

## Study on Modified mechanism of asphalt of PPA in conjunction with SBS

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**Abstract.** Modified mechanism of asphalt of PPA in conjunction with SBS is studied on from the microscopic view by experiments. These experiments include four constituents, fluorescence microscopy, infrared spectroscopy and DSC. The results show that the proportion of asphaltene increase and the proportion of colloid decrease because of PPA adding. Its can promote the dissolve dissolution of SBS modifier in order to enhance the network structure of asphalt. PPA contributes to the colloidal structure of asphalt conversion from sol to sol-gel structure. That is helpful to improve high temperature performance; aging-resisting performance and storage performance of SBS modified asphalt.

### Introduction

Poly phosphoric acid modified asphalt is a kind of acid modified asphalt what can improve high temperature performance, aging-resisting performance, increase storage stability of SBS modified asphalt and decrease project cost. It is analyzed a series of chemical and physical changes of SBS modified asphalt under the different proportion of PPA by experiments. These experiments include four constituents, fluorescence microscopy, infrared spectroscopy and DSC. That is can be evaluated modified mechanism of asphalt of PPA in conjunction with SBS.

### Four Constituents

Four constituents analysis utilize the principle that material dissolve in alternative in different organic solvent and absorb in the alternative in different adsorbent. So the asphalt can be separated four chemical similar characteristics constituents such as asphaltene, saturated fraction, aromatic fraction and colloid. It is analyzed four constituents of asphalt by solvent sediments and chromatographic columns in this experiment. As is well known, polymer is dispersed many granules by swelling and high speed shearing when polymer is joined in asphalt. It is physical miscible process and polar of the swelling polymer is similar to colloid. It is considered that the SBS has little influence on performance of asphalt because polymer is used as part of colloid. So it is major studied on that PPA influence on each component of asphalt in this paper. The proportion of PPA is 0%, 0.5%, 1%, 1.5% and 2%. The test results are shown in fig1.

The content of asphaltene obviously increase and the content of colloid obviously decrease When the proportion of PPA increase from 0% to 2% from fig1. The content of asphaltene increase from 9.4% to 16.7% and the content of colloid decrease from 36.6% to 28.5%. The content of saturated fraction and aromatic fraction has no significant change.

Changes in constituents of asphalt can affect changes of colloidal structure according to modern colloidal theories. The contents of asphaltene increases will lead to the contents of colloidal core increase. Colloidal core can absorb surrounding oil which results in the formation larger micelle. The number of micelle increase means the distance of micelle decrease and part of micelle

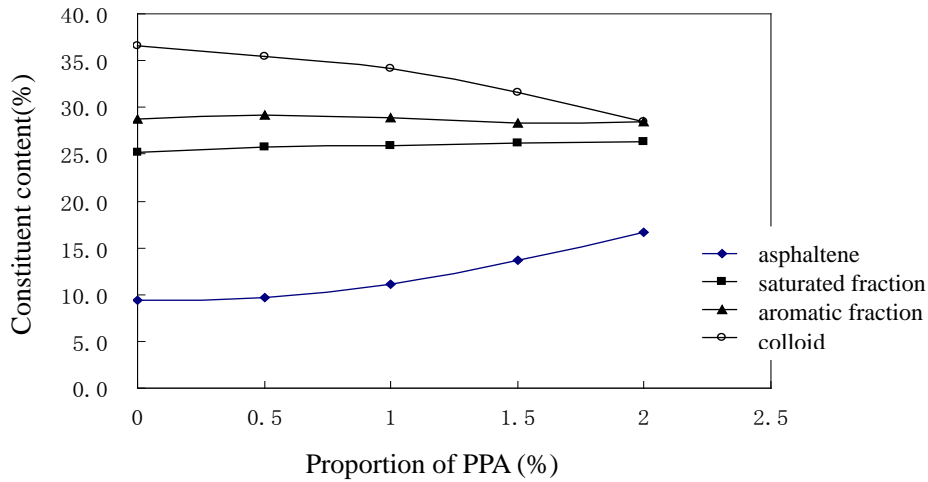


Fig1 the relationship between different proportion of PPA and asphalt

even come into contact with each other. So the viscosity of asphalt increases because the forces of between micelles increase. As the same time, the forces of between micelles increase with the volume of micelles which lead to form the intensive space network structure. That is helpful to enhance the storage stability of asphalt.

PPA contributes to the colloidal structure of asphalt conversion from sol to sol-gel structure. The content of asphaltene increase and colloid decrease which lead to asphalt stiffness increase, the softening point and viscosity increase and penetration reduce. So PPA can effectively improve the high temperature performance and storage stability of asphalt.

