	>150	57	42.3	+0.017	27.8
As4	4	146	59	40.1	+0.303	28.3
As5	5	87	60	39	+0.437	29.7

AsO:Original Asphalt

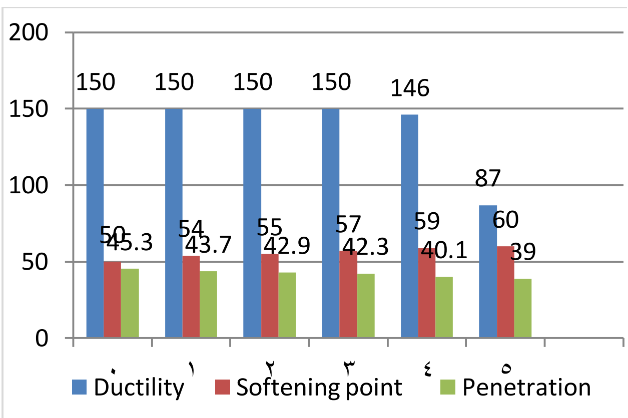


Figure (1) Rheological properties of asphalt treatment with (0.9g EVA: 0.1g SBR)

It is evident from Table (2) that adding the polymer blend to the asphalt leads to obtaining modified asphalt with a good rheological properties to the extent of 4% of the polymeric blend, as all the Ductility values at these percentages were more than 100, as well as the values of Softening point and Penetration within the required values for paving asphalt,according to the Iraqi standard specifications shown in Table (7), as well as the values of the penetration index, all were within the required values.

Also, we note from the table that the percentage of asphaltens increases in general with the increase in the percentage of the polymeric additive and the reason for this is that increasing the percentage of the polymeric additive to the asphalt material leads to the occurrence of More interactions, especially if there is a compatibility between the additive and asphalt, and thus an increase in the molecular weight and then an increase in the percentages of separated asphaltens .

In an attempt to increase the additive percentages (SBR), the additive percentage was increased by 0.1 per treatment gradually.

Table (3): Rheological properties of asphalt treated with different percentages of (EVA : SBR) blend[0.8: 0.2] with (0.5%) of anhydrous aluminum chloride at 150 ° C for one hour.

Samples no.	**Add. %**	**Ductility cm.25C_o**	**Softening point C_o**	**Penetration 100gm. 5sec.25 C_o**	**Penetration index (PI)**	**Asphaltenes %**
As0	0	>150	50	45.3	-1.413	19.2
As6	1	>150	57	42.7	+0.038	24.2
As7	2	>150	56	42.9	-0.161	24.8
As8	3	145	57	41.8	-0.009	28.9
As9	4	120	61	40.5	+0.716	29.3
As10	5	73	62	37.5	+0.730	31.2

AS0 Original Asphalt

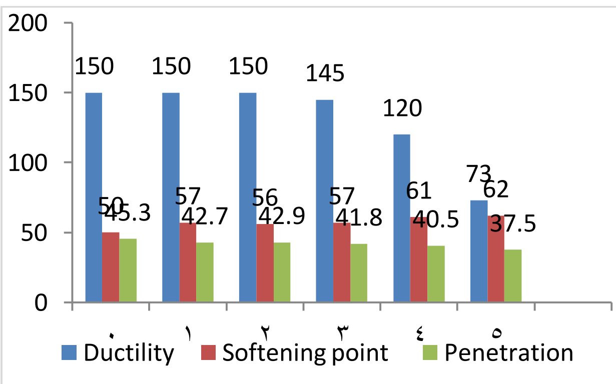


Figure (2) Rheological properties of asphalt treatment with (0.8g EVA: 0.2g SBR)

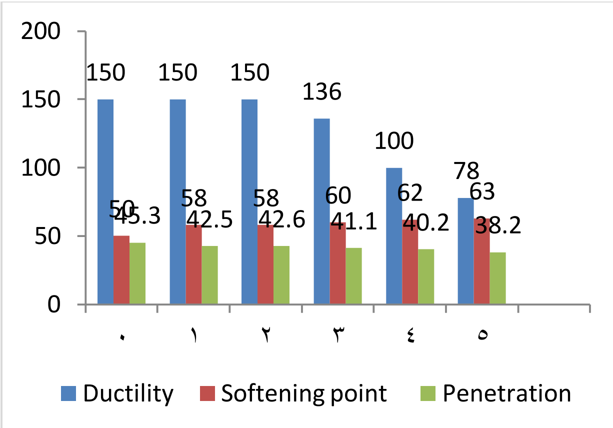
We note from the table that the rheological properties were within the acceptable values, to the extent of 3%, while the percentage 4%, the values of Ductility and Penetration were within the acceptable values for the asphalt of the paving , while the value of Softening point was outside the required specifications.

As for Table (4) and Figure (3), they show the results obtained using different percentages of the mixture (0.7 grams from EVA: 0.3 grams from SBR).

Table (4): Rheological properties of asphalt treated with different percentages of (EVA : SBR) blend[0.7: 0.3] with (0.5%) of anhydrous aluminum chloride at 150 ° C for one hour .

