The Effect of Bioasphalt on Aged Asphalt

IOP Conf. Series: Materials Science and Engineering **508** (2019) 012041 doi:10.1088/1757-899X/508/1/012041

The Effect of Bioasphalt on Aged Asphalt

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Abstract. This study aims to determine the potential of bioasphalt as a rejuvenating ingredient on aged asphalt. Two different bioasphalt are used, which is bioasphalt from coconut shell and bioasphalt bitutechRAP, aged asphalt is extracted from Recycled Asphalt Pavement (RAP) taken from Karawang, West Java, and the original asphalt as a control is pen 60/70 from Pertamina. The samples were made by mixing each bioasphalt on aged asphalt at 7 different percentage of 2%, 4%, 8%, 16%, 20%, 25%, 30%, then each samples tested the penetration and softening point of asphalt (referring to control asphalt properties), to get the optimum percentage of bioasphalt. Samples with optimum bioasphalt then tested with FTIR for chemical structure and SEM for morphology. The results of this study are (1) the percentage optimum of bioasphalt as rejuvenator, which is 23% for bioasphalt coconut shell and 17% for bioasphalt bitutechRAP; (2) the addition of bioasphalt to aged asphalt shows that the morphological conditions, chemical structure and rheology of asphalt are almost close to the new asphalt condition; (3) bioasphalt are potencially as rejuvenator.

1. Introduction

This study aims to determine the potential of bioasphalt as a rejuvenator for aged asphalt. In Indonesia, recycling asphalt technology still uses wasted oil or imported rejuvenator that are certainly not environmentally friendly and economic. The main purpose of using recycled materials, one of which is saving natural resources that are considered to be more economical and environmentally friendly. Based on this, it is necessary to find a rejuvenator that is environmentally friendly and economical.

Bioasphalt is an alternative to asphalt made from non-Petroleum materials based on renewable resources (biomass containing lignin) [1][2]. Bioasphalt has a function, among others, used as an alternative to asphalt replacement, can reduce the use of natural resources that can not be renewed, and can increase the use of biomass materials. In addition bioasphalt raw materials are cheaper and available in sufficient quantities. Besides being able to replace 100% asphalt as a binder, bioasphalt can also be an extender by replacing 25-75% asphalt, while as a modifier or additive, bioasphalt can be added by 10% [2][3]. Based on data from Green Asphalt Technologies LLC, 2011 it is known that bioasphalt can break down enlarged asphaltenes particles and at the same time replace them with malthenes particles, this ability is said to be a rejuvenation process [4][5].

In other countries, the use of bioasphalt as a rejuvenator has been widely researched and its applications are carried out directly in field, one of which is America that has produced and developed bioasphalt as a rejuvenator, which it's call bioasphalt bitutechRAP. Whereas in Indonesia, the bioasphalt that has been produced is a coconut shell bioasphalt, but its potential has not been tested further. So that in this study, it is necessary to do more testing regarding the potential of coconut shell bioasphalt, namely by testing it as a rejuvenator for aged asphalt. The tests carried out were asphalt rheology by Penetration test and Softening Point Test, asphalt chemical structure test by FTIR and asphalt morphology test by SEM.

2. Method and materials

2.1. Sample preparation

The material that used in this study are:

a. Original asphalt as a control are asphalt pen 60/70 from Pertamina.
b. Bioasphalt as a rejuvenator, that are bioasphalt from coconut shell and bioasphalt bitutechRAP.
c. Aged asphalt are bitumen from extraction RAP was taken from Karawang, Jawa Barat.

Samples were prepared by mixing bioasphalt and aged asphalt using magnetic stirrer with speed rotation 0,4 kr/sec ~ 0,6 kr/sec and mixing temperature of 120 °C for 15 – 20 minutes [1]. While the variation of bioasphalt percentage to the weight of aged asphalt is 2%, 4%, 8%, 16%, 20%, 25%, 30%.

2.2. Method

The test method used to determine the asphalt base rheology (penetration and softening point) in accordance with SNI 06-2456-1991 and SNI 06-2434-1991, asphalt chemical structure test using Fourier Transform Infrared (FTIR) Spectroscopy, and asphalt morphology test using Scanning Electron Microscope (SEM).