### Infrared absorption spectroscopy

Infrared absorption spectroscopy belongs to the category of molecular absorption spectra which is usually used to analyze chemical structure of substances. The principle is what polar molecules absorb infrared ray correspond of vibration energy levels. Parts of wavelengths radiation are absorbed into sample when the sample is irradiated by different wavelengths infrared ray. Some wavelengths of radiation are absorbed by the sample, then weaken, thus formed the infrared absorption spectrum. We can analyze group and molecule structure of the material from the position, the number, the relative intensity and the shape of absorption peak of the infrared absorption spectrum.

First the asphalt is dissolved in 5 percent carbon tetrachloride solution. Then this solution is smeared on flake of potassium bromide in order to form a thin film coating. Finally we can analyze the sample which carbon tetrachloride solution is volatilized using the spotlight. We consider that the coating thickness of asphalt is not being the same on the potassium bromide[1]. It's only comparison of the spectral curve of different samples is pointless because the different coating thickness will affect the strength of the absorption peak. So we can compare changes of different asphalt absorption peaks using the area ratio method.

It is chosen the proportion of SBS is 0%, 3% and 4% and the proportion of PPA is 0%, 0.5%, 1%, 1.5% and 2% under each SBS dosage. We can know that absorption peak of asphalt is mainly located in  $1030\text{ cm}^{-1}$  from spectrum of asphalt. So we calculate percentage of absorption peak area in  $1030\text{ cm}^{-1}$  by the sum of absorption peaks area within  $600\text{ cm}^{-1}$ - $2000\text{ cm}^{-1}$  as the reference area. It is showed by the index of  $I_{s=o}$  and the test results are shown in Fig2. At the same time we can know that the absorption peak of SBS modified asphalt mainly located in  $6965\text{ cm}^{-1}$  and  $97\text{ cm}^{-1}$ . It is showed by indexes of  $I_{C=C}$  and  $I_{C-H}$ . The test results are shown in fig3 and fig4.

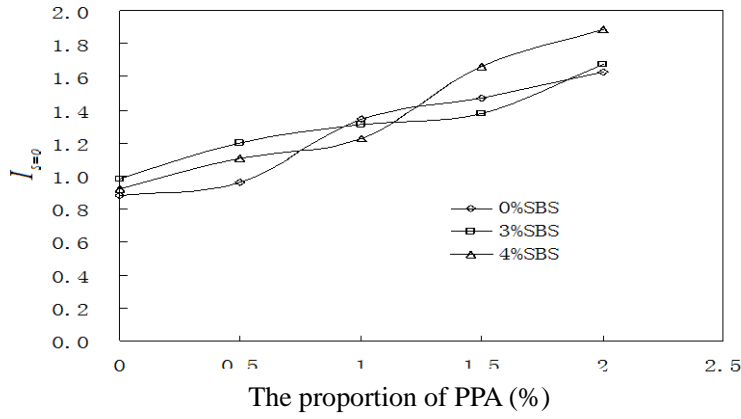


Fig2 the relationship between the index of  $I_{s=0}$  and different proportion PPA

We know that the index of  $I_{s=0}$  increase with the proportion of PPA increases in the different dosage of SBS from fig2. It is due to the index of  $I_{s=0}$  corresponds Pressure sulfonic functional group what belong to polar group. Its can Interact with asphalt to form Larger and more closely new group. So it leads to increase the viscosity of asphalt. At the same time, the dosage of SBS has little effect on the index of  $I_{s=0}$ .

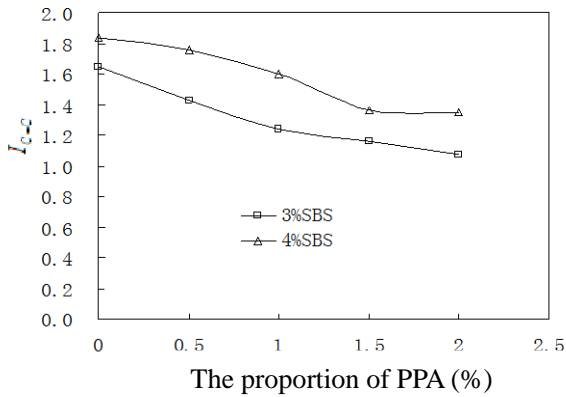


Fig3 the relationship between the index of  $I_{c=c}$  and different proportion PPA

