Latest Innovation in the Low-Exudation-Binder (LEB) technology for masonry coatings

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Introduction

The main feature that makes water based coatings in general, and masonry coatings in particular, attractive from an environmental, toxicological, health and safety point of view, is that they contain water. This desirable constituent, however, is also the main cause of most of the problems that customers of paint companies, whether DIY'ers or professional painters, face in terms of application of exterior paints in all regions.

In the architectural or decorative coatings market, solvent based coatings continue to exist, and their use is still permitted despite VOC regulations and the like, because no acceptable alternative presently exists for "All Weather" masonry coatings.

Problems with water based masonry coatings

The weather - Application and drying

The physical properties of water are dramatically different from those of other solvents used in coatings. Most water based architectural coatings today employ polymer dispersions in which water serves as the dispersion medium. The coatings formulations form films by a process of coalescence. As such, it is important that the application, drying and coalescing conditions are controlled. Important parameters in this respect are temperature, relative humidity and air movement.

For successful application, the consensus of paint manufacturers is that the application window for water based coatings is limited to relative humidities between 40 and 60% and to temperatures between 10 and 40°C. In practice, because "Mother Nature" is not as cooperative as we would like, the application window for exterior coatings is extended to more than just a handful of "ideal" days, by expanding these ranges somewhat. (Figure 1).

The Weather - Resistance to early rain

An obvious problem with water based coatings is their susceptibility to "wash-out" by rain occurring during or shortly after application, while the paint film is still sufficiently sensitive to water to be resolubilised, especially by hard, wind-driven rain, and washed off the substrate.

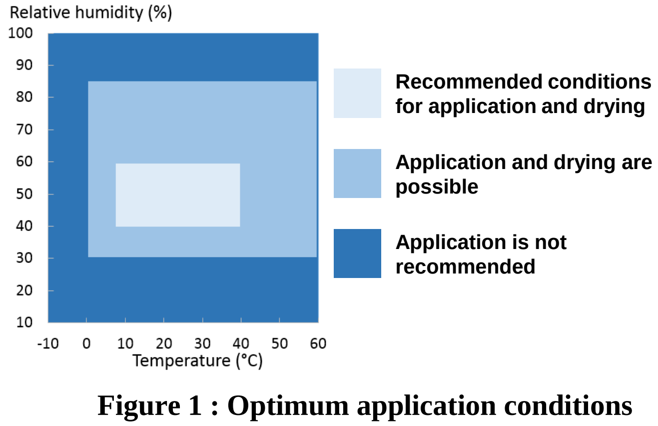


Figure 1 : Optimum application conditions

The vagaries of the weather mean that this cannot be completely avoided, and it can be costly to clean up when it happens. For a water-borne coating to be fully cured and to resist water and humidity, it needs to coalesce and develop hydrophobicity to a state where it is not readily resolubilised by water droplets. This is not easy to achieve with polymer dispersions, but is possible, as will be demonstrated later.

Exudation or Surfactant Leaching / Staining [1]

A quick internet search will show that surfactant leaching (also known as surfactant or exudate staining, streaking, weeping, snail trails, etc.) is a paint defect listed by many paint manufacturers in the "Common Paint Problems" pages of their websites. As the various terms imply, exudation gives rise to unsightly stains on the surface of freshly applied paint.

All water-borne paints contain water soluble materials. As a general rule, the properties and ultimate performance of all water-borne paints depend on the concentration of these water-soluble materials that remain in the film after drying. In the case of exterior masonry coatings, under normal field conditions these materials are eliminated by rainwater or condensation during the first few weeks' life of the paint, without affecting the appearance.

The problem of exudation is liable to occur on any water-borne exterior paint if atmospheric conditions are such that they promote migration of water soluble components within the coating to the surface. These problems often occur on paint that has been applied near dusk where, with the drop in temperature that naturally follows as day turns to night, dew or condensation forms on the surface of the fresh paint, causing surfactant to migrate to the surface, which, after drying, produces visible stains.

