The summary for modification mechanism of SBS modified asphalt

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Abstract

In this paper, by summarizing the domestic and abroad researches on modification mechanism of SBS modified asphalt, we obtain that the modification mechanism includes physical blending modification mechanism and chemical modification mechanism. Moreover, physical blending modification mechanism refers to its swelling and solubility, and chemical modification mechanism includes addition reaction, sulfur- containing cross-linking agent reaction and reaction with other functional groups. Based on these, the future research directions of the SBS modified asphalt has been put forward.

Keywords

SBS modified asphalt; Physical blending modification mechanism; Chemical modification mechanism; The future research directions.

1. Introduction

With the development of transportation, the construction of asphalt concrete pavement increases fast, especially, for the demand of high quality asphalt [1]. Because of many large vehicles in our country, and the temperature difference for north and south, summer and winter. The quality requirements of the asphalt pavement becomes much higher than before and the general traffic road asphalt is difficult to meet the corresponding requirements. Therefore, the asphalt modification for existing roads is an urgent task.

The asphalt modification means a certain amount of asphalt modifier is added in the asphalt [2]. This can fully improve the thermal resistance, stability, durability, adhesive, and the aging resistance of asphalt, which can develop the asphalt surface performance. SBS modifier have the following characteristics. Firstly, the SBS modifier can satisfy both the requirements of high temperature performance and the requirements of low temperature performance. Besides, it can be used both to the light vehicle road asphalt modification and to the highway as well as the first class road asphalt modification, etc. What is more, the processing method of SBS modified asphalt is simple which makes the cast decrease and it owns the wide raw material sources. Therefore, SBS modified asphalt have very important engineering practical value. In this paper, taking the SBS modified asphalt as an object, the modification mechanism research both at home and abroad would be discussed. And based on these, the future research direction has been put forward.

2. The modification mechanism of SBS modified asphalt

Recently, at home and abroad, the modification mechanism includes physical blending modification mechanism and chemical modification mechanism.

2.1 The physical blending modification mechanism

Many scholars at home and abroad do many relevant researches for the physical blending modification mechanism of SBS modified asphalt. The physical blending modification mechanism refers to its swelling and solubility. If the SBS particles don't swell and dissolve or just partly dissolve, it is difficult to form the physical blending grid structure and only has the effect to fill volume, which cannot modify the asphalt. Therefore, its solubility and swelling are the key to SBS asphalt modification.

The swelling

According to the similar compatible principle of, the degree of swelling increases with the improvement of the aromatics content in SBS asphalt. The formed SBS swelling grid can limits the flow of the matrix asphalt effectively, which improves the flexibility, elasticity and viscosity of the asphalt. By researching, Airey GD[3], Scortical MS, Larsenb DO and Bianchetto H[4], Masson JF，Polomark G and Collins P[5] obtained that the SBS particles swell by the effect of asphalt saturates and aromatics and dispersed evenly in the asphalt. This can make Asphalt composition change, the road performance of modified asphalt system is greatly improved. Kraus [6] researched that the SBS can swell to network structure when the mass fraction of SBS modified asphalt is 30% to 40% and the relative molecular mass of PS area is more than 10000. This can modify the asphalt effectively. Based on the blending thermodynamics and phase separation, Masson. Etc [7] use the infrared spectrum analysis and thermodynamic phase diagram was used to study the different influences of SBS relative molecular mass, block ratio and asphalt source on the stability of modified system. This can reveal the situation of the interaction force between molecules in SBS network structure.

The solubility

The compatibility means the ability that the the asphalt can form a uniform system with SBS by any proportion and would never stratify or separate and is always in the state of thermodynamic equilibrium. Moreover, the swelling SBS particles could form the continuous network structure when the SBS content reaches a certain percentage. This can obviously improve the performance of asphalt as well as the storage stability of SBS and also can reduce the heat accumulation precipitation. The compatibility which is good or bad depends on the molecular structure of SBS and the composition of asphalt [8]. The compatibility of SBS and asphalt is better when the aromatics content is high [9]. By using the base oil as compatilizer, SP Li etc.[10] got the excellent high and low temperature performance of modified asphalt. The compatilizer can promote the swelling of SBS molecular chains in PS micro area and decrease the acting force between SBS molecular chain. This can improve the processing performance and the stability of the modified asphalt.

2.2 The chemical modification mechanism

The asphalt exists the organic functional groups of hydroxy, carbon base and ester group, which can make chemical cross-linking or chemical addition with the material to generate new chemical bonds. And the acidic or alkaline functional groups in the asphaltene can make addition, cross-linking and grafting reaction with the corresponding group of other additives to form the strong covalent and ionic bonds. This can change the chemical structure of asphalt and then improve the chemical properties of asphalt.