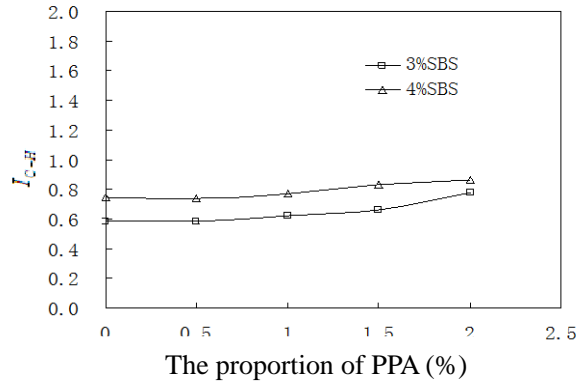


Fig4 the relationship between the index of  $I_{c-H}$  and different proportion PPA

We know that the index of  $I_{c=c}$  gradually decrease with the proportion of PPA increases but  $I_{c-H}$  basically unchanged from fig3 and fig4. The index of  $I_{c=c}$  decrease indicates that more  $-C=C-$  double bond of butadiene block have been disconnected when the PPA is added. Asphalt activity increasing can increases the crosslinking effect between SBS and the grafting function between SBS and asphalt. Crosslinking of SBS contributes to form a network structure that asphalt be wrapped in the network structure and prevent separation between SBS and asphalt. There are products present in the interface of SBS and asphalt by the grafting function between SBS and asphalt[2]. It is can be prevent the aggregation of SBS and inhibit the separation of SBS and asphalt. Obviously, PPA is added to the SBS modified asphalt that it's can enhance network structure to improve high temperature storage performance of SBS modified asphalt.

### Fluorescence microscope

Fluorescence microscope is an effective tool for analysis of phase structure of polymer modified asphalt. Polymer phase will produce a fluorescent of the modified asphalt while asphalt phase does not inspire any light when they are inspired by Shortwave light of ultraviolet ray. Fluorescence microscope using this principle can clearly distinguish the polymer phase and asphalt. Fluorescence microscopy can real observe phase structure of the modified asphalt and won't destroy the morphology of polymer phase and asphalt phase because of using the reflected light field.

It is chosen the proportion of SBS is 3% and 4%, the proportion of PPA is 0%,0.5%,1 %,1.5% and 2% under each SBS dosage. The test results are shown in fig5 and fig6.

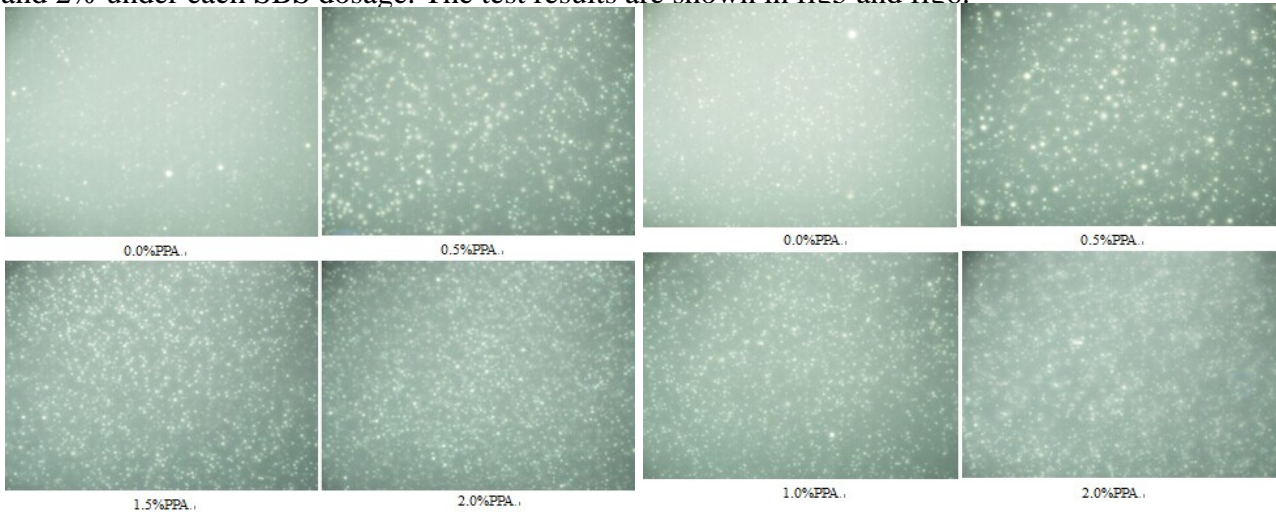


Fig5 3% SBS+PPA (different proportion)

Fig6 4% SBS+PPA (different proportion)

Particle size of SBS has larger difference having a lot of big size particles and uneven distribution when the PPA is not added from fig5 and fig6. SBS particle mutual independent suspend in the asphalt and does not form network structure. Particle size of SBS is less and there is an increased in the number of particle with the increasing of proportion of PPA that the distribution is more even. Big size particles of SBS cannot be basically detect when the proportion of PPA more than 1%. Its show that PPA can effectively prompt SBS to disperse into tiny particles in the process of making modified asphalt. It is can effectively shorten the particle spacing because of the number of SBS particle increases and uniform distribution and make the synergy improved. The synergy was occurred by the long-term effect of many particles through interface layer[3]. That is can enhance network structure of modified asphalt and improve the high temperature storage performance.

