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New D-Iso /NPG Advanced Polymer Technology Gelcoat from Scott Bader Offers Exceptional UV Colour Stability

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The advanced new D-Iso/NPG polymer technology resin chemistry used in Crystic® Permabright gelcoat has set a new standard in long term UV weathering performance. It provides significantly improved colour stability than existing marine Iso/NPG gelcoats. This latest innovative development from Scott Bader was showcased at this year's JEC Composites show in Paris. Markets expected to benefit from this new gelcoat technology are those where retaining a high level of aesthetic quality in exposed gelcoated surfaces is highly desirable such as: leisure marine, transportation and building.

Introduction

This technical paper covers the development of Crystic® Permabright gelcoat and the approach taken by Scott Bader's research scientists to weathering protection in relation to the overall gelcoat formulation. Comparative long term testing was carried out in the critical performance areas of osmotic blistering and colour stability. The new advanced D-Iso/NPG polymer chemistry used as the base resin for Crystic® Permabright was tested against established Iso/NPG and Iso gelcoat technologies. The paper also covers the production aspects of this new gelcoat with respect to its rheology, ease of application and repairability.

Effects of Weathering

Weathering is a combination of physical degradation and chemical decomposition. A gelcoat has to combat surface oxidation and ultraviolet (UV) attack when exposed to sunlight. It also needs to resist hydrolysis, which a gelcoat is most prone to when there is a combination of heat and moisture.

It is well known that gelcoats change colour after prolonged exposure to sunlight. Over time, the effects of weathering on a gelcoat can be seen with the naked eye, such as a loss of gloss and chalking (whitening) in a darker colour, and a gradual dulling and yellowing of white, off-white and cream colours; in many applications this is not aesthetically desirable. In some cases, where there has been prolonged exposure to strong sunlight, this eventually requires a refurbishment of the gelcoated surface.

Market led Innovation

Scott Bader identified the market need for a superior gelcoat that could provide vastly improved gloss retention and colour stability. The leisure marine market in particular has been demanding much better long term weathering performance from the gelcoats used on the decks and hulls of their prestigious luxury yachts which retail from hundreds of thousands to millions of Euros. Other markets could also benefit and new gelcoat applications created, replacing paint; for manufacturers there are cost benefits to eliminating the need for a secondary painting operation.

Strategic Gelcoat Innovation Project

Back in 2006, in response to these market needs, Scott Bader initiated a strategic gelcoat development project at its global R & D facility in Wollaston, England. History is repeating itself as this facility is in the same location where over 50 years ago pioneering Scott Bader chemists invented the first aerobic polyester resins and then went on to develop the first ever marine grade resins and gelcoats. Wollaston is also the location of the Company's head office and UK manufacturing facilities for its composite and specialty chemical products.

The R & D team's goal was to discover a next generation gelcoat that would provide a step change in UV weathering performance to meet the demanding long term weathering and hydrolysis resistance needs of exterior marine applications, while still offering a gelcoat which handles well and would be easy to apply by spray or brush. Five years later this objective has been achieved, with the successful development of Crystic Permabright marine approved gelcoat, with its new D-Iso/NPG advanced polymer chemistry gelcoat base resin.

What is a D-Iso/ NPG Resin?

This new D-Iso/NPG unsaturated polyester resin technology is unique to Scott Bader. It took over three years of research to develop this new resin chemistry, which derives its superior UV weathering properties from the chemical structure of the resin having a deconjugated polyester backbone. After many laboratory scale formulation tests and trials, it was discovered that a deconjugated Iso/NPG polyester was much more resistant to degradation from sunlight and UV radiation. Further tests demonstrated that if used as the base resin for a white pigmented gelcoat, that the deconjugated polyester resin made a significant contribution to reducing yellowing and improving gloss retention.

Gelcoat Formulation

Scott Bader's Gelcoat technology team has long understood the importance of having not just the right base resin for a gelcoat matched to specific application needs, such as blistering and UV resistance for exterior marine applications, but also the need for other key ingredients in a gelcoat formulation to provide the overall performance. Pigments and UV additives both play a critical part in the overall long term weathering resistance of a gelcoat.

