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EXTENDED ABSTRACT

Effects of Metallic Nano Materials on the Cohesion and Adhesion Properties of Asphalt Binders and Aggregates Using Surface Free Energy Method

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1. Introduction

One of the most common damages in asphalt mixtures is due to the destructive effects of moisture on the cohesion of asphalt binder and adhesion of asphalt binder-aggregate which is called moisture damage (Xiao et al, 2010). Moisture damage can be divided into two mechanisms, adhesion and cohesion. They are related to the strength loss of asphalt mixtures (Tan and Guo, 2013). Water can penetrate between the surface of asphalt binders and the aggregates. It reduces adhesion between binders and aggregates. Also, water can be absorbed in the asphalt binder. It decreases the cohesion properties of asphalt binders. When the cohesion and adhesion properties of asphalt binder reduce, stiffness of asphalt mixtures reduces. There are several different approaches for improving adhesion and reducing moisture sensitivity in asphalt mixtures. One convenient approach is modifying the asphalt binder with a suitable agent. Most of road and transportation agencies have tried to use anti striping additives to increase adhesion at the aggregate-asphalt interface (Kakar et al, 2015). Liquid anti strip additives are chemical surfactants that decrease the aggregate's surface tension and improve the surface coverage of aggregates. In contrast in this research, the potential of two types of metallic nano materials in two different percentages (nano AL_2O_3 and Fe_2O_3) were evaluated.

2. Methodology

A 60/70 base asphalt binder, two different aggregates including siliceous and lime aggregate and two types of nano materials in two different percentages (nano AL_2O_3 and Fe_2O_3), were used for fabricating the samples. Figs. 1 and 2 show images of nano AL_2O_3 and Fe_2O_3 in 500nm. To assess the effect of these nano materials, the concept of surface free energy (SFE) was applied for determining the adhesion and cohesion properties of aggregate and modified binders. Surface free energy is defined as the energy needed to create a new unit surface area of material in vacuum condition. A sessile drop test was used for determining some basic components. Acid, base, polar, nonpolar and total surface free energy of binders was calculated. Also, adhesion free energy between binders and aggregate in both dry and wet condition were determined for siliceous and limestone aggregates.

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3. Results and discussion

Table 1 show the effects of metallic nano materials additive on the surface free energy of adhesion for siliceous and lime stone aggregates in wet and dry conditions. The value of adhesion free energy is positive for dry conditions, while it is negative for wet conditions. From the table, modified binders have higher values of surface free energy when compared to base binder. It means that, nano metalic additives enhance the moisture sensitivity of asphalt mixtures. In dry condition, surface free energy of adhesion increases when additive content increases. Higher surface free energy value are preferable than its lower value. The improvement effects of these additives for lime stone aggregate are higher than those for siliceous aggregate.

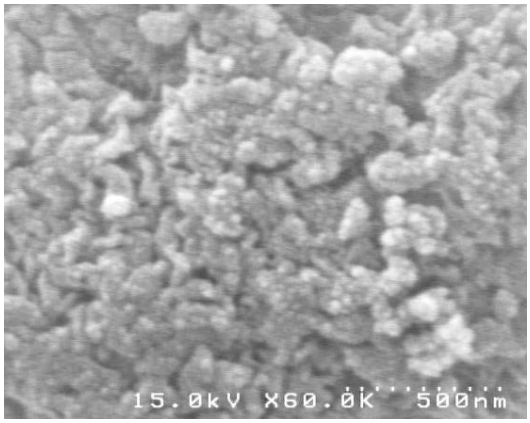

Fig. 1. Image of Nano AL_2O_3

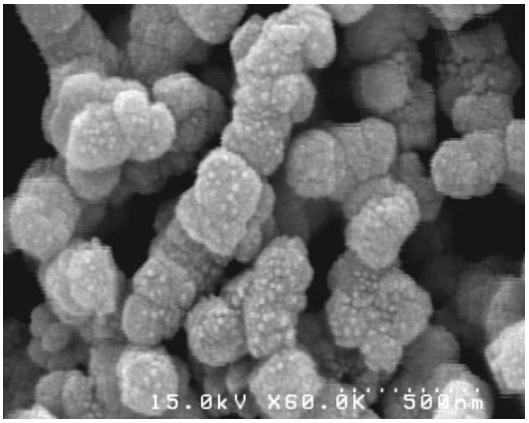

Fig. 2. Image of Nano Fe_2O_3

Table 1. Surface free energy of adhesion

Aggregate		Without additive	Al_2O_3		Fe2O3	
		0	0.5	1	0.5	1
Siliceous aggregate	dry	150.2	151.9	153.4	152.4	153.3
	wet	-123	-111.1	-112	-112.2	-116.3
Lime aggregate	dry	154.6	156.1	157.5	156.3	157.4
	wet	-119	-111	-111.9	-112.1	-116.4

4. Conclusions

This study showed that nano material significantly improves the moisture strength of samples made with the modified asphalt binder in comparison with the nonmodified asphalt binder samples. Results of surface free energy theory show that the nano materials increase the cohesion free energy of the asphalt binder and decrease the probability of the occurrence of cohesion failure in the mastics. Also, nano materials decrease the acid component and increase the base component of surface free energy of the asphalt binder which increases its adhesion with the aggregates.

5. References

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