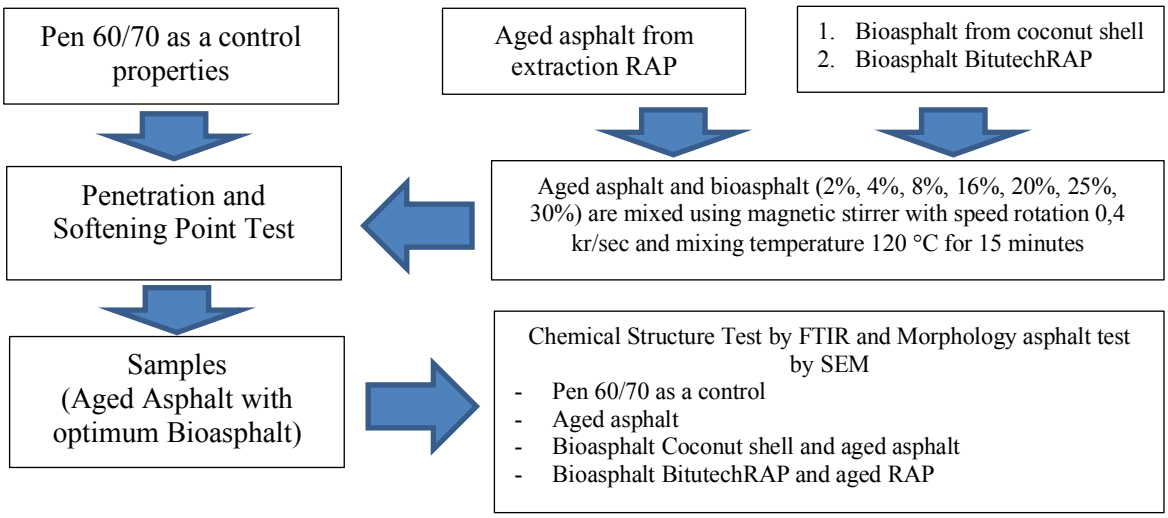


Figure 1. Flow chart Samples Test

3. Results and discussion

3.1. Result test of basic rheology of bitumen

Basic rheological test results (penetration and softening points) of bioasphalt and aged asphalt can be seen in Table 1, Figure 2 and Figure 3, it is known that adding bioasphalt to aged asphalt

will increase the value of penetration and reduce the value of softening points, these conditions indicate that aged asphalt rheology can be change to become more elastic after the addition of bioasphalt. To get the same penetration and softening point as pen 60/70, the optimum composition of bioasphalt coconut shell and bitutech RAP is 23% and 17%.

Table 1. Penetration and Softening Point

Sample	Percentage of Bioasphalt	Penetration (0,1 mm)	Softening Point (°C)	Penetration Index	Pen 60/70	
					Penetration	Softening Point
Bioasphalt Coconut Shell and Aged Asphalt	0	10	80	0,98868		
	4	11	76	0,65231		
	8	14	73	0,52841		
	14	26	71	1,38393		
	17	33	63	0,54073		
	20	54	59	1,02288		
	23	65	54	0,41806		
	25	68	52	0,05848	65	51
	29	75	51	0,07733		
					60-70*	≤48*
Bioasphalt BitutechRAP and Aged Asphalt	0	10	80	0,9887		
	4	11	68	-0,5206		
	8	15	60	-1,4357		
	14	43	58	0,1583		
	16	58	56	0,4592		
	17	65	54	0,3593		
	20	79	51	0,2264		