As part of the development of Crystic Permabright, significant R & D work was also carried out to evaluate all available pigments and UV additive combinations. They identified the best combinations in a gelcoat formulation which enhance weathering performance. The combination of the three critical factors of the base resin, the pigment and the UV additives is the key to having outstanding gelcoat weathering performance. (Figure 1.) Other additives were also evaluated in the overall formulation with respect to rheology, air release and handleability.

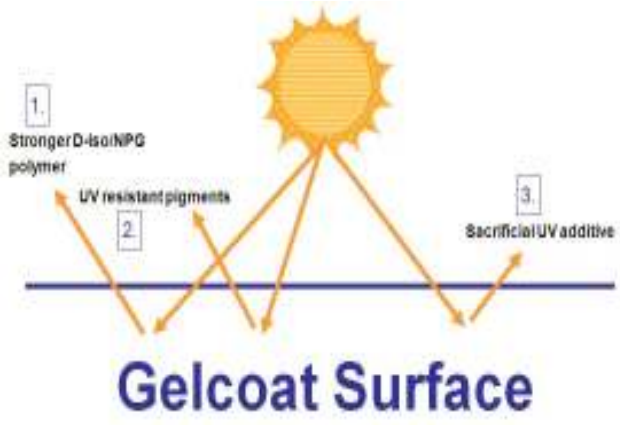

Figure 1. Gelcoat UV weathering depends on three critical factors: base resin chemistry, pigments and UV additives.

For both Crystic Permabright spray and brush applied gelcoats, the new D-Iso/NPG polyester base resin has been combined with best in class UV protection additives and by only using selected pigments in white, off-white and cream colours which are able to provide the highest level of long term colour stability. All the pigment pastes used in Crystic gelcoats are proprietary, manufactured by Scot Bader using their in-house milling and mixing facilities.

The importance of having the right pigments and UV additives has been recognised by Scott Bader for a considerable time. This has been demonstrated by the proven long term performance of existing Lloyds approved marine grade Crystic Iso and Iso/NPG gelcoat products in their range, which have been successfully used for over 45 years in marine and other market applications.

Colour Stability Testing & Measuring

The prime objective was to develop a gelcoat with exceptional gloss retention and colour retention. This has been achieved with Crystic Permabright, which has undergone both QUVA and Xenon arc accelerated testing for colour change, as well as undergoing rigorous 12 month Florida natural weathering testing. Comparative colour change test results were obtained from plaques made and tested at the same time, measured accurately by established methodology.

Measuring Colour Change:

The accepted industry standard to measure a colour is to use the CIE colour space L* a* b* values. (Figure 2.) The test results give Delta E values, which measure the total change in colour before and after exposure. Delta b* is the specific measure of the colour change from blue to yellow; as reducing the yellowing of white and cream coloured gelcoats was a critical factor, this was a key colour change measure for this project.

Comparative Colour Change Tests:

Crystic Permabright was tested against a range of "best in class" white gelcoats which currently exist. The test plaques were made from gelcoats manufactured by both Scott Bader and competitor producers. A standard Iso gelcoat was tested alongside top performing Iso and Iso/NPG marine approved gelcoats.

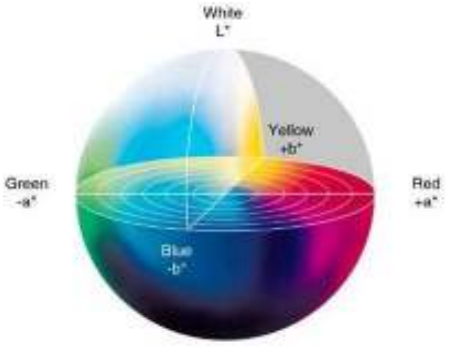

Figure 2: CIE colour space L* a* b* values used to measure colour change in a gelcoat.

1000 Hours QUV Exposure Delta E Test Results

Accelerated QUV testing was carried out in advance of the longer term Florida testing. Good performance under accelerated UV weathering conditions is an indicator of good long term natural weather performance.

