tbScientific and Social Research, 2021, Volume 3, Issue 4
http://journals.innosciencepress.com/index.php/ssr
ISSN Online: 2661-4332

Study on Performance of Wax Warm Mix Asphalt Cracked by Mixed Polyethylene Waste Plastics

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Abstract: In order to study the modified performance of polyethylene waste plastic cracking wax on asphalt, this paper prepared polyethylene wax (PE wax) by catalytic cracking using waste polyethylene as raw material and Ni-based zeolite as catalyst in a pressure reactor under closed conditions. 70# base asphalt was modified with PE wax, and the properties of pyrolysis wax on asphalt under different catalytic cracking time were studied by three indexes test, Brinoll rotary viscosity test, DSC test and dynamic shear rheology test. The test results show that the cracking products of mixed polyethylene waste plastic cracking wax have good viscosity reduction effect on asphalt under different cracking time. After modification, the high temperature performance of asphalt is improved, and the low temperature performance has a certain influence, but it still meets the specification requirements; In the temperature range of 0℃~60℃, the addition of pyrolysis wax can make the phase transformation of matr-ix asphalt more stable.

Keywords: Zeolite; Ni catalyst; Waste polyethylene; Pyrolysis; PE wax

Publication date: October 2021; ***Online publication:*** October 29, 2021

1. Introduction

With the increasing volume of traffic around the world, people are increasingly aware of the need for reinforced asphalt binders and mixtures to ensure the functional durability of transportation facilities [1]. Conventional Hot Mix Asphalt mixture (HMA)between 150℃ to 190℃ under the temperature of mixing and compaction, the construction temperature demand is higher, when the production not only need to consume large amounts of energy, but also in the mixing, transportation, and release a large amount of harmful gas in the process of construction, the construction personnel and atmospheric environment caused serious harm [2-3].Under these circumstances, it is imperative to study a kind of energy saving and emission reduction, green and environmental protection warm mix asphalt mixture (WMA) to replace or make up for the shortage of hot mix asphalt mixture (HMA).Warm mix asphalt mixture (WMA) pavement technology reduces the mixing and compaction temperature of asphalt mixture by adding warm mixture to asphalt or aggregate, preventing harmful gas release and reducing energy consumption. Warm mixed asphalt mixtures (WMA) have been shown to significantly reduce emissions and save energy. In addition, improvements in the work, safety and health of personnel and workers on the construction site have been observed [4]. At present, researchers at home and abroad have invested a lot of research on warm mixing technology. The widely used warm mixing agent mainly includes zeolite, wax, surfactant, etc. On behalf of the manufacturers were Aspha-min (Eurovia Services Gmbh, Germany), Sasobit (Sasol, Germany) and Evotherm (MeadWestvac, USA). The organic warm mixture consists of wax, which is added to the asphalt mixture during the mixing process [5].

In this paper, from the point of view of reducing “white pollution” and resource reuse, the catalytic cracking method of high-density polyethylene (HDPE) and low-density polyethylene (LDPE) mixed waste plastic was used to prepare waxy products to modify 70# base asphalt. Physical properties, viscosity reduction and rheological properties were used to evaluate the feasibility of waste plastic cracking products as asphalt warm mixing additives, in order to provide some theoretical reference for the further study of warm mixing technology.

2. Experimental materials and methods

2.1. Shell 70# base asphalt

In this paper, the base asphalt used in this study is AH-70 base asphalt, which con-forms to JTG 40-2004 technical Specification for Construction of Asphalt Pavement for Highway.

2.2. PE plastic

The PE plastic used in this study is the mixed waste plastic particles of high-density polyethylene (HDPE) and low-density polyethylene (LDPE).

2.3. Preparation of waxy warm mixing agent

In this paper, polyethylene wax was prepared by catalytic pyrolysis to reduce the reaction temperature of pyrolysis. The waste plastic particles of high-density polyethylene (HDPE) and low-density polyethylene (LDPE) (mass ratio 1:1) were mixed with the catalyst in a certain proportion, and then placed in a high temperature pressure kettle for catalytic cracking at 280℃ for 30 min. Under the condition that other pyrolysis conditions remain unchanged and only the pyrolysis time is changed, four different pyrolysis waxes are obtained, which are denoted as I, II, III and IV respectively. The pyrolysis time of I is 15 min, II is 30 min, III is 45min and IV is 60 min.

2.4. Test method for performance index of modified asphalt

According to the relevant provisions of “Test Regulations for Highway Asphalt and Asphalt Mixture” (JTG E20-2011), three indexes’ tests (penetration, softening point and extensibility), Brinard rotary viscosity test, DSC test and dynamic shear rheological test were carried out on matrix asphalt and modified asphalt.