Other common problems

Efflorescence is caused by water soluble salts present in the masonry substrate, that migrate via capillary action to the surface. If the permeability of the film to liquid water permits, the salts pass through the film and form unsightly deposits on the surface of the paint when the water evaporates. If the film is not sufficiently permeable to liquid water, and the adhesion of the paint film to the masonry is not high enough, salt deposits build up under the film and result in blistering, peeling or flaking of the paint.

Additionally, exterior durability, especially in terms of colour or tint retention, is of prime importance for a façade coating. This depends not only on the polymer chemistry, but also on the efficacy of film formation (coalescence) because even the best binders will not perform as expected if film formation is deficient. Incomplete film formation can give rise to early film degradation on exposure to the elements, resulting in excessive chalking or fading. With the increasing consumer preference for bright, deep tones for façades and the move to lower VOC colorants, which contain higher amounts of surfactants, due to legislative, regulatory or "green" reasons, means that colour retention has become the origin of increasing customer claims. Any improvement in film forming ability of new paint binders, such as better tolerance to climatic conditions during application and drying of exterior coatings is thus beneficial in ensuring extended durability.

Polymer development - LEB Platform

Polymer design considerations

These have been outlined in some detail in previous publications [2] [3]. Our polymer chemists, using the best of modern raw materials and the large toolbox of polymerisation processes at their disposal, have developed a latex polymer that minimises leaching of water-soluble components from paint films. In the Low Exudation Binder (LEB) technology, the latex or polymer dispersion is stabilised with anionic groups bonded to the polymer, and a multi-step process designed to favour the distribution of functional monomers at surface of particles is used, resulting in a much-reduced “free” surfactant content.

Need for elastomeric version of LEB

The first product to be developed and launched using the LEB platform was a pure acrylic polymer designed especially for thin film exterior masonry coatings, especially for the European market where this class of product is well established. Even from the beginning of this project quite a few years ago, it had been envisaged to develop a family of products based on the same technology platform to serve different segments of the market and different regions of the world. One identified follow-on project was an elastomeric pure acrylic for formulation of thick film flexible coatings, especially for the European market.

Thus, in addition to the well-known key advantages of the LEB technology, namely outstanding exudation and efflorescence resistance, the polymer’s composition of the new Elastomeric LEB (E-LEB) has been modified to achieve very high flexibility at low temperature while simultaneously maintaining outstanding resistance to dirt pick-up. The product has also very high UV resistance and has been designed without APEO-containing surfactants, and does not contain added formaldehyde.

The basic characteristics of the new E-LEB latex are shown in Table 1 below:

Characteristics	Value
Solids content (%)	50.0
pH	8.5
Viscosity at 60rpm/25°C (mPa.s)	500
MFFT (°C)	0.0
VOC	< 0.2 g/L
Film formation	Coalescence

Table 1 : Typical characteristics of new E-LEB

Experimental - Test Methods

The nature of exudates from water-based paints

An extensive analytical study, using mainly Thermal Gravimetric Analysis (TGA), Gas Chromatography / Mass Spectrometry (GC/MS) and Pyrolysis/GC/MS has been carried out on exudates obtained (using the method outlined in the next section) from both commercial products and formulations prepared using known ingredients, including our own commercial and experimental LEB binders and competitive binders, in an effort to identify the chemical nature of species present in leachates, and their source in terms of raw materials used in the formulations.

Exudation Resistance (evaluation of leaching of surfactants and water-soluble components)

At the start of our development, no relevant international standards existed for measurement of leaching of surfactants. This necessitated the development of an in-house method. Although standards now exist [4] [5], these are still not considered to be reliable for façade coatings subject to wind driven rain because they involve continuous immersion in water.

The aim of the in-house method is to predict the behaviour of paints in terms of release of water-soluble materials and surfactants during the early stages of drying under adverse conditions.