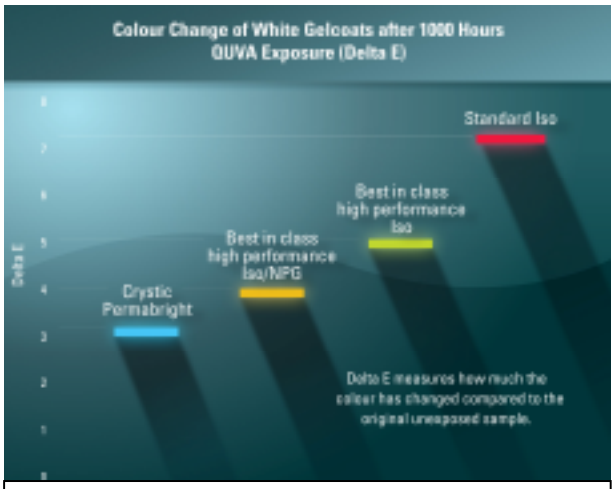

Figure 3: QUVA Delta E 1000 hrs. accelerated weathering test results.

The graph (figure 3.) shows the Delta E colour change results of the four gelcoat technologies tested after 1000 hours of accelerated UV exposure. The delta E value is 3.20 for Crystic Permabright compared with 4.03 for the best in class Iso/NPG.

Outstanding Florida 12 Month UV Exposure Results

Scott Bader has independently tested Crystic gelcoats in Florida for a great many years. They have concluded that Florida weathering is the most accurate way of predicting how a gelcoat will resist harsh UV light over a prolonged period of time and so it is a key test for a Crystic gelcoat product to pass. This is because the extreme natural exposure conditions in Florida accelerates product weathering by an order of two to three times faster than most other locations.

Once again, comparative tests were carried out between the standard Iso, the best in class Iso and the best in class Iso/NPG versus Crystic Permabright gelcoat with its new formulation and D-Iso/NPG base resin. (Figures 4. and 5.)

All four sets of gelcoat plaques were tested at the same time and exposed to 12 months continuous exposure in Florida. Both delta E and delta b* (db*) colour change measurements were taken. The Florida colour change test results showed the colour stability performance of Crystic Permabright to be even better than the accelerated QUV indications.

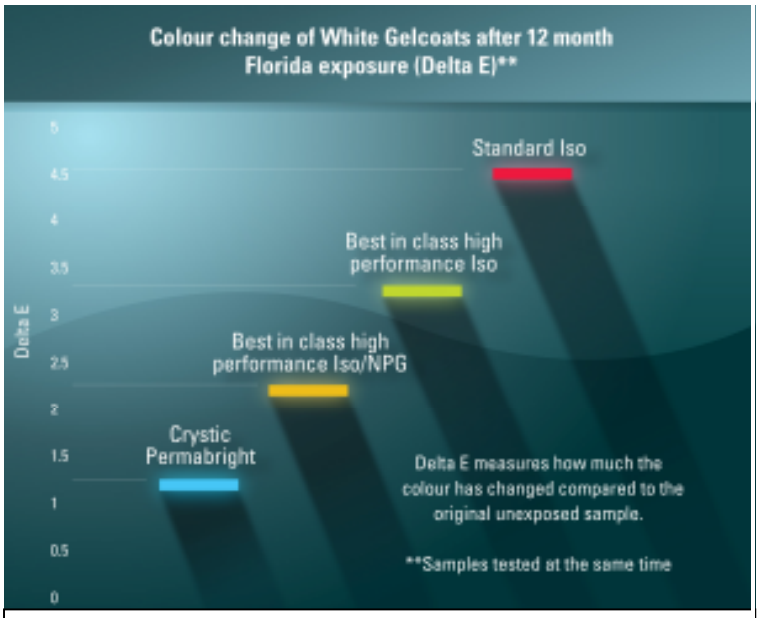

Figure 4: Florida 12 Month Natural exposure delta E test results.

