Development of an Easy Construction Type Aqueous Color Paint Having Excellent Abrasion and Skid Resistance

KEISUKE NARUSHIMA, MAI OIKAWA, SATOSHI TADA, MASATO MURAYAMA, NAOYUKI YACHI

TOA ROAD CORPORATION, TSUKUBA, IBARAKI, JAPAN
Introduction

Color paint

- landscape
- protect
- safety

visibility
skid resistance
Introduction

Complicated application

- Cleaning
- Priming
- Mixing paint materials

... etc
Introduction

Complicated procedure

- Cleaning
- Priming
- Mixing paint materials
  - etc

Environment

- VOC reduction
- Aqueous paint
  - Lower abrasion resistance
  - Lower adhesion

Color paint

- Oil paint
- Toluene
- Xylene
  - and more
Development Objective

Easy application
- Without complicated procedure
- An one-liquid paint
- Good workability even in low temperature

Excellent abrasion and skid resistance
- More than oil paint and the same class

Aqueous color paint
Evaluation method

1. Film formation at low temperature

2. Abrasion resistance

3. Skid resistance

Digital microscope image
Evaluation method

1. Film formation at low temperature

2. Abrasion resistance

3. Skid resistance

Calculating the abrasion ratio after 1–6 cycles

Wet track abrasion tester (JEAT-1)
Evaluation method

1. Film formation at low temperature

2. Abrasion resistance

3. Skid resistance

A pendulum skid resistance tester

Skid resistance Value (Road Research Laboratory)

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of site</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Difficult sites such as 1. Roundabout 2. Bent with radius less than 150m 3. Approaches to traffic lights on on unrestricted road</td>
<td>65</td>
</tr>
<tr>
<td>B</td>
<td>Motorways, trunk and class 1 roads and heavily trafficked road in urban areas</td>
<td>55</td>
</tr>
<tr>
<td>C</td>
<td>all other site</td>
<td>45</td>
</tr>
</tbody>
</table>
Evaluation method

1. Film formation at low temperature
2. Abrasion resistance
3. Skid resistance

A pendulum skid resistance tester

The value of standard 60 BPN or more.

Asphalt pavement
Minimum 60 BPN
## Investigation of materials

Constituents of prototype material

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<tr>
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## Candidates for resin and their properties

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<th>Item</th>
<th>Resin a</th>
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<tbody>
<tr>
<td>Constituents</td>
<td>Acrylic/styrene</td>
<td>Silica-modified</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Particle dia.</td>
<td>0.09</td>
<td>0.15</td>
<td>0.15</td>
<td>0.17</td>
<td>0.17</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>(μm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_g$ (°C)</td>
<td>-20</td>
<td>-15</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>MFTs (°C)</td>
<td>Below 0</td>
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<tr>
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Checking these **abrasion resistance** after curing at 23°C
### Investigation of materials

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Resin a and Resin b have low MFT, but their **abrasion resistance is too low**.

**Soft type resin**
### Investigation of materials

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Resin g shows highest abrasion resistance.

After 6 cycle, abrasion ratio 0%.

Decrease MFT of resin g.
Investigation of materials

MFT : Minimum Film-forming Temperature

The film can’t formed correctly below MFT.

Method 1

Mixing low $T_g$ emulsion
Investigation of materials

MFT: Minimum Film-forming Temperature

The film can’t be formed correctly below MFT.

Method 2

Coalescence prompt to adhesion between emulsions

Lowering the abrasion resistance
Investigation of materials

MFT: Minimum Film-forming Temperature

The film can’t be formed correctly below MFT.

Method 2

To avoid lowering abrasion resistance, the choice and quantity of coalescence is important.