In this method, paints are applied by brush to the exterior of plastic cans, at a spreading rate of 250g/m². After 16 hours of drying, the painted cans are filled with water and ice, and then placed in a climatic chamber at 25°C and 90% relative humidity for a period of 90 minutes. The leachate is collected during the test in a cup positioned below the can. The amount of leachate is measured by weighing the exudates after dying for 4½ hours at 60°C, and is expressed in g/m².

Efflorescence Resistance

The coating (in 2 coats / 24 hours between coats) is applied to porous clay bricks, leaving a few centimetres at the bottom of the brick uncoated. After 24 hours of drying, the bricks are placed in a saturated sodium chloride solution for several weeks, adding water or salt to the solution from time to time to ensure that the level remains constant. Changes in film appearance (blisters, salt deposits, cracking, etc.) are observed over a period of up to 3 weeks

Elongation / Tensile Strength at -10°C

Paints are applied at 400µm dry film thickness on to a PTFE block, and dried according to following protocol: 1 day at 23°C, 5 days of exposure under Xenon lamp and 1 day at 23°C. Then specimen are cut according to shape of S2 type dog-bone. An elongation test is carried out on an Instron® 5582 testing machine (Illinois Tool Works Inc;) at a temperature of -10°C at a rate of 200 mm/min. For each paint tested, the result is expressed as the average of 5 measures.

Dirt pick-up Resistance

Paints are applied at 300 µm wet film thickness on glass panels, and dried according to following protocol: 1 day at room temperature, 5 days of UV-B exposure, and 1 day at room temperature. Then, a carbon black pigment is applied on half of the panel with a brush. Afterward, the pigment is removed rubbing vigorously with a white tissue, until trace of black pigment has disappeared from the tissue. Finally, the color difference between the soiled and the un-soiled part is measured and reported.

Q-UV exposure

A Q-UV apparatus is set to perform alternating cycles of 4 hours of UVA at 70°C, and 4 hours of condensation at 40°C. The paints are applied in one coat with a wire-wound drawdown bar at 300µm WFT on aluminium Q-panels. After 1 week of drying, paints are exposed to cycles during 1500 hours. Appearance and colour changes (Cie L*, a*, b*) are checked every week.

Results and Discussion

Analysis of exudates from water-based paints

Water based façade paint formulations typically contain 15 to 20 ingredients, including pigments(s) and/or colorants, extenders and a number of additives in addition to the binder. Each raw material is often a mixture rather than a single specific chemical (for example, an additive such as a rheology modifier may contain solvents(s), preservatives, surfactants, in addition to the main chemical species that functions as the thickener). As a consequence, a paint formulation contains dozens of individual chemical species, many of which are water soluble to a greater or lesser extent, and which therefore can potentially leach out of the paint film under the right conditions. Even that which would normally be regarded as “inert” raw materials, such as pigments, contain chemical species, for example, from surface treatments to improve dispersibility of the pigment, that are water soluble and leach from the coating.

A typical chromatogram resulting from an analysis of exudate of façade paint by Pyrolysis/GC/MS, (left part of Figure 2), contains many peaks, and demonstrates clearly the complexity of the chemical nature of the exudate. In contrast, the chromatogram for a paint of the same formulation prepared with an LEB (right side of Figure 2) shows considerably fewer peaks and therefore less complexity.

In order to try to understand from which raw materials the individual chemical species found in the exudate are derived, a series of paints was prepared omitting each ingredient of the formulation in turn, and the exudates collected and analysed. In this way, it was possible to identify the source of each chemical species found in the exudates.
The mechanism by which water soluble species, even though present in the paint film, are prevented from leaching from the paint is not fully understood at this stage, but the morphology of the polymer binder is such that it is thought to form a sort of "fishing net" that traps and holds certain chemical species within the film, thus preventing them from ending up in the exudate.

