Performance Evaluation of a Hydrophobically Modified Anti-Slide and Anti-icing Coating

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Abstract. Two-component oil-based polyurethane and two-component water-based polyurethane were used as main raw materials, and a hydrophobic modified anti-slip snow coating was prepared by adding a sodium chloride modified snow melting agent which was subjected to zeolite-diatomite slow release treatment. The performance of the coating was evaluated. The viscosity test showed that the viscosity of the coating was 4200 MPa, which ensured the fluidity of the coating. The contact angle test shows that the coating has a contact angle of 99.2° and belongs to a hydrophobic surface. The friction coefficient and texture depth tested shows that the material has a friction coefficient and depth of texture up to 81BPN and 72.5mm. The research results show that the coating has certain hydrophobic ability, can hinder the road surface freezing, and can release the snow melting agent for a long time, prolong the ice-suppressing effect of the coating, and has good anti-sliding ability, which can ensure the safety of driving in ice and snow weather.

1. Introduction
The snowmelt technology of asphalt pavement is the current research hotspot. At present, there are mainly the following methods of snow removal and ice removal: mechanical equipment shoveling snow, removing most of the snow on the macroscopic road surface but the snow on the concave surface of the microscopic road surface cannot be removed[1-3]. Moreover, the domestically produced snow shoveling machine has a single function, low equipment utilization rate, multiple times and repeated snow removal, and serious damage to the pavement structure. The method of removing snow from snow melting agent is widely used, but the snow melting efficiency is low, and the commonly used snow melting agent has corrosive effect on the environment[4-5]. The geothermal snow melting system and the conductive concrete pavement respectively passed the pipeline laying, and use the heat storage capacity of the water to convert the solar energy into heat energy for melting snow in winter, and add conductive materials to the concrete when the pavement is laid, and convert the electric energy into heat energy for melting snow[6-8]. These two methods have better snow melting effect and less damage to the environment, but they need to be systematically laid for complete sets of equipment, and the cost of paving, repairing and curing is high[9-10].

This study used oily polyurethane and waterborne epoxy resin and modified by slow release treatment. A hydrophobic modified anti-slip coating was prepared by the snow melting agent, and its hydrophobic properties, fluidity, and the slip resistance of the test pieces coated out of the asphalt mixture were evaluated.
2. Materials and methods

2.1. Materials

Two-component oil-based polyurethane (The massed ratio of polyurethane and hardener is 1:1.5).

Two-component water-based polyurethane (The massed ratio of polyurethane and hardener is 1:1.5). Non-ionic waterborne epoxy resin (The massed ratio of waterborne epoxy resin and hardener is 1:1.5). Zeolite powder, diatomite, absolute ethanol and sodium chloride are analytical purity. A silane coupling agent: Y-aminopropyltriethoxysilane (KH500) is analytical purity. The water used is distilled water. Other materials are basalt, limestone Mineral, powder and Heavy traffic paving petroleum asphalt.

2.2. Slow release test of modified snow melting agent and contact angle test of hydrophobic coating

2.2.1. Preparation and slow release effect test of modified snow melting agent

Prepare a saturated solution to sodium chloride, add zeolite and diatomite with a mass ratio of 1:2, stir well for 10 mins under heating in a water bath, and cut the mixture of a high-speed shear for 30 mins, after standing for 24 h. The mixture was filtered, and a solid residue was taken and dried in vacuo. The dried sample was placed in absolute ethanol, ultrasonically shaken to form a suspension, and then 3% of a silane coupling agent was added, and ultrasonic vibration was continued for 4 hours. After vacuum filtration, a solid precipitate was obtained, and the precipitate was precipitated. Vacuum drying was carried out to obtain a modified snow melting agent. The modified snow melting agent was added to a clean cup, distilled water was added, and the supernatant was filtered after soaking for 24 hours. After 3 days, the supernatant was filtered out. After 8 days, the supernatant was filtered off, and after 12 days, sodium hydroxide was added drop wise. And silver nitrate solution to observe the precipitation in the solution.

2.2.2. Hydrophobic coating contact angles test.

The specific ratios of the materials of the experimental group and the comparison group are shown in Table 1, and the modified snow melting agent was a modified snow melting agent prepared by 2.3.1. After preparing each group of samples, each sample was uniformly coated out of a slide, and the thickness of the coating was controlled to about 1 mm. After curing, a coating was obtained, which was measured by a contact angle measuring instrument, and a static drop method was using.

| Material composition and specific proportion of the sample | mass ratio |
|-----------------------------------------------------------|------------|
| experimental group 5(E5) Two-component oil-based polyurethane : Two-component waterborne epoxy resin : Modified snow melting agent | 1:0.1:0.1  |
| comparison group 1(C1) Two-component oil-based polyurethane : Two-component waterborne epoxy resin | 1:0.1      |
| comparison group 2(C2) Two-component water-based polyurethane : Two-component waterborne epoxy resin | 1:0.1      |
| comparison group 3(C3) Two-component water-based polyurethane : Two-component waterborne epoxy resin : Modified snow melting agent | 1:0.1      |