Adding coalescence
Investigation of materials

Constituents of material

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Cured at 5°C

- Only resin g
- Defective film

Method 1

- Mixing resin a

Cured at 5°C

- Resin a + g
- Intact film

After 6 cycle

- Abrasion ratio 0%
  
  (23°C)

After 1 cycle

- Abrasion ratio 40%
  
  (23°C)

Abrasion resistance was immediately decreased
Investigation of materials

Constituents of material

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Method 2

- Comparison with butyl acetate
- Boiling point (°C): 170, 229, 254
- Evaporation rate*: 7, 1, less than 1

* Comparison with butyl acetate

![Defective film](image1)

![Intact film](image2)

![Defective film](image3)

![Intact film](image4)
**Investigation of materials**

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**Method 2**

*Low abrasion resistance*

- **after 1 cycle**
  - Coalescence H (5°C)
    - Abrasion ratio 40%
  - Coalescence I (5°C)
    - Abrasion ratio 5%
  - Coalescence J (5°C)
    - Abrasion ratio 40%

**Evaporation rates**

<table>
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*Comparison with butyl acetate*
Investigation of materials

Constituents of material

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Method 2

Coalescence H (5°C)
- after 1 cycle: abrasion ratio 40%

Coalescence I (5°C)
- after 1 cycle: abrasion ratio 5%
- after 6 cycle: abrasion ratio 0%

Coalescence I (23°C)
- after 6 cycle: abrasion ratio 0%

Boiling point (°C)

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Investigation of materials

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Rounded shape

Prototype
Investigation of materials

Constituents of material

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Mixing another shape aggregate

Rounded shape

+ Angular shape

Easy to tear off

Prototype

Improved aggregate

narrow the gap
Investigation of materials

Constituents of material

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Mixing another shape aggregate

Rounded shape + Rounded shape

Abrasion resistant improvement

after 1 cycle
abrasion ratio 5%
cured at 5°C

after 6 cycle
abrasion ratio 0%
cured at 5°C
## About development

### Package of development

### Standard properties for developed paint

<table>
<thead>
<tr>
<th>Item</th>
<th>Quality standards*</th>
<th>Results</th>
<th>Test methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1.05 g/ml or more</td>
<td>1.32 g/ml</td>
<td>JIS K 5600-2-4</td>
</tr>
<tr>
<td>Heating residue</td>
<td>minimum 50 %</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>Drying time</td>
<td>Within 3 hours</td>
<td>81 mg</td>
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<tr>
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<tr>
<td>Skid resistance</td>
<td>minimum 40 (our objective is minimum 60)</td>
<td>78</td>
<td>A pendulum skid resistance tester</td>
</tr>
<tr>
<td>Water resistance</td>
<td>Without cracks, peeling, and changes of color</td>
<td>81 mg</td>
<td>JIS K 5665 8.19</td>
</tr>
<tr>
<td>Weather resistance</td>
<td>Without cracks, peeling, and changes of color after 250 hours of weather proofing test</td>
<td>81 mg</td>
<td>JIS K 5600-7-7</td>
</tr>
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* The manual of procedure for the application of color pavement paint

---

[Image of paint package]
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* The manual of procedure for the application of color pavement paint
Application

1. Covered
2. Kneading
3. Pouring

4. First layer
5. Second layer
6. Completion

Procedure for applying development
Application

Application for a parking lot

Before

After

6 Month

No defects

Application for a building entrance

Before

After

6 Month

No defects
Conclusion

Easy construction at low temperature

- Selecting resin and adding coalescence improve the formation of film at 5°C.

Excellent abrasion and skid resistance

- The combination of aggregates with another shape rose abrasion resistance of film.

- Skid resistance of this development is 78 BPN.
Thank you for your attention!
Supporting

Construction examples

- Side walks
- Pillars or Walls
- Slopes for a wheelchair
Supporting

Weather resistance

The accelerated weathering test

The chroma meter CR410
(KONICA MINOLTA)

<table>
<thead>
<tr>
<th>$\Delta E^*$</th>
<th>ocher</th>
<th>gray</th>
<th>green</th>
<th>red</th>
<th>black</th>
<th>blue</th>
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<tbody>
<tr>
<td>after 1125 hour</td>
<td>0.44</td>
<td>1.13</td>
<td>0.85</td>
<td>0.44</td>
<td>0.48</td>
<td>3.80</td>
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※ a standard value is within 5 after 300 hours
Supporting

Weather resistance

The direct weather test

After one year