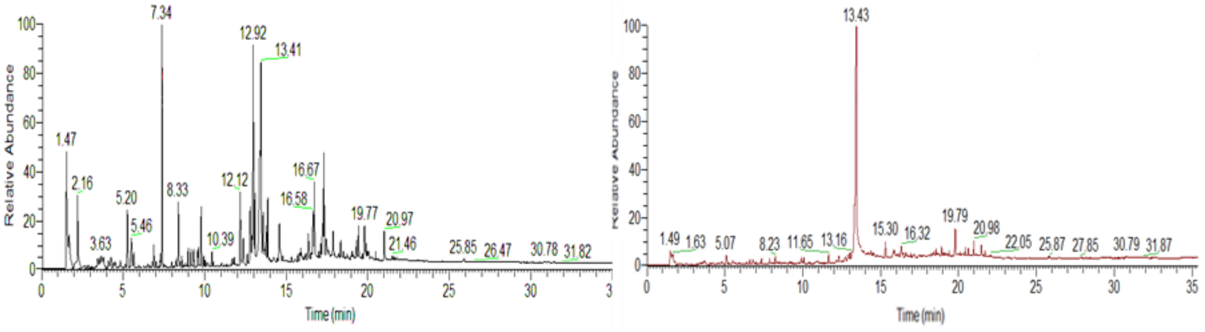


Figure 2 : Chromatograms of exudates from standard styrene acrylic based façade paint (left) and same formulation based on the LEB (right)

The analytical study is continuing in an effort to further understand the mechanism, and the results of this interesting research will probably form the basis of a future technical paper.

Application of E-LEB in elastomeric exterior masonry coatings

Elastomeric Wall Coatings (EMC) have two primary functions. The first is to protect the exterior surface of buildings from degradation by weather and pollution, especially when cracking are still present on the masonry surface after the surface preparation. In Europe, exterior masonry coatings are classified by the standard EN 1062. Even if its use vary from country to country, this norm is of first importance as it also defines for each category of exterior masonry coatings some classification according to performance requirement for the key properties associated to the end use. As an example, the ability of the coating to permanently bridge the cracks of the surface, is defined in part 7 of the norm [6]. Six categories are defined (A0 to A5) according to the width of the cracking on the masonry surface, and the associated performance requirement and test method are described.
The second function of EMC is to decorate the substrate. This aesthetical function is the more easily recognised one, because the immediate effect of the paint application is very visible. The trend for the use of deep colours has experienced an important growth in the DIY, but also in trade market, along with the intensification of "Point of Sales" tinting machines. The benefits of this preparation method using calibrated bases and colorants (quick tint preparation, tailor-made colour, low stock of tinted paint, etc.) can be easily understood. However, the formulator is in fact introducing more water sensitive additives into EMC formulations to improve the compatibility of colorants for which zero VOC is becoming the standard, with all the drawbacks of the increase in water sensitivity brought by these additives. As described in a previous paper [2][3], the impact of water sensitivity is directly linked to increase in exudation of the coating and resistance to efflorescence is negatively affected. Elastomeric wall coatings have been proposed for many use in pastel shades only, nevertheless during past few years a trend toward deeper tones have been also seen for this category of product especially for grey or beige colours.

Based on the new Elastomeric LEB, a formulation of an Elastomeric Wall Coating (EWC), referenced as FPS316, has been developed and is presented below (Table 2). This formulation meets the expectations of premium EWC in terms of high durability, as determined by crack-bridging properties (A4), Q-UV and efflorescence resistance.