The 12 month Florida natural weathering test results for Crystic Permabright measured a delta E of 1.25 and a delta b of only 1.06. By comparison, the best in class marine approved Iso/ NPG had a delta E of 2.25 and a delta b* of 2.20. These colour change results are highly significant as the smallest colour difference that humans can detect with the naked eye is a delta E of 1.0. So, the exceptionally small colour change in the Crystic Permabright test plaque is virtually impossible for most people to detect.

Additionally, the delta b* test results confirmed Scott Bader's belief that their new advanced polymer gelcoat base with its deconjugated Iso/NPG polyester backbone, when used with the right pigment and UV additives could significantly reduce yellowing in a white or cream gelcoat. This was a key project deliverable for the luxury yacht market, who are keen to use a gelcoat which would help to maintain the showroom look and condition of a vessel for longer. The Florida test results obtained clearly show that Crystic Permabright gelcoat is able to do this, providing two times better colour stability than the next best in class Iso/NPG and four times better than a standard isophthalic gelcoat.

Figure 5: Florida 12 Month Natural exposure delta b* test results which measure the degree of yellowing.

This dramatic improvement in gelcoat colour stability is a step-change in technology for the industry.

Osmotic Blister Performance

Alongside weather resistance, needing excellent blistering resistance is vital for marine applications. Blister resistance is a measure of osmosis and how quickly the gelcoat and laminate takes up water. This blister performance test was originally developed by Scott Bader following significant work on blistering for GRP in the early 1980's. It has been used successfully for over 30 years to ensure gelcoats can be used below the water line with no surface degradation, when used as part of a matched marine laminate system. For this osmotic blister test, circular gelcoated test panels undergo rigorous blister testing (Figure 6.), being permanently immersed in de-ionised water at 40°C for 12 months.

Figure 6: Circular gelcoat panels are placed in the blister test container and then undergo 12 months of testing

Comparative gelcoat technology blister testing was also carried out. This critical performance requirement has also been successfully achieved by Crystic Permabright. The graph below (Figure 7.) shows the comparative mean water uptake in grams over the 12 months by Crystic Permabright compared to the best in class Iso/NPG and Iso gelcoats. The water uptake results obtained clearly show that Crystic Permabright has excellent long term blister resistance. Based on these and other test results, Scott Bader has a high degree of confidence to approve Crystic Permabright for use in white hulls below the water line, provided it is used as part of their matched Crystic marine laminate system with their VE 679PA skincoat and a marine approved Crystic back up resin.

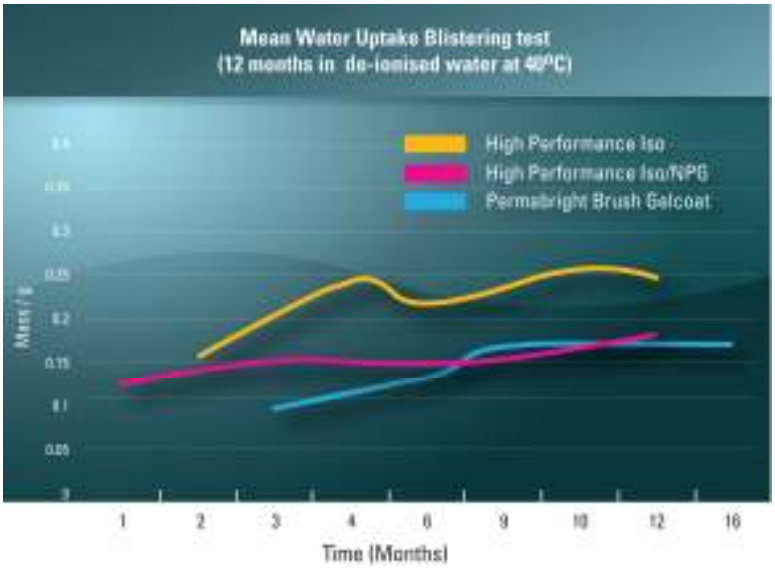

Figure 7: Blister test results, measured by mean weight of water uptake in grams during 12 months immersion in de-ionised water at 40°C.

