High Performance Redispersible Powder for the Use in 1K Waterproofing Applications

ABSTRACT

With the megatrend Urbanisation happening globally, the demand for high-rise buildings continues to increase. This drives the needs for better performance and efficient waterproofing systems for the construction chemical market.

Surface protection is needed to avoid water penetration into moisture sensitive substrates. It is also used to protect surfaces against the migration of chemicals like de-icing salt in concrete or to secure critical substrates from attack by chlorine, acidic rain, carbon dioxide, etc.

To get a functional membrane (or protective coating) it is necessary to use a polymer which builds a polymer matrix in the membrane to form a very dense layer against liquids after curing. The elastomeric waterproofing coating maintains its flexibility under permanent immersion in water and when exposed to a wide variety of weather conditions. These systems can withstand extreme weather conditions and climate changes (hot / cold, freezing, dry / wet) and are typically being used in cisterns as well as water tower storage tanks, waterproofing of balconies under tiles, showers and wet rooms like bathrooms, ….

Such hydraulic setting surface protection systems can be split into three different categories depending on the flexibility of the cementitious membrane. No flexibility required, semi flexible membrane and crack bridging performances or highly flexible even at temperatures below 0°C, with excellent low temperature elasticity and very good crack bridging performance.

In recent years, the market is actively searching for a one-component waterproofing system as a replacement to the more conventional two-component (bucket & bag) system. One-component systems have the advantage of producing less waste (eg. plastic buckets), easy handling and being fool proof. Two-component systems may cause problems such as using the wrong mixing ratio. In addition, the polymer dispersion needs to be protected against freezing during transportation and storage.

The most common redispersible powder for dry mixes is based on vinyl acetate polymers. However that type of technology is not the most suitable to achieve high elongation performance at negative temperatures simply because the Tg of the polymer is not low enough. The best choice is a styrene-acrylate based polymer and in that case a specific additive for the redispersibility of the powder is required.

Synthomer has been very active in the research and development of redispersing systems to propose a wide range of technologies to the construction market. This study investigates the performance of a new redispersible powder based on styrene-acrylate technology in combination with a new redispersing agent. We have tested that new powder in waterproofing membrane application according to the Standard EN 14891.
1 REDISPERSIBILITY OF POWDERS

Redispersible powders are obtained by spraydrying of the corresponding aqueous polymer dispersions containing a redispersing agent while simultaneously adding finely ground inorganic materials as anti-caking agents. The redispersibility of the polymer powder is the most important parameter in order to achieve mortar performances like adhesion onto the substrate, abrasion resistance, etc.

1.1. Vinyl Acetate Based Redispersible Powder

As far as the redispersibility of vinyl acetate based\textsuperscript{1,2,3,4} powder polymer is concerned, the most common additive used is polyvinyl alcohol\textsuperscript{5}. It is soluble in water and then guarantees a good redispersibility of the powder when the drymix mortar is being mixed with water. In addition, the polyvinyl alcohol is a stiff polymer and contributes to avoid caking or agglomeration of polymer particles during the drying step. It is normally being added at the end of the polymerisation and its dosage and the grade used (viscosity and saponification level) can vary depending of the polymer composition. The polyvinyl alcohol is absorbed at the surface of the polymer particle through Van Der Wall forces. During the spray drying step of the polymer, the water is removed and individual polymer particles are smoothly agglomerated to form bigger particles around 100 µm but it can be adjusted with the process parameters.

The redispersibility of the powder can be controlled by putting the powder into water and then comparing the particle size of the redispersed polymer versus the initial polymer. The measurement is done on a Malvern- Mastersizer M5 2000 apparatus (Fig. 1).

Figure 1 : Redispersed vinyl acetate powder. Initial polymer particle size= 2.2 µm
1.2. Styrene Butadiene Based Redispersible Powder

Through the enhancement of its portfolio, Synthomer can now offer a powder based on styrene-butadiene polymer. The redispersing system (amino acid or one of its salts) used in combination with the styrene-butadiene polymer has been patented. Despite the fact, that this patent has now expired, the performance of this technology is very much based on process and internal “know-how”.

This technology makes it possible to spray-dry a styrene-butadiene polymer having a very low particle size, around 0,15 μm, while conventional vinyl acetate base polymers typically have particle sizes around 1 to 2 μm. The low particle size polymer (Axilat PSB 150) is beneficial for adhesion properties. It is widely used for gypsum applications, Ceramic Tile Adhesives and Repair Mortars.

The technology described above has been tested in combination with styrene-acrylate polymer but the first application results have shown that this technology does not give the expected performances. Then our work has been focused on a novel redispersing system.

1.3. Styrene-Acrylate Based Redispersible Powder: new Redispersing System

As mentioned at the beginning of this Paper, the only way to achieve high elongation performance for cementitious 1K waterproofing membranes is to select very soft polymers. For this study, we have selected a soft styrene-acrylate dispersion already used in 2K waterproofing membranes with a Tg of -8°C. Our research work had been focused on the choice of a new redispersing system which is compatible with cementitious materials. The dosage of redispersible powder in highly flexible cementitious waterproofing membranes is easily above 20% by weight versus total drymix and then it must not influence the fresh paste characteristics of the mortar and the final performance of the membrane.

The styrene-acrylate has been modified in order to graft the appropriate chemical groups onto the surface of the polymer particle to create the needed interaction with the redispersing system.

The redispersing system must contain the appropriate chemical groups to graft around the polymer particle.
The redispersing system then creates a barrier to protect the polymer particle against irreversible agglomeration which can appear during the spray-drying step or during the storage of the powder. Figure 3 summarizes our approach regarding that new redispersing system.