Raw Materials	Percentage
Water	11.15
E-LEB	***30.00***
Cellulosic thickener	0.15
Buffer	0.20
Dispersing agent	0.50
Defoamer	0.30
Titanium dioxide	11.30
Calcium carbonate 1	7.50
Calcium carbonate 2	15.00
Talc	6.60
E-LEB	***9.60***
Water	3.30
Coalescing solvent	3.00
Defoamer	0.20
Associative thickener 1	0.20
Associative thickener 2	0.50
Paint film preservative	0.50

Characteristics	Value
Weight Solids (%)	61.6
Volume Solids (%)	46.3
PVC (%)	42.7
PVC / CPVC	0.70
Specific Gravity	1.41
MFFT (°C)	0.0
VOC (g/L) EU calc.	3.5
Crack-bridging at 450g/m²	1.4mm (A4)

Table 2 : Formulation and characteristics of FPS316 for Elastomeric Wall Coatings

Assessment of the new Elastomeric LEB performance compared to incumbent binders

The performance of the new E-LEB binder has been compared to a number of good quality commercial elastomeric binders collected from the market. All the binders have been formulated according to the same recipe FPS316 presented above in Table 2. The basic characteristics of the commercial latex are given in Table 3 below.

Reference	Chemical nature of the binder	Tg °C (Technical Data Sheet)	Tg °C (Measured- Onset)	Viscosity (cPo.)
#1	Acrylic	-25	-19.6	1080
#2	Acrylic	-28	-21.7	470
#3	Acrylic	-28	-25.4	800
#4	Acrylic	-25	-18.7	220
#5	Acrylic	-24	-20.1	12440
FPS316	E-LEB	-22	-20.2	275

Table 3 : Characteristics of elastomeric latex evaluated in the benchmarking study

Exudation resistance

Evaluation of exudation resistance of the paints was made using white paints.

Results, presented in Figure 3, are expressed as weight of exudate released per square meter after testing.

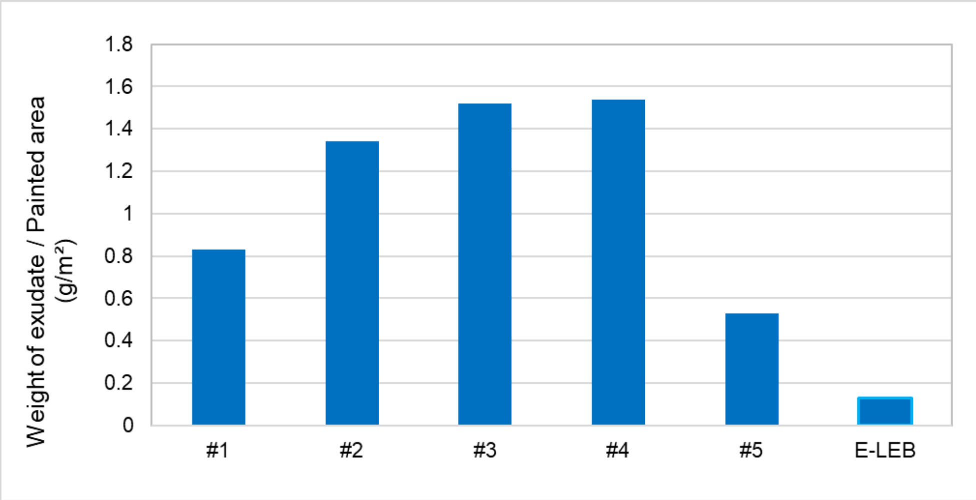


Figure 3 : Exudation resistance of white paints

Thanks to the Low Exudation Binder technology the new Elastomeric LEB (E-LEB) results in resistance to exudation that is better than that obtained with all commercial elastomeric acrylic binders in similar coating formulation. The benefit is a reduction of the quantity of exudates of at least 70% compared to the very best elastomeric binders from the market.

Efflorescence resistance

Efflorescence resistance of the paints was assessed after 3 weeks of exposure to sodium chloride solution. To assess the performance of the coatings tested, the below colour code was used to rate the resistance in terms of overall efflorescence (on the left), formation of speckles (in the middle) and formation of blisters (on the right).

Overall Efflorescence		Speckles		Blisters	
Ok	None	Ok	No defect	Ok	No defect
1	Minimal	A	Few	I	Few
2	Medium	B	Medium	II	Medium
3	Strong	C	Dense	III	Dense

The pictures below show the ability of the paint to maintain good adhesion to the substrate and block the development of salt deposits on the surface of the paint or at the paint/substrate interface, in spite of the osmotic pressure applied on the paint.