Rheological Properties

For ease of use on the shop floor during production, the importance of having optimised and consistent rheological profiles for the spray and brush grades of Crystic Permabright has been taken into account by Scott Bader. For the spray grade, it has been designed with a low viscosity at high shear rates to allow for ease of spraying, while having a high viscosity at low shear rates to prevent drainage and sagging. The rheological profile of Crystic gelcoats over time are closely monitored to ensure quality. The graphs below (figures 8. and 9.) show the limited changes in viscosity over time of Crystic Permabright at both high and low shear rates.

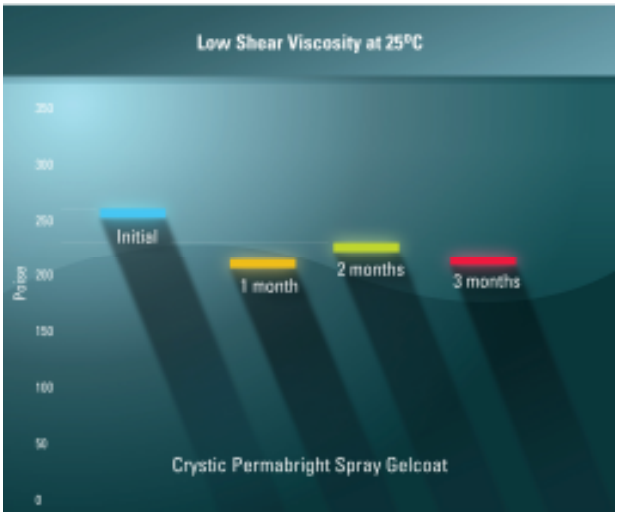

Figure 8: Low shear viscosity variation over 3 months.

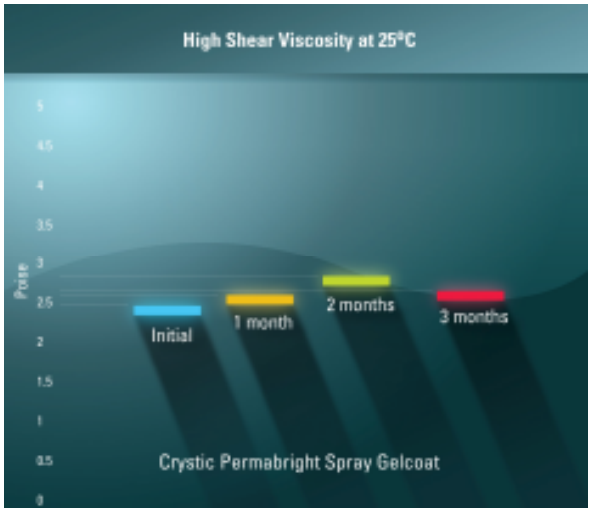

Figure 9: High shear viscosity variation over 3 months.

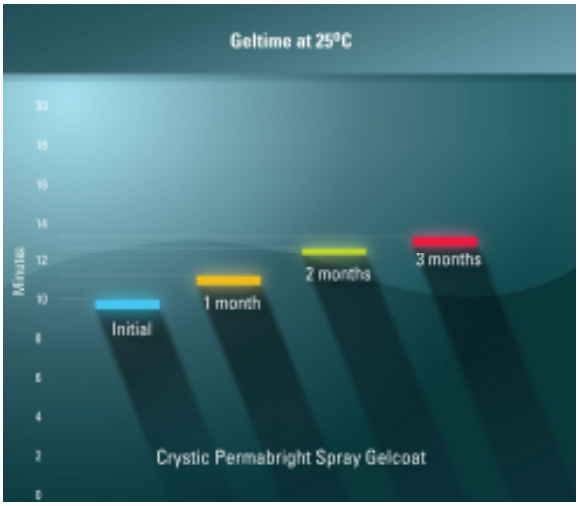

Figure 10. Crystic Permabright has a minimal geltime drift over 3 months of less than 4 minutes.

Gel time Drift

Another important area for composites convertors which helps them to ensure consistency in production is to use gelcoats and resins which have a minimal geltime drift over time.

