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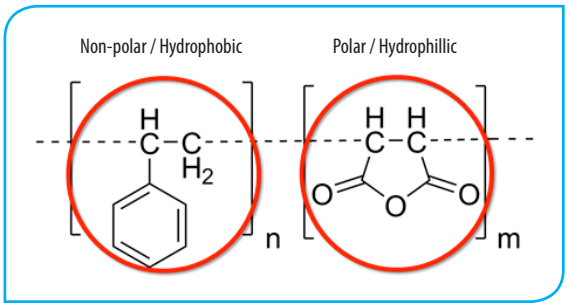
Styrene maleic anhydride co-polymers as dispersants for wax emulsions for improved wallboard hydrophobicity

Styrene maleic anhydride co-polymers offer unique properties due to having polar and non-polar moieties on the same molecule. Here, Daniela Ribezzo from Polyscope Polymers BV highlights how these can help disperse wax emulsions in the gypsum wallboard production process, resulting in improved board hydrophobicity.

Figure 1 illustrates the general structure of a styrene maleic anhydride (SMA) co-polymer. The structure is similar to a surfactant, in which a water soluble (hydrophilic) and a water insoluble (hydrophobic) component are both present.

Styrene maleic anhydride co-polymers of different molecular weights, varying from 5000g/mol to 250,000g/mol and various maleic anhydride content from 8-42% (by weight) are produced by Polyscope Polymers and commercially available under the trade name XIRAN.



Right - Figure 1: Hydrophilic and hydrophobic groups in a SMA co-polymer.

SMA is intrinsically non water soluble, however it can be hydrolysed in caustic solutions. It can also be reacted with alcohols and amines, resulting in esterification, amidification and imidisation reactions. These reactions add functionalities to the copolymer as its properties such as solubility, HLB value (hydrophile-lipophile balance) and glass transition temperature (T_g) are modified.

Hydrolysis will occur in the presence of sodium (or potassium) hydroxide or ammonia, generating anionic, alkaline solutions that can be added into water-based formulations. Sodium or potassium salts show a more hydrophilic behaviour. Ammonium salts are less hydrophilic than sodium salts and become hydrophobic after imidisation. Hydrolysis to amic acid leads to a solution that is slightly acidic to neutral. When heated, the amic acid solution will imidise and become hydrophobic.

Applications

Typical applications of SMA co-polymers in the building and construction industry are as thermosetting binder systems in insulation and glass fibre mats for non-woven applications. In the electronics industry, they are used as cross-linking agents in epoxy systems in copper clad laminates for printed circuit boards. SMA copolymers are also used in bottle labelling applications due to their ability to improve ice-water resistance while increasing alkaline removability.

SMA co-polymers are used as dispersants for organic, inorganic pigments and fillers, as well as superplasticisers in concrete, because they can provide superior dispersion stability and reduced viscosity. Furthermore, they are also used as polymeric dispersing agents in emulsion polymerisation or as post-stabilisers for polymer dispersions/emulsions. As a polymer, SMA is REACH exempt.

Moreover, SMA co-polymers can be used as polymeric dispersing agent for wax emulsions. Hence, it can be used for dispersing paraffin wax emulsions in gypsum boards.

Hydrophobicity

It is known that a major challenge in gypsum wallboard is water absorption in applications where water/moisture resistance is required. There are several routes known to increase its hydrophobicity.

Poly methyl hydrogen siloxane (PMHS) or paraffin wax emulsions are added to the slurry during the manufacturing process. These hydrophobising agents should reduce the water absorption level to less than 5%. However, the addition of siloxanes to the slurry results in the release of hydrogen, which is highly flammable. Further, in presence of oxygen, siloxanes form formaldehyde during the wallboard drying process.