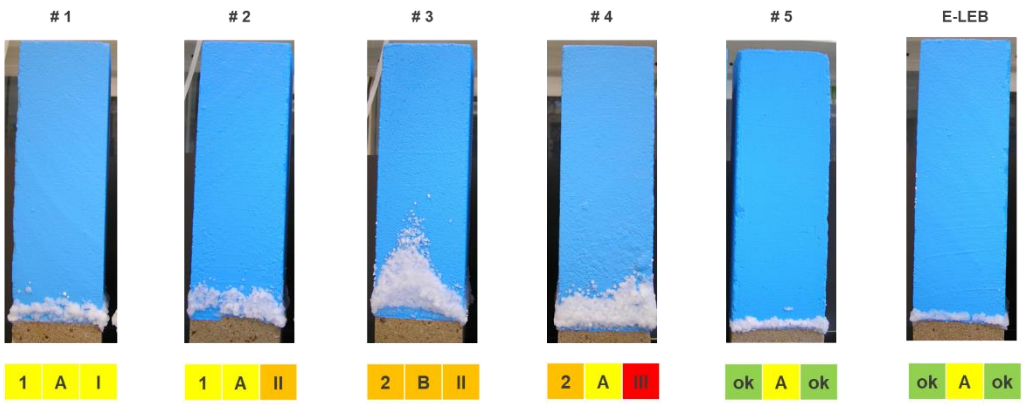


Photo 1 : Efflorescence of white paints

The formulation FPS 316 based on E-LEB demonstrates efflorescence resistance superior to that of conventional water-based binders. As was described previously, optimisation of water resistance thanks to the LEB stabilisation system of the polymer allows the formulator to develop new flat elastomeric wall coatings with good resistance to efflorescence, limiting potential problems where salts may be present in the substrate.

Elongation / Tensile Strength at -10°C

The results of elongation at low temperature demonstrates that the Tg of the binder is the main factor influencing the performance. The highest flexibility is achieved with the binders #2, #3 and #5, that are those with the highest measured on-set glass transition temperatures. The E-LEB follow the rule with a flexibility in line with our development specifications. Indeed, the formulation FPS316 prepared with our new LEB binder was tested according to the standard EN-1062, and with 1.4 mm was able to pass the requirement for A4 category (superior than 1.25 mm) for a spreading rate of 450g/m².

The commercial binders #1 and #4, with the lowest Tg level have also the lowest low temperature flexibility.