3. Analysis of test results

3.1. Analysis of experimental results of three indexes

Table 1. Experimental results of the three indexes

Type of pyrolysis wax	Pyrolysis wax content（%）	Penetration 25℃（0.1mm）	Softening point /℃	Ductility（5℃）/cm
Base asphalt	6	61	49.6	11.8
Ⅰ	6	57.3	54.6	9.9
Ⅱ	6	67.2	55.75	14.3
Ⅲ	6	66.8	55.6	12.8
Ⅳ	6	65.4	55.5	12.4

3.1.1. Penetration

It can be seen from **Table 1** that the penetration degree of modified asphalt II, III and IV is higher than that of base asphalt at the same dosage of warm mixture, indicating that the resistance of modified asphalt II, III and IV to plastic deformation is weakened and the fluidity is stronger. The reason may be that the wax melts in the base asphalt at high temperature and thus has the effect of viscosity reduction.

3.1.2. Softening point

As can be seen from **Table 1**, under the same temperature mixing agent content, softening point of modified asphalt, first after rising downward trend, the reason may be that the addition of wax cracking, act as the saturates, colloid and other components of the asphalt, improving these components in the proportion of asphalt, wax belongs to polymer materials, molecular weight, added to the matrix asphalt will reduce the liquidity of asphalt, after high temperature performance increase, Therefore, the softening point of asphalt is increased, but with the increase of cracking reaction time, the cracking is more sufficient, there will be a little oil, and the existence of oil will reduce the softening point of asphalt.

3.1.3. Ductility

It can be seen from **Table 2** that the ductility of modified asphalt at 5℃ decreases first, then increases and then decreases with the different cracking time, among which the ductility of modified asphalt II is the largest. The ductility of asphalt reflects the total capacity of asphalt to withstand plastic deformation under the action of external forces. Low ductility cannot meet the technical requirements of asphalt pavement, poor elastoplastic performance, easy to crack in winter. With the increase of the ductility, the modified asphalt can show good plasticity and viscosity, and its ability to resist external deformation also increases.

3.2. Brinell rotational viscosity

Figure 1. shows the influence of waste plastic cracking wax on asphalt viscosity at the same temperature and different cracking time.

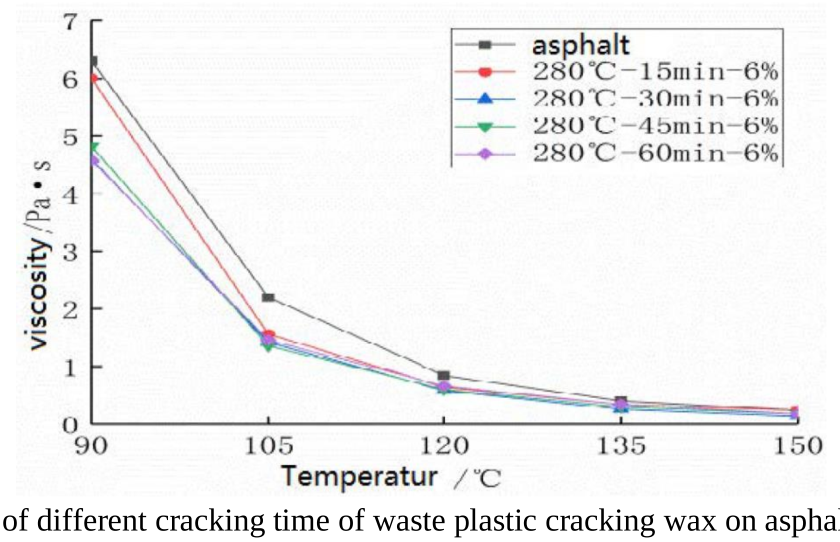

Figure 1. Influence of different cracking time of waste plastic cracking wax on asphalt viscosity

Figure 1 shows that:

(1) Under the same dosage (6%) and other test conditions, the modified asphalt with wax cracking time of 30min has better viscosity reduction effect. Under the condition of 135℃ test, the viscosity of modified asphalt II, (cracking time of 30min) is reduced by 35% compared with the base asphalt, which indicates that modified asphalt ii has better wettability and can be mixed and compacted at a lower temperature.

(2) According to the specification, the temperature under the asphalt viscosity of (0.17±0.02) Pa•s is generally regarded as the mixing temperature. As can be seen from the figure, under the asphalt viscosity, the mixing temperature corresponding to the modified asphalt II with the best viscosity reduction effect is about 10℃ lower than that of the base asphalt, indicating that the cooling range of the warm mixture corresponding to the cracking time is about 10℃. It has good cooling effect.