Samples no.	**Add. %**	**Ductility cm. 5C_o**	**Softening point C_o**	**Penetration 100gm. 5sec.25 C_o**	**Penetration index (PI)**	**Asphaltenes %**
As0	0	>150	50	45.3	-1.413	19.2
As11	1	>150	58	42.5	+0.234	24.6
As12	2	>150	58	42.6	+0.240	25.5
As13	3	136	60	41.1	+0.557	28.6
As14	4	100	62	40.2	+0.888	28.9
As15	5	78	63	38.2	+0.956	30.4

AS0 Original Asphalt



We can see from this table that good results are obtained to the extent of 3. As for the results obtained using different percentages of a mixture (0.6 grams of EVA: 0.4 grams of SBR), they are shown in Table (5) and Figure (4).

Figure (3) Rheological properties of asphalt treatment with (0.7g EVA: 0.3g SBR)

Table (5): Rheological properties of asphalt treated with different percentages of (EVA: SBR)blend [0.6: 0.4] with (0.5%) of anhydrous aluminum chloride at 150 ° C for one hour

Samples no.	**Add. %**	**Ductility cm. 5C₀**	**Softening point C₀**	**Penetration 100gm. 5sec.25 C₀**	**Penetration index (PI)**	**Asphaltenes %**
As0	0	>150	50	45.3	-1.413	19.2
As16	1	>150	58	42.3	+0.223	24.8
As17	2	>150	59	41.8	+0.398	25.7
As18	3	120	59	37.6	+0.160	28.6
As19	4	94	63	40.1	+1.068	.332
As20	5	68	66	32.2	+1.105	33.4

AS0 Original Asphalt

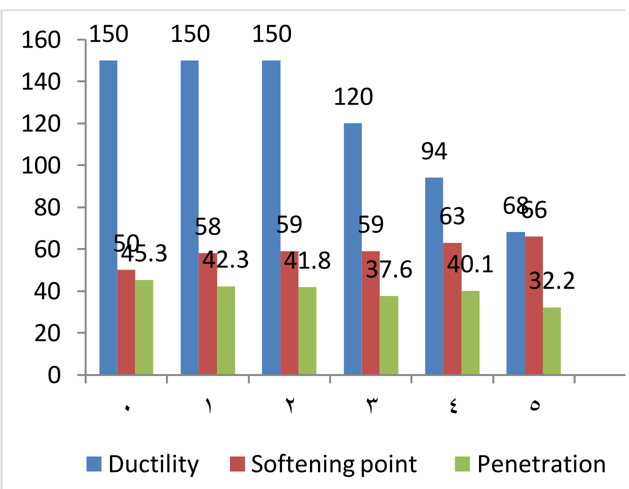


Figure (4) Rheological properties of asphalt treatment with (0.6g EVA: 0.4g SBR)

We note from Table (5) that the specifications were acceptable to the extent of the ratio of 2%, while the ratio of 3% was the rheological properties of which were acceptable except for the value of Penetration, which was outside the standard specifications for asphalt used in paving .

Table (6) and Fig. (5) show the results obtained from treating asphalt with different proportions of the polymeric mixture consisting of equal proportions of EVA and SBR.

Table (6): Rheological properties of asphalt treated with different percentages of (EVA: SBR) with (0.5%) of anhydrous aluminum chloride at 150 ° C for one hour .

Samples no.	Add. %	Ductility cm. 25C_o	Softening point C_o	Penetration 100gm. 5sec.25 C_o	Penetration index (PI)	Asphaltenes %
As0	0	>150	50	45.3	-1.413	19.2
As21	1	>150	57	41.7	-0.014	25.8
As22	2	135	59	.840	+0.337	27.4
As23	3	87	61	.238	+0.583	29.8
As24	4	74	63	.636	+0.859	32.7
As25	5	62	67	32.6	+1.301	35.6

AS0 Original Asphalt

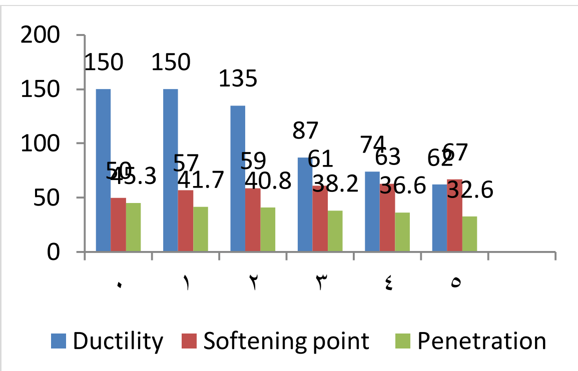


Figure (5) Rheological properties of asphalt treatment with (0.5g EVA: 0.5g SBR)

We note from Table (6) that the values that were acceptable to the extent of the ratio of 2% and that the rheological properties were better at the ratio of 1%.

We also notice from the previous tables, in general, that the good rheological properties are reduced by increasing the percentage of additive SBR in other words, they are better when increasing the percentage of additive (EVA).The styrene butadiene rubber (SBR) worked to give the samples of asphalt the required rigidity.