* Standard Properties Aspal Pen 60/70

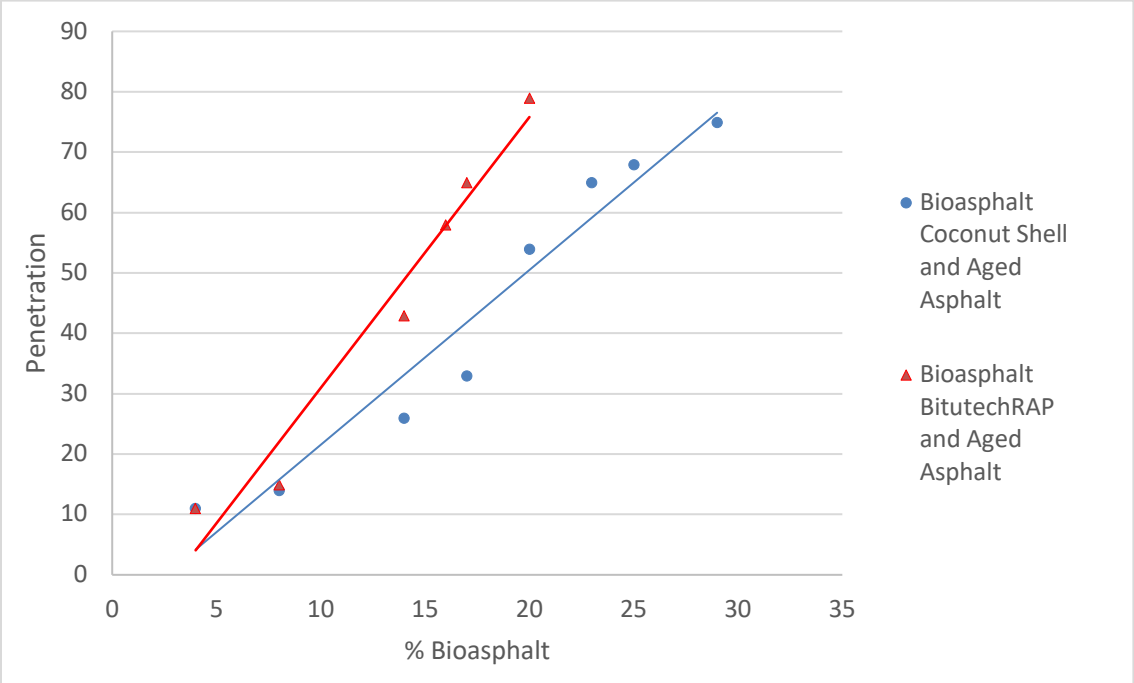


Figure 2. Penetration Bioasphalt and Aged Asphalt

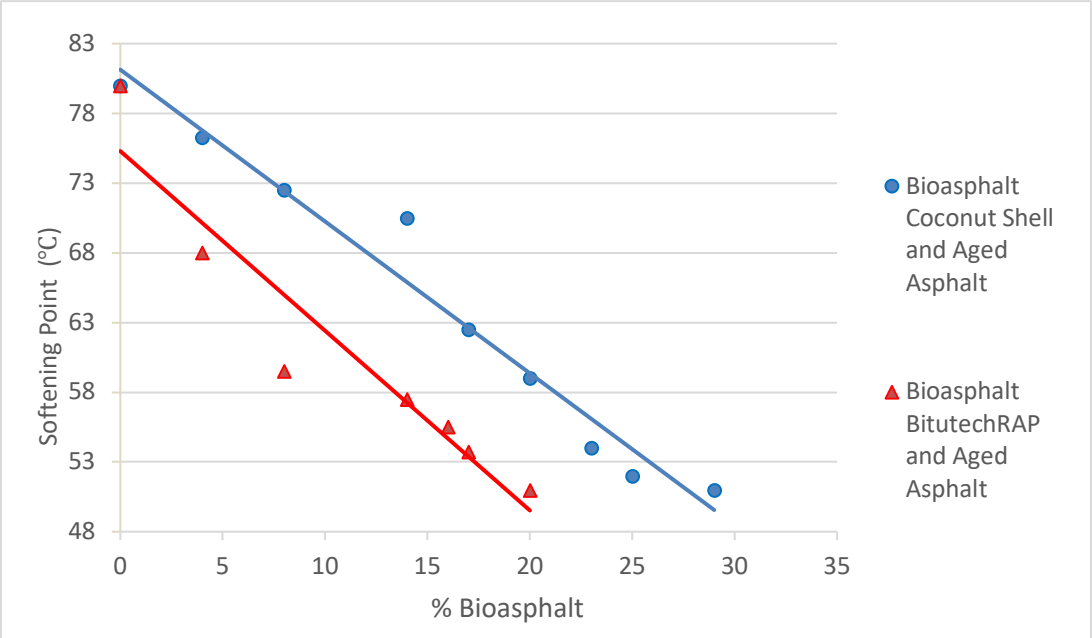


Figure 3. Softening Point Bioasphalt and Aged Asphalt

3.2. Result test of Chemical Structure and Morphology Asphalt

Chemical structure of bioasphalt mixed aged asphalt are presented in Figure 4. Based on FTIR spectrum analysis bioasphalt and aged asphalt showed that O-H stretching groups on IR uptake were identified around 3427.51cm^{-1} indicating the presence of phenol and alcohol, C-H stretching groups in uptake IR 2800 - 3000 cm^{-1} indicates the presence of aliphatic compound. The O-H functional group in the bioasphalt coconut shell and aged asphalt has stronger absorbance compared to aged asphalt, indicated by a small % T which has an impact on the increase of the IR aromatic group 650-750 cm^{-1} [6]. This increase in aromatic groups showed an increase in the SARA phase (Saturated, Aromatic, Resin, and Asphaltene) asphalt and the chemical structure of the aromatic IR almost resembled pen 60/70 (control asphalt). Whereas in bitutech RAP and aged asphalt, the absorptive rate is smaller in O-H stretching groups, indicated by a large % T value and almost close to