Far right -Table 1: XIRAN® salt solutions used in this study

Sample	Type of SMA solution	Maleic Anhydride (% by weight)	Molecular weight (g/mol)
1	Ammonium salt	42%	5000
2	Ammonium salt amic acid	42%	5000
3	Sodium salt	42%	5000
4	Ammonium salt	25%	10,000
5	Ammonium salt amic acid	25%	10,000
6	Sodium salt	25%	10,000

Right - Table 2: Wax emulsion formulations.

Material	% by weight
Paraffin wax	50.0
XIRAN salt	5.0
Water	45.0

Far right - Table 3: Gypsum board formulations.

Material	% by weight
Gypsum	60.0
Emulsion	2.5
Water	37.5

On the other hand, Paraffin wax emulsions are non-reactive, non-flammable and do not generate volatile organic compounds (VOCs) during production and/or incineration.

Common dispersing agents for wax emulsions are montan wax and C20-C50 alcohol ethoxylates. Possible disadvantages of montan wax are that it is a finite product and crude montan wax has a dark colour. Being a hard wax, it needs high loadings of co-surfactants to disperse. However, it is commonly used as a hydrophobising agent. C20 – C50 alcohol ethoxylates are non-ionic surfactants that do not contribute to the hydrophobic character of the end product. They are also quite expensive compared to montan wax.

Study objective

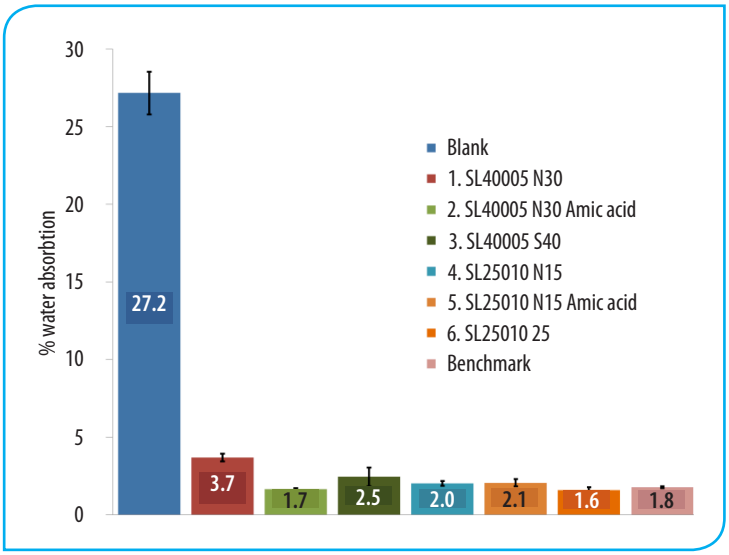
A recent Polyscope study sought to further examine the XIRAN® SMA as a dispersing agent for paraffin wax emulsions in combination with the extent of hydrophobisation effect in gypsum wallboards.

Commercially-available ammonium and sodium styrene maleic anhydride salt solutions were used in order to examine the water repellent effect in gypsum board (See Table 1). The formulation used to make paraffin wax emulsion with SMA co-polymers can be found in Table 2.

The SMA-based wax emulsions were added to gypsum slurry at a level of 2.5%, as shown in Table 3. The water absorption was measured after 2hr of water immersion at 23°C, as per ASTM C473-10.

Results

The results of this study can be found in Figure 2. The data showed that emulsions made with SMA copolymers with lower maleic anhydride content (25% by weight) performed better than the ones prepared with higher maleic anhydride content (42% by weight). This can be explained due to a higher hydrophobic styrene content. It is worth mentioning that salt solutions 2 and 6 exhibited equivalent performance to the benchmark / industry standard.



Right - Figure 2: Percentage water gained (by weight) of gypsum board made with SMA based wax emulsions.

Conclusion

Gypsum boards treated with SMA-based paraffin wax emulsions exhibited low water absorption in general and complied with the industrial requirement. Moreover, XIRAN® salt solutions have a dual role. Primarily, they are polymeric dispersing agents for paraffin wax emulsions with no need for additional surfactants. Secondarily, SMA salt solutions further improve the required water repellency in gypsum boards. Further research is ongoing.