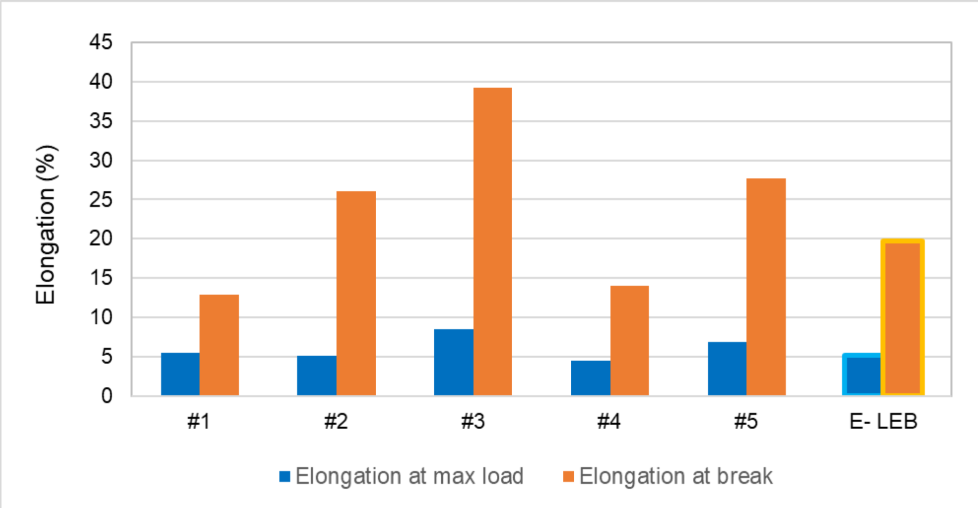


Figure 4 : Flexibility at -10°C on PVC 43% formulations

Dirt Pick-up Resistance

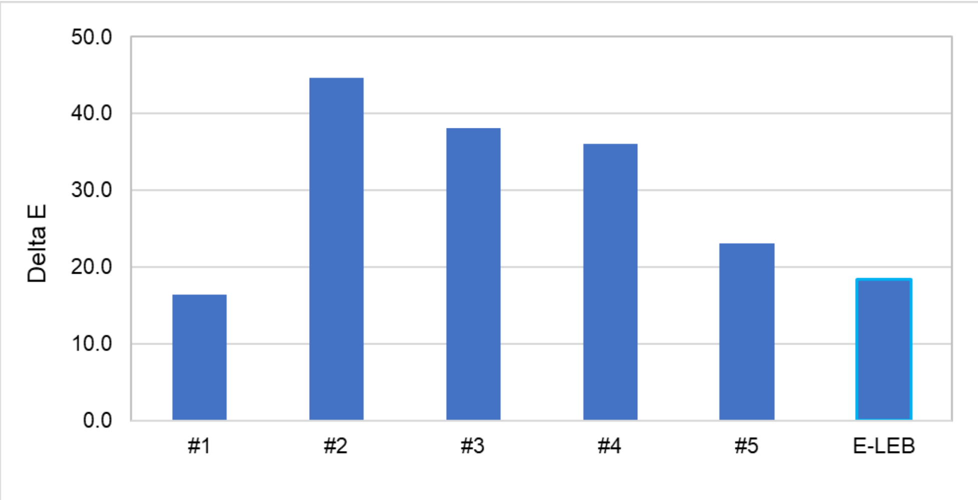
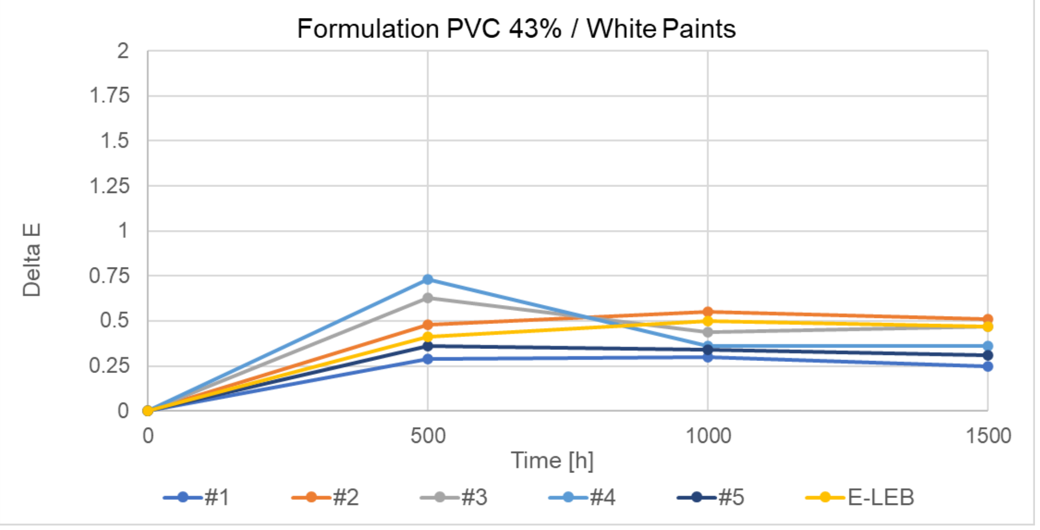
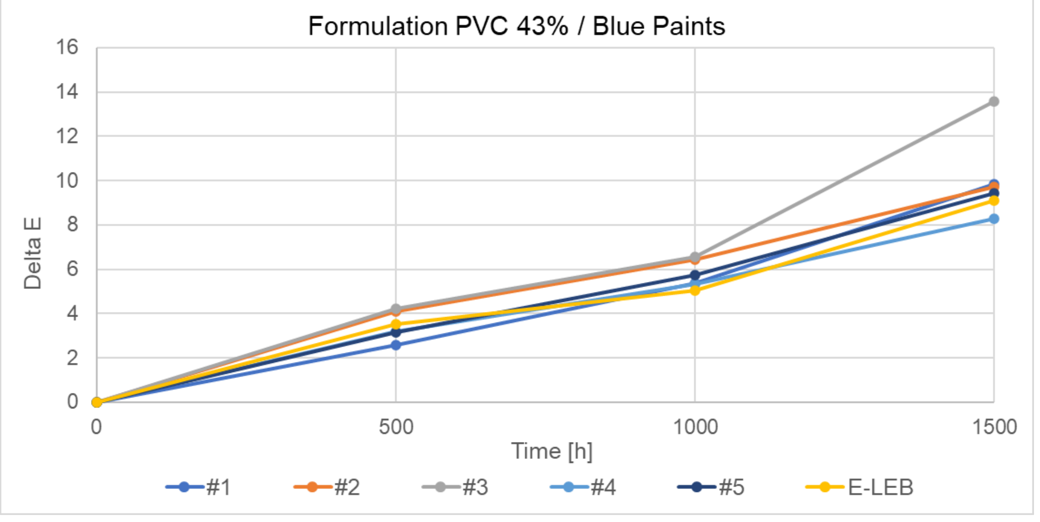