the 60/70 pen bitumen absorption level. Based on Lamontagne et. al (2001) [7], the use of FTIR to identify aging on asphalt based on the carboxylic index (Ic = o) and sulfoxide index (Is = o). The index that is relevant to Ic is IR 1700 cm^{-1} in the range 1740 - 1690 cm^{-1} and Is is IR 1030 cm^{-1} in the range 1055 - 1030 cm^{-1}. Lamontage proposes quantitative analysis of carboxylates and sulfoxides as follows:

$$I_{c=o} = \frac{Area\ of\ the\ carbonyl\ band\ around\ 1.700\ cm^{-1}}{Area\ of\ the\ spectral\ bands\ between\ 2.000\ and\ 600\ cm^{-1}}$$

$$I_{s=o} = \frac{Area\ of\ the\ carbonyl\ band\ around\ 1.030\ cm^{-1}}{Area\ of\ the\ spectral\ bands\ between\ 2.000\ and\ 600\ cm^{-1}}$$

The results of asphalt aging analysis based on FTIR are shown in Table 2, it is known that adding bioasphalt to aged asphalt will reduce the carboxylic index and sulfoxide index. This shows that there is an indication of rejuvenation on aged asphalt with the addition of bioasphalt.

Table 2. Aging Index Asphalt by FTIR

Aging Index	Samples			
	Pen 60/70	Aged Asphalt	Bioasphalt Coconut Shell and Aged Asphalt	Bioasphalt Bitutech RAP and Aged Asphalt
Carboxylic ($I_{C=O}$)	0,0047	0,0168	0,0137	0,0165
Sulfoxide ($I_{S=O}$)	0,0094	0,0337	0,0171	0,0179