At the same time, the smaller the SBS particle is, the easier light component of asphalt will penetrate. It is conducive to penetrating through macromolecule network of SBS which can promote infiltration and adsorption between asphalt and SBS and swelling of SBS particle. Obviously PPA can effectively reduce the cost of the asphalt and improve its storage stability using the modified asphalt of PPA in conjunction with SBS.

### Differential scanning calorimetry (DSC)

DSC analyzes the power difference and temperature curve between sample and reference under a certain temperature. So the glass transition temperature of material can be found in order to evaluate its low temperature performance. The glass transition temperature of asphalt is a reversible change from viscous flow state or rubber state to a relatively rigid of glassy state. The glass transition temperature of asphalt is the temperature of glass transition when the asphalt starting to happen.

Asphalt is a complex structure that it is made of high polymer and low polymer and some small molecule. Asphalt is the state of solid and liquid aggregation at different temperature. The change of the aggregation state determines the changes of asphalt performance which mainly reflect the transformation from plastic to brittle. The optimum glass transition temperature should be lower than its service temperature in order to ensure the low temperature performance of asphalt. So asphalt has a good ability of deformation resistance during the whole service. The lower the glass transition temperature is, the better the low temperature performance will be.

It is chosen the proportion of SBS is 0%,3% and 4% and the proportion of PPA is 0%,0.5%,1 %,1.5% and 2% under each SBS dosage. The test results are shown in fig7.

We can see that the glass transition temperature has little change during the process of the

proportion of PPA is gradually added from 0% to 2% under different SBS dosage. So PPA has little impact on low temperature performance of asphalt. Meanwhile we can also see that the glass transition temperature of modified asphalt is decreased with the increase of SBS dosage[4]. This is mainly due to the glass transition temperature of SBS is lower than asphalt in low temperature (the glass transition temperature of SBS is usually - 80 C or so). Therefore, the increase of SBS dosage is helpful to improve the low temperature performance of asphalt.

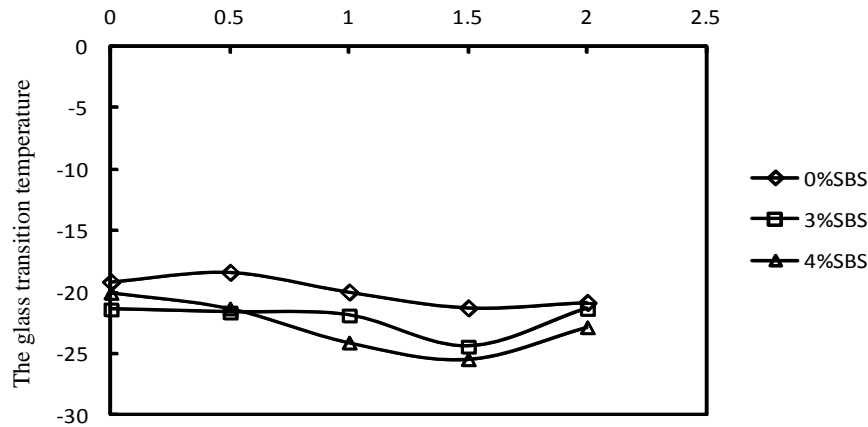


Fig7 The influence of PPA proportion on the glass transition

## Conclusion

(1) PPA is added in the asphalt which results in asphaltene and saturated fraction content increase but the aromatic fraction and colloid content have no obvious change. That is can improve softening point and viscosity and reduce the temperature sensitivity. So PPA can effectively improve the high temperature performance of asphalt.

(2) PPA contributes to the colloidal structure of asphalt conversion from sol to sol-gel structure. It is can increase the crosslinking effect between SBS and the grafting function between SBS and asphalt in order to enhance the network structure of asphalt. That is helpful to improve high temperature storage performance of SBS modified asphalt.

(3) PPA has little impact on low temperature performance of asphalt but the increase of SBS dosage is helpful to improve the low temperature performance of asphalt.

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