3.3. DSC analysis

The raw material used in this experiment is modified asphalt II, and the dosage of warm mixing agent is 6%. The DSC curve obtained is shown in **Figure 2**.

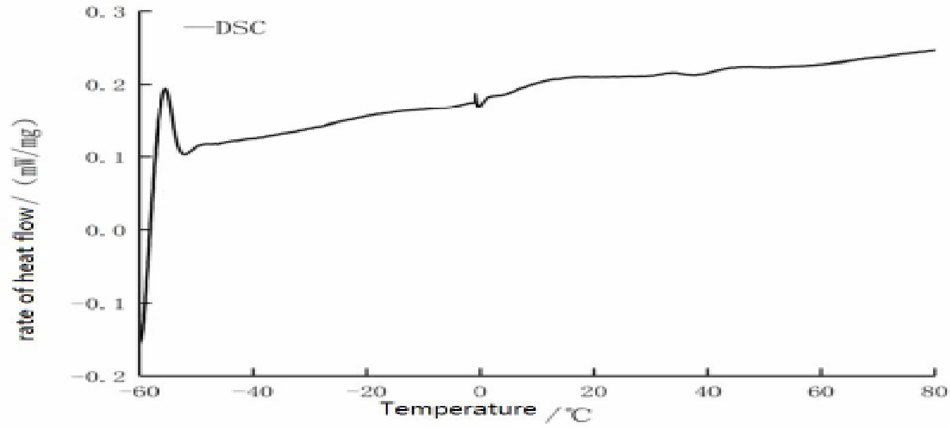

Figure 2. DSC curve of modified asphalt II

Can be seen from the **figure 2**, when starting from the low temperature of asphalt test, in this range -55℃~ 20℃, the asphalt in a larger endothermic peak, the main reason is because in as the mixture of asphalt, there is a light component, there are differences between the various components of the phase change temperature, can produce a kind of component phase change is not over, Other components have begun to absorb heat, which leads to the generation of the endothermic peak in the DSC curve. In the temperature range of 20℃~60℃, neither absorb nor release heat, in a relatively stable state.

3.4. Influence of warm mixture on rheological properties of asphalt

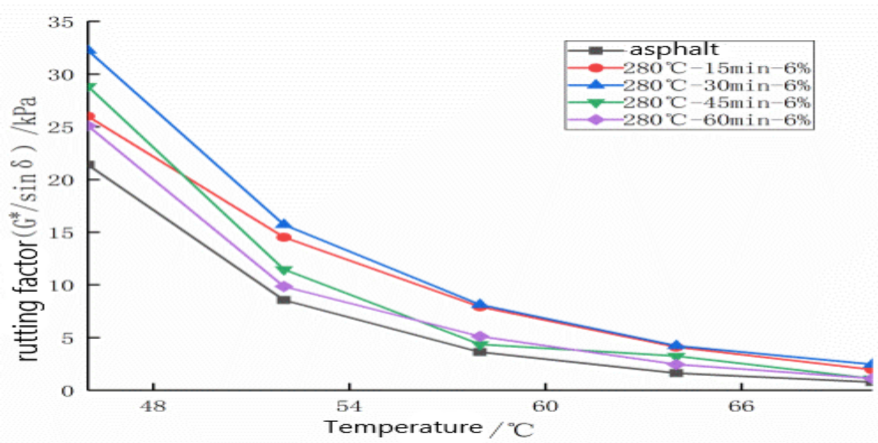

Figure 3. Rutting factors at different cracking times before aging

As can be seen from **Figure 3**, the rutting factors of the four modified bitumen are significantly higher than that of the base bitumen, which indicates that the addition of modifiers has a favorable effect on the rutting performance of the base bitumen, and the rutting performance of modified bitumen II is the best.

4. Conclusion

(1) The cracking products of mixed waste plastics have good viscosity reduction effect on asphalt under different cracking time, among which the modified asphalt with the viscosity reduction effect of 280℃-30 min-6% has the best, and its cooling range is about 10℃, which has good cooling effect, and is beneficial to the construction and ease of modified asphalt.

(2) The cracking products of mixed waste plastic under different cracking time can improve the permanent deformation resistance of leaching and the rutting resistance, so as to prolong the service life of asphalt pavement.

(3) The addition of pyrolysis wax can increase the stability of the matrix asphalt in a large temperature range, shown in the DSC curve in the temperature range of 0℃~60℃ heat absorption and discharge are 0, the curve is relatively flat.

Disclosure statement

The author declares no conflict of interest.

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