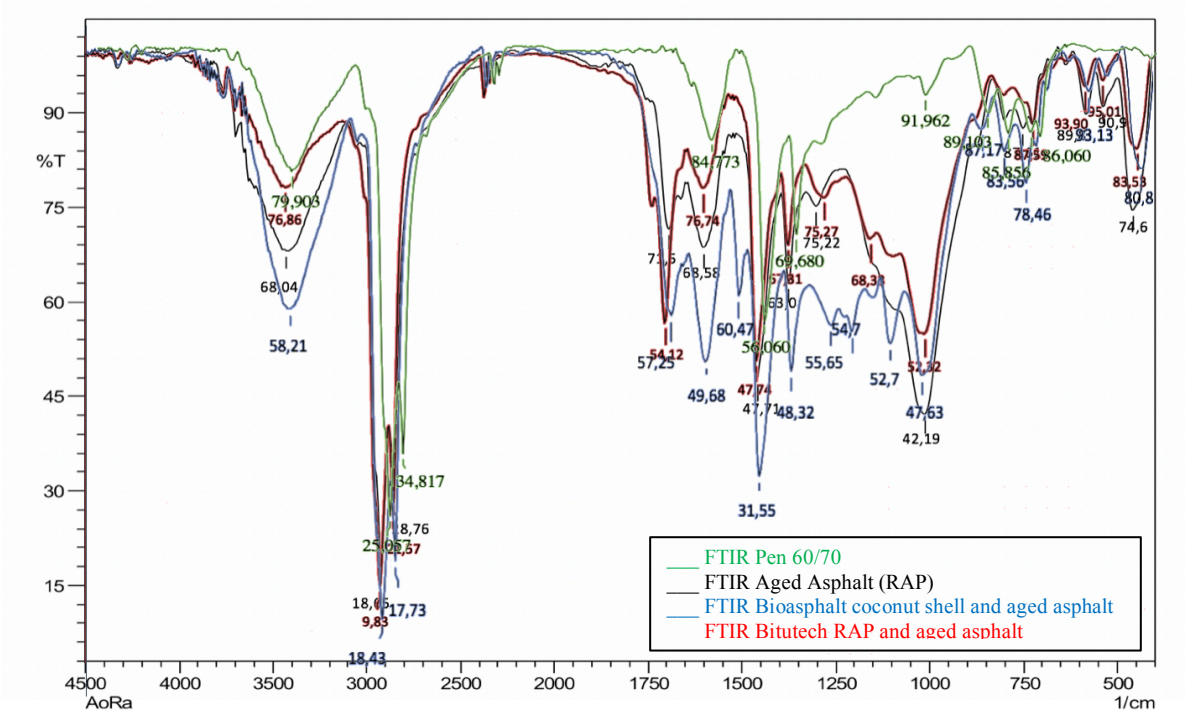
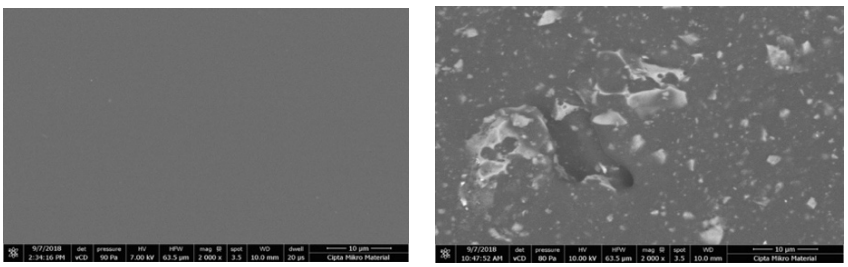
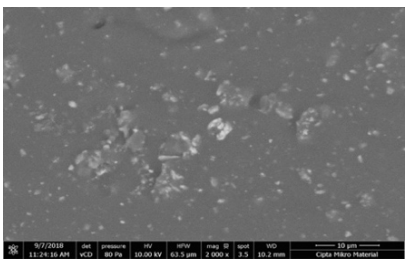


Figure 4. Chemical Structure of Asphalt by FTIR

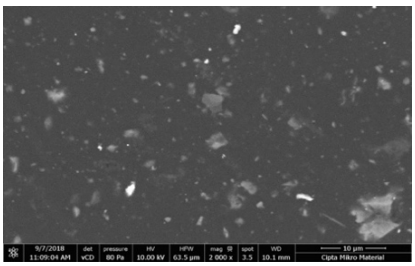


a. New Asphalt pen 60/70

b. Aged Asphalt



c. Bioasphalt coconut shell and aged asphalt



d. Bioasphalt BitutechRAP and aged asphalt

Figure 5. Asphalt Morphology (SEM 2000x)

Morphology of pen 60/70 (Figure 5a) as new asphalt based on SEM test results looks clean and homogeneous (blackish gray color spreads evenly), while on aged asphalt (Figure 5b), it looks blackish gray with white patches which is quite large, white spots can be said to be the "bee" or katana phase or disperse phase [9]. The greater the diameter of the phase "bee" or katana (the dominant dispersion phase) indicates that asphalt is getting older [10], on the aged asphalt it can be seen from the results of SEM. After the addition of bioasphalt (Figure 5c and 5d) it can be seen that the white patch has a smaller diameter and evenly distributed to all parts of asphalt, it shows that the aged asphalt after bioasphalt added can be rejuvenated, even are not as clean and homogeneous as asphalt new.

Asphalt morphology by SEM as show as **Figure 5.**

4. Conclusion

This study shows that the addition of bioasphalt on aged asphalt can change the chemical and physical properties of aged asphalt to be almost similar to new asphalt, this indicates that the bioasphalt can be used as a rejuvenator.

- By basic rheology asphalt test, addition bioasphalt on aged asphalt can increase elasticity of aged asphalt.
- Bioasphalt can change the chemical structure and renew aged asphalt.
- Bioasphalt can change the morphology of aged asphalt almost similar new asphalt.

The use of bioasphalt as a rejuvenator is a new environmentally friendly technology that has many better opportunities by improving its biomaking process.

5. References

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