Figure 5 : Dirt-pick-up resistance on PVC 43% formulations

As most of the latex tested may contain photo-initiator, it is important that the test method used comprises some UV exposure steps in the conditioning protocol.
The three commercial binders with the lowest Tg level and higher flexibility, exhibits in this test lower dirt pick-up resistance than the Elastomeric LEB. Even compared to the 2 commercial latex with higher Tg level, the E-LEB has equal or higher resistance to dirt pick-up. This excellent performance is achieved thanks to a very efficient photo-initiator system. System that doesn't lead to any classification of the latex, despite the new regulation on benzophenone classified as carcinogen 1B since 2023.

Accelerated ageing in QUV





Regarding white paints, all coatings allow to achieve very good resistance to yellowing. This is obviously due to the monomeric compositions that are all acrylic for all the binders. Nevertheless, these results also confirm that there is no negative impact induced by the photo-initiator systems.
As far as blue paints are concerned, the difference from one binder to another is not so significant, except for the binder #3 exhibiting lower colour retention beyond 1000 hours of QUV exposure.
Generally speaking, the new elastomeric LEB allow to achieve similar colour retention as very best binders available on the market.

Conclusion

The new Elastomeric LEB latex has been designed based on our LEB platform and maintains the same low level of water sensitivity that leads to outstanding exudation and efflorescence resistance in coatings formulated with it. Extensive analysis of exudates has shown that the polymer network significantly reduces the quantity of exudate from the paint film by a mechanism that continues to be further investigated. Comparative studies have demonstrated the excellent performance of the new E-LEB in elastomeric wall coatings, and allow to consider the use of deeper shade without any issue of early discoloration, and with excellent longer-term colour retention. Furthermore, the improved efflorescence resistance would lead to higher security of application and durability, in case of application of the elastomeric coatings on basement part of exterior walls.

The new E-LEB latex has been found to minimise many of the common problems associated with the application of water based elastomeric wall coatings, in particular problems such as resistance to efflorescence and exudation that are directly related to the presence of water as an ingredient in the coating formulation. This technology appears to take us one step closer to the realisation of “All Weather” options for the different segments of exterior masonry coatings.

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