The addition reaction

The asphalt has free radicals and alkenyl groups which can make chemical addition reaction with the organic compounds, unsaturated monomers or low molecular compound to generate the new compound. The maleic anhydride (MAH) can be added in the SBS modified asphalt to generate the SBS - g - MAH modified asphalt [11]. And because of the higher polarity of the SBS - g - MAH than the SBS, it would form the more stable and uniform twine-structure with asphalt to improve the hot storage stability of asphalt. By using the polar monomer methylacrylic acid to graft the SBS in the 60 CoC ray irradiation, the SBS - g - M modified asphalt has been formed [12]. Meanwhile, compared with SBS, the higher polarity of SBS - g - M improves the high temperature rheological properties of asphalt and reduces the temperature sensitivity of asphalt better.

The reaction with sulfur cross-linking agent

The cross-linking agent of elemental sulfur, sulfur, sulfur compounds are added in SBS modified asphalt to make cross-linking reaction between SBS and asphalt or between cross-linking agent and asphalt. The addition of sulfur cross-linking agent can make SBS partly vulcanization, which can form vulcanization macro-molecular network structure to improve the heat resistance, weather resistance and mechanical properties of asphalt. By adding the disulfide in SBS modified asphalt,

Koen [13] obtains that the disulfide whose diaryl is substituted by nitro can both improve the storage stability of the blending system and enhance the low and high temperature performance of asphalt. By using the elemental sulfur as cross-linking agent and zinc oxide as activator, Z Liu [14] got the SBS modified asphalt whose stability is better. Through the dynamic vulcanization technology, Jim etc.[15] implement the reactive modification that the SBS is grafted in the PS surface. In asphalt modification research, Wen etc.[16] added the elemental sulfur into AH-90 asphalt and two types of SBS in high speed mixer to proceed the dynamic vulcanization. And this can get the blend whose performance and high temperature storage stability are better.

The reaction with other functional groups

Kluttz etc.[17] gained that the compatibility between it and asphalt has been improved significantly after the SBS oxidation. Bonemazzic etc.[18] obtained that the addition of phosphorus compounds can improve the durability and high temperature stability of the modified asphalt system. Moreover, the 2% ~ 3% modifier with the acid treatment has the same modification effect of the 5% ~ 6% modifier without acid treatment. The reason is that phosphorus compounds can promote the transformation from sol to gel structure for asphalt components and the homogeneous system is more easy to be formed with the larger the asphaltene content and the greater average relative molecular mass. By adding the esters and inorganic metal oxides to make SBS form stable chemical cross-linking network structure in the asphalt, SR Li [20] improved the high temperature storage stability of the SBS modified asphalt.

2.3 The conclusions for modification mechanism

From an overall point of view, the physical blending modification mechanism refers to its swelling and solubility. According to the similar compatible principle of, the degree of swelling increases with the improvement of the aromatics content in SBS asphalt. The formed SBS swelling grid can limits the flow of the matrix asphalt effectively, which improves the flexibility, elasticity and viscosity of the asphalt. The compatibility means the ability that the asphalt can form a uniform system with SBS by any proportion and would never stratify or separate and is always in the state of thermodynamic equilibrium. Moreover, the swelling SBS particles could form the continuous network structure when the SBS content reaches a certain percentage. This can obviously improve the performance of asphalt as well as the storage stability of SBS and also can reduce the heat accumulation precipitation. Besides, the chemical modification mechanism means that asphalt exists the organic functional groups of hydroxy, carbon base and ester group, which can make chemical cross-linking or chemical addition with the material to generate new chemical bonds. And the acidic or alkaline functional groups in the asphaltene can make addition, cross-linking and grafting reaction with the corresponding group of other additives to form the strong covalent and ionic bonds. This can change the chemical structure of asphalt and then improve the chemical properties of asphalt.

3. The future research directions of the SBS modified asphalt

Although the outstanding performance of the SBS modified asphalt has a wide applications, there is still some insufficient through the research on the modification mechanism at home and abroad. For example, SBS can easily layer with asphalt segregation in the high temperature storage process. In order to product the SBS modified asphalt whose quality is much higher, the future possible research directions of the SBS modified asphalt have the following aspects.

(1) The development of stabilizing agent for SBS modified asphalt.

(2) The mathematical model for the relationship between stabilizing agent and the matrix asphalt composition should be built.

(3) We can take the in-situ regeneration technique and bring inorganic nanometer into SBS to conduct the enhanced reaction, which could improve the mechanical properties and thermal stability.

(4) Chemical modification is one of the inevitable development trends. The reaction promoters and new reaction monomer should be introduced to develop the interactions for modification agent,

additives and asphalt, which can form new chemical bonds. This would increase the thickness and strength of interface layer fundamentally, which can increase the stability of the system and the effect of modification.

(5) Strengthen the study on weather-ability and the aging of SBS modified asphalt.

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