Tables (7_9) illustrate the standard properties for asphalt used in paving[19] as well as asphalt used for the production of (Mastic) used as a waterproofing material [20]and the standard specifications for asphalt used in Flattening [21,22]which were relied upon in previous results of the modification process.

Table (7) :Iraqi paving asphalt[19]

Rheological properties	Minimum	Maximum
Softening point (°C)	54	60
Penetration (100gm.5sec.25°C)	40	50
Ductility (cm.25°C)	100	-

Table (8): American mastic asphalt [20]

Rheological properties	Minimum	Maximum
Softening point (°C)	54	65
Penetration (100gm.5sec.25°C)	20	40
Ductility (cm.25°C)	15	-

Table (9): Flattening asphalt [21]

Rheological properties	Minimum	Maximum
Softening point (°C)	57	66
Penetration (100gm.5sec.25°C)	18	40
Ductility (cm.25°C)	10	-

Three samples with a good rheological properties (AS3, AS7, AS21) were selected and conducted (Marshall, aging test and chemical immersion), in addition to measuring these properties of the original asphalt in order to know the suitability of these models for paving wor.

Table (10) Marshall Test[23].

Samples No.	Asphalt (%)	Marshal Test		
		Stability (KN)	Flow (mm)	MQ
AS0	4.5	11.3	5.1	2.21
AS2		15.7	3.2	4.9
AS7		15.4	2.9	5.31
AS21		16.8	3.4	4.94
AS*		7 Minm.	2-4	3.5Minm.

AS * Iraqi Roads and Bridges Authority specifications.

It can be seen from the above table that all the modified samples are better than the original sample if it is used as paving asphalt. It can also be seen that the MQ value of the modified samples is higher than the MQ value of the original asphalt, and this indicates that the modified asphalt is more resistant to permanent deformation than the original asphalt.

To find out the extent of asphalt resistance after mixing it with aggregates to acid rain and high temperature, a chemical immersion test of the samples (AS3, AS7, AS21) were performed as well as the original sample and Table (12) shows the results of the slurry of asphalt from the aggregates for the original asphalt and the modified samples[23,24].

Table (12) :Chemical Immersion Test

Samples No.	Percentage of Na2Co3gm	R&WNO	R&WNO For the original asphalt	R&WNO For the modified samples
	0.025	1		
	0.041	2		
AS0	0.082	3	3	
	0.164	4		
AS21	0.328	5		5
	0.656	6		
AS3,AS7	1.312	7		7
	2.624	8		

We note from Table (12) and through the values of melt (i.e. the amount of sodium carbonate at which the asphalt started to slough off or separate from the aggregate) that the modified samples began to cleave with a greater amount of sodium carbonate compared to the original asphalt. As numbers from (0) to (8) refer to (R&W) Riedel and Weber number [25, 26]. The number (1) indicates the amount of sodium carbonate, which is (0.025) grams in (50) ml of distilled water, and the number (8) indicates the highest amount of sodium carbonate, which is (2.624) grams. The possession of pivot asphalt has higher shedding values. From the original asphalt, the modified asphalt is able to adhere to the aggregates more than it is in the original asphalt[27], which gives greater resistance to acid rain and high temperatures.

In order to know the extent to which the modified asphalt models are affected by the aging conditions, an aging test was performed on both the original sample and the modified samples mentioned previously, and the test was carried out according to the American standard specifications [28-30]and as shown in Table (11).

Table (11): The Aging Test (TFOT)

Samples No.	Describe Sample	Rheological properties	Before the examination	after examination
AS0		Ductility (cm.25°C)	>150	>150
		Softening point (°C)	50	53
		Penetration (100gm.5sec.25°C)	45.3	42.1
		Penetration index (PI)	-1.413	-0.863
AS3		Weight loss%	-----	0.05
		Ductility (cm.25°C)	>150	>150
		Softening point (°C)	57	58
		Penetration (100gm.5sec.25°C)	42.3	41.8
		Penetration index (PI)	+0.017	
AS7		Weight loss%	------	0.02
		Ductility (cm.25°C)	>150	>150
		Softening point (°C)	56	58
		Penetration (100gm.5sec.25°C)	42.9	42.2
		Penetration index (PI)	-0.161	
AS21		Weight loss%	------	0.024
		Ductility (cm.25°C)	>150	>150
		Softening point (°C)	57	60
		Penetration (100gm.5sec.25°C)	41.7	40.8
		Penetration index (PI)	-0.014	
		Weight loss %	------	0.03

We note from the above table that the degree to which the modified asphalt models are affected by the aging conditions of temperature and oxygen is less than that of the original asphalt, and we infer from this that the modified asphalt have greater resistance to stress and fewer cracks in addition to the long service life and this is positive for the modification.

4. Conclusions:

1-After completing this study, we can conclude that the use of the mixture in the rheological modification of asphalt has performed a dual action, as EVA works to give the required flexibility to the asphalt, while the SBR works to give the asphalt the required hardness, and this is the purpose of using this mixture.

2- This study gave better Marshall values for the modified samples than it is for the original asphalt, and this indicates the possibility of using this additive in tiling operations.

3- This study indicated that the modified samples are less affected by the aging conditions compared to the original asphalt.

5. Acknowledgement

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