Maintaining a consistent geltime has been incorporated into the overall formulation of Crystic Permabright, which as the graph in figure 10, shows, exhibits a minimal geltime drift at 25°C of less than 4 minutes over a three month period.

Application and Reparability Trials

The handling properties of both the spray and brush applied versions of Crystic Permabright are very similar to a conventional Iso/NPG gelcoat. It is easy to apply evenly and exhibits little if any porosity. It is also easy to repair, which is another practical aspect that was taken into consideration by Scott Bader as part of this project.

Customer Trials

In addition to extensive in-house handling trials that were carried out during the development of Crystic Permabright, several customers also carried out trials. Morgan Sports Boats, based near Plymouth in the south west of England, have used marine grade brush Crystic gelcoats for many years.

Andy Morgan, their founder and Managing Director was keen to trial Crystic Permabright and used it to produce a hull for their new 20ft fibreglass ski boat. (Figure 11.) After demoulding the trial hull, Morgan Sports Boats were extremely impressed with the sheer brilliance of the white colour and the level of gelcoat gloss.

Figure 11. Morgan Sport Boats trial: 20 ft ski boat hull fabricated using new Crystic Permabright gelcoat. A significant improvement in gelcoat gloss and the brilliance of the white colour was noted.

Mr Morgan stated: *"As well as being superb to use during production, handling and laying off really easily with a brush, the visual results we have seen from this trial are remarkable. The gelcoat is much glossier and noticeably brighter, so much so that I have decided that our next show boat will be gelcoated entirely with white Crystic Permabright for the hull, deck, dashboard and all the exterior GRP parts."*

Crystic Permabright Spray and Brush Gelcoat Tables of Properties

Below are the typical properties of the two Crystic® Permabright grades available. Technical data sheets are for both the spray and the brush on hand lay–up grades are available from Scott Bader.

Properties	Typical Result Brush	Typical Result Spray
Viscosity, 25°C 0.6s^{-1}	350 – 450 poise	230 - 280 poise
Viscosity, 25°C 4500s^{-1}	12 – 18 poise	2.3 - 2.5 poise
Specific Gravity at 25°C	1.2	1.2
Stability at 20°C	3 months	3 months
Geltime 25°C 2% Butanox M50 (or other equivalent catalyst)	6 – 10 minutes	6 – 10 minutes

Mechanical Properties	Method	Typical Value Brush	Typical Value Spray
Barcol Hardness (Model 934-1)	EN 59	46	48
Water Absorption 24 hours at 23°C	BS EN ISO 62 part 6.2	9.4 mg	6.3 mg
Tensile Strength	BS EN ISO 527- 2	58 MPa	61 MPa
Elongation at Break	BS EN ISO 527- 2	3.3 %	2.7 %
Flexural Strength	BS EN ISO 178	103 MPa	97 MPa
Flexural Modulus	BS EN ISO 178	2980 MPa	3490 MPa

Conclusions

The comparative technical results obtained clearly show that this advanced D-Iso/NPG polymer chemistry developed by Scott Bader has enabled them to develop a step change technology gelcoat which significantly outperforms established Iso/NPG and Iso gelcoat technologies. The luxury marine industry is likely to be the first to benefit from this new gelcoat technology, which will enable them raise the quality of their product offering. Other markets using composites which also value the retention of long term aesthetics in exposed gelcoat surfaces, such as for the exteriors of buildings, are also starting to show increasing interest in this new technology gelcoat.

For more information on Crystic Permabright and full range of Crystic resins, gelcoats, pigments, bonding pastes and structural adhesives go to www.scottbader.com

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About Scott Bader

Scott Bader was established in 1921. Today it is a £180 million multinational chemical company, employing 560 people worldwide. It is a common trusteeship company, having no external shareholders, with a strong commitment to support its customers, workforce and the environment.

Scott Bader's headquarters is based in the UK where they have purpose-built, state-of-the-art technical facilities that provide R & D as well as complete evaluation, testing and application support. They have manufacturing facilities in the UK, France, Croatia, The Middle East and South Africa. For further information regarding Scott Bader, please call +44 (0)1933 663100, visit www.scottbader.com or e-mail info@scottbader.com.

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