According to our measurements, the experimental styrene-acrylate powder shows good redispersability (Fig. 4).

This experimental styrene-acrylate powder has been tested in a 1K waterproofing membrane versus one other powder used in the construction industry.

Figure 3: Schematic of the redispersing system used for the styrene-acrylate based powder

Figure 4: Redispersed styrene-acrylate based powder – Initial polymer is around 400 nm
2. SCREENING OF THE PROTOTYPE IN 1K CEMENTITIOUS WATERPROOFING MEMBRANE

The prototype has been tested in the cementitious formula described in Table 1.

Table 1: formula of the cementitious 1K waterproofing membrane

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Weight compounds</th>
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<tbody>
<tr>
<td>Grey Portland Cement 42,5 R</td>
<td>15,00%</td>
</tr>
<tr>
<td>Quartz sand 0,0 - 0,3 mm NE34</td>
<td>45,45%</td>
</tr>
<tr>
<td>Lime Stone Powder 15 mic.</td>
<td>10,00%</td>
</tr>
<tr>
<td>Bentonite</td>
<td>2,50%</td>
</tr>
<tr>
<td>Plastorit /Mica</td>
<td>1,50%</td>
</tr>
<tr>
<td>Dry Defoamer 770DD</td>
<td>0,30%</td>
</tr>
<tr>
<td>Fibers</td>
<td>0,15%</td>
</tr>
<tr>
<td>Cellulosic ether</td>
<td>0,10%</td>
</tr>
<tr>
<td>RDP</td>
<td>25,00%</td>
</tr>
<tr>
<td>Total</td>
<td>100,00%</td>
</tr>
<tr>
<td>Water dosage</td>
<td>24%</td>
</tr>
</tbody>
</table>

The performance of the membrane has been tested according the norm EN 14891 concerning the following parameters:

- Adhesion performance on slab,
- Waterproofing,
- Crack-bridging at 23°C, -5°C and -20°C.

2.1. Adhesion Properties

The cementitious membrane has been applied onto slabs which are in line with EN 1323. The membrane was cured for 24 h at 23°C and 50% moisture and then we applied a CTA mortar (C2TE) on the membrane (Fig. 5) according to the recommendation of EN 14891. The adhesion was measured after 28 days of curing at 23°C and 50% moisture.

The Synthomer prototype shows all adhesion values above the minimum requirement of EN 14891 (0,5 MPa), which is not the case with the industry benchmark selected for this study (Table 2).

Table 2: Bonding strength according to EN 14891

<table>
<thead>
<tr>
<th>Redispersible powder</th>
<th>Bonding strength in MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry conditioning</td>
</tr>
<tr>
<td>Prototype Synthomer</td>
<td>1,28 ± 0,15</td>
</tr>
<tr>
<td>Industrial Benchmark</td>
<td>1,18 ± 0,2</td>
</tr>
</tbody>
</table>

Figure 5: samples for adhesion test: Slab + membrane + mortar + tile
2.2. Waterproofing

The cementitious membrane has to be waterproof for 7 days at 1.5 bars according to EN 14891. The membrane is supported on a concrete slab. For practical reasons, we have prepared a concrete support by ourselves, which fits into our equipment to measure the waterproofing performance (Fig. 6). The membrane thickness has been fixed at 4 mm thickness and then cured for 28 days at 23°C and 50% moisture.

Right after the exposure to water pressure (for 7 days at 1.5 bars), the concrete support is cut immediately into two pieces to control if water has migrated into the support. It can be easily checked by looking at the concrete just below the membrane if we do see a “water front line” or not. The condition of the membrane is also controlled, because if the membrane shows poor waterproofing performance, we see in many cases a damage of the membrane like a swelling or a decohesion from the support. The pictures of the samples are presented in Figure 7.
2.3. Crack Bridging Performance

The elongation of the cementitious membrane is a key performance to make sure that the waterproofing membrane can follow dimensional variations of the support (dilatation, expansion) linked to weather conditions or simply to building movements linked to aging.

This difficult test was performed on a membrane applied on a 160*40*12 mm concrete support.

We have prepared the cementitious membrane according to our formulation (see Table 1) and applied it in a thickness of 2 mm on both sides of the concrete support. The curing of the membrane was done during 28 days at 23°C and 50% moisture. The measurement of the elongation of the sample was done with a traction machine from MTS System Corporation (speed = 0,15 mm/min according to the norm). The norm requires a minimum elongation value of 0,75 mm before any damage of the membrane.

For practical reasons the elongation at break has been measured while the norm requests to stop the elongation test as soon as the membrane starts to be damaged (cracks). In order to run such measurement, the climate chamber has to be equipped with a video camera which was not our case. According to our experience, the elongation at break and at the first damage (cracks) are very close. As soon as the membrane is damaged, the total rupture of the membrane follows rapidly.

Synthomer’s prototype shows excellent elongation properties at 23°C (Fig. 8). At -5°C, the elongation value obtained is not far from the norm (0,75 mm) and can be easily improved with formula optimisation like increasing the dosage of redispersible powder and reducing the cement dosage.

For performance at -20°C, the polymer composition has to be changed in order to reach Tg in the range of -15°C to -20°C.
CONCLUSION

A novel approach of the redispersing system has been used for the preparation of a soft redispersible powder based on styrene-acrylate chemistry for the 1K waterproofing application. This new redispersing system shows a very good efficiency as far as the redispersibility in water is concerned, which is a key element to achieve the expected contribution of the polymer in the cementitious membrane.

The experimental soft powder has been prepared and tested in a 1K waterproofing system and achieves excellent performances in regards to adhesion and crack bridging, it performs better than an industry benchmark.

Further work to broaden the scope of this new redispersing chemistry.

REFERENCES

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