2.3. Preparation of hydrophobic coating Marshall test piece

Refer to the Highway Engineering Asphalt and Asphalt Mixture Test Procedure (JTG E20-2011) to prepare the Marshall test piece of AC-13 type asphalt mixture. The experimental group 6(E6) sprays the hydrophobic modified anti-slip snow melting paint on the surface of the test piece, the thickness of the coating. The control is about 1mm, the comparison group 4(C4) is blank coating, and the comparison group 5(C5) is coated from two-component oily polyurethane and two-component waterborne epoxy resin (1:0.1 ratio). The sample of comparative group 6(C6) was coated with a mixed
coating of two-component waterborne polyurethane and two-component waterborne epoxy resin (ratio 1:0.1). The gradation design is shown in Table 2.

| sieve aperture/mm | 19  | 16  | 13.2 | 9.5  | 4.75 | 2.36 | 1.18 | 0.6  | 0.3  | 0.15 | 0.075 |
|-------------------|-----|-----|------|------|------|------|------|------|------|------|-------|
| grading ceiling/% | 100 | 100 | 80   | 53   | 40   | 30   | 23   | 18   | 12   | 8    |       |
| lower limit of grading/% | 100 | 100 | 90   | 60   | 30   | 20   | 15   | 10   | 7    | 5    | 4     |
| synthetic grading% | 100.0 | 100.0 | 97.8 | 75.6 | 42.4 | 30.9 | 24.2 | 16.1 | 10.9 | 8.2  | 6.4   |

2.4. Texture depth and friction coefficient
Refer to the test procedure for road engineering asphalt and asphalt mixture (JTG E20-2011) for the friction coefficient and structural depth test of E6, and C4, C5, and C6.

3. The results and discussion
3.1. Slow release test results and contact angle test results and analysis of modified snow melting agent
The titration of silver nitrate in the supernatant after 12 days is shown in Figure 1.

![Figure 1. Chloride ion titration results](image)

As shown in Figure 1, the supernatant was titrated with silver nitrate solution to produce a large amount of white precipitate after 12 days. Because the supernatant was dropped into the silver nitrate solution, enough sodium hydroxide solution was added to eliminate the solution. The chloride ion in the presence of acid, so the white precipitate is derived from the chloride ion in the sodium chloride in the snow melting agent, indicating that the release of the modified snow melting agent has a sustained release effect, because the zeolite itself is a molecular sieve pore. The volume is 0.037 cm$^3$/g, the pore size is 3.9 nm, and the pore volume of diatomaceous earth is 0.45-0.98 cm$^3$/g, and the pore size is 2.9 nm, which is a denser and finer pore structure. After sodium chloride is slowly released, sodium chloride enters the channel formed by zeolite and diatomaceous earth. Due to the difference in pore size and pore size distribution, sodium chloride will pass through the channel stepwise during the release process, it will not be completely released in a short time, so there is a sustained release effect. The test results of the contact angle are shown in Figure 2.
According to the contact angle test results, the contact angle of E5 is the largest, and greater than 90 degrees. According to the Young's equation, the coating is a hydrophobic surface, and the comparison group is less than 90 degrees, and does not have a good hydrophobic effect. Compared with C2, the hydrophobic effect of the oily polyurethane is better than that of the waterborne polyurethane. C1 is comparable with the experimental group, and C2 and E5 are added to increase the coating roughness and increase the hydrophobic effect.

3.2. Friction coefficient and texture depth test results

The test results of friction coefficient and structure depth are shown in Figure 3. The friction coefficient and friction coefficients of the experimental group are greater than the three groups of comparison, and maintained at a higher level, indicating that the coating is applied to the Marshall test piece of the asphalt mixture. The anti-sliding performance of the test piece surface is greatly increased. This is because the oil-based polyurethane has good hydrophobicity. After compounding with the water-based epoxy resin, the surface texture of the formed coating is developed, and the modified snow melting agent is added to further to improve the roughness of the surface. It has a certain frictional adhesion when rubbed against the road tires, thus showing good anti-sliding ability.
4. Conclusion

a. A modified anti-slip ice-suppressing coating uses zeolite powder and diatomaceous earth to form a channel, which delays the release rate of sodium chloride, so that the ice-suppressing effect of the coating has a sustained release effect, and can cope with long-term winter snow and ice weather.

b. The friction coefficient value and structure depth of the coating can be as high as 81BPN and 72.5mm, and can form a large frictional adhesion when rubbed on the road surface and between the tires. By rolling the tire, the weak ice layer can be broken, and the anti-sliding and anti-icing effect can be achieved. Obviously, it can reduce the unsafe hidden dangers of driving on the road with long-term rain, snow and cold weather.

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