Issue 55 • April 2021

Connection

The official magazine of Composites Australia

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allnex

aquaguard® X
Next Generation Pool Gelcoat

Aquaguard® X – an exciting new range of pool gelcoats, manufactured in Australia, to withstand harsh outdoor conditions

Aquaguard® pool gelcoats have long been the flagship product of our offering to the local and global composite pool markets with over 20 years of proven field history.

Aquaguard® X gelcoats are an exciting new range of pool gelcoats from allnex Composites, proudly manufactured in Australia, and designed to withstand our harsh outdoor conditions. They are high performance finishes for the manufacture of composite swimming pools exhibiting high durability, outstanding UV protection, weathering and chemical resistance properties.

Product Features	Benefits
High Performance Surface Coating	A striking and visually appealing cosmetic finish with exceptional durability
High Quality Gelcoat Pigments	Vibrant and long-lasting colours
Outstanding UV Protection	The Aquaguard® X technology protects the decorative finishes from harsh effects of the sun
Excellent Chemical Resistance	Products are tested extensively for chemical fade resistance to ensure a longer lifespan for the cosmetic finish

Performance Advantages:

- Improved chemical (chlorine) & water resistance
- Improved UV resistance, protecting the finish of your pool for many years
- Increased colour retention during outdoor exposure
- Superior aesthetics of laminate during service life which maintains the original cosmetic appearance for a longer period

Aquaguard® X gelcoats are available in a range of contemporary colours and striking finishes.

For more information, please contact allnex on 1800 789 607 or visit www.allnex.com

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Aaron Stephens,
Composite Technician
FDP Composites

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Composites Australia

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President's Letter

COVID-19 galvanised us all into reassessing national self-reliance, particularly for onshore manufacturing to secure domestic supply chains and to support economic reconstruction. For my own - and all other Australian composite manufacturing companies - chemical inputs are our lifeblood. Our businesses depend on consistent, high quality, innovative chemistry. As Professor Russell Varley, of Carbon Nexus at the Institute for Frontier Materials Deakin University, puts it in his article on next generation smart resins (page 12), it is the polymer matrix from where virtually all functional properties of a composite originate. Needless to say, we wouldn't be in business without chemical inputs and the suppliers and chemistry behind them. For these reasons, our feature story is on Allnex, which is not only the largest, but the only local producer of composite resins such as unsaturated polyester and vinyl ester resins, gelcoats and flowcoats.

Our Allnex article is followed by an informative story about Scott Bader Australia which acquired Summit Composites on June 2020. Headquartered in rural Northamptonshire, the company now has distribution presence in Australia for its wide range of structural adhesives, synthetic resins, gelcoats and polymers. Of interest to me is the company's unique structure and socio-economic vision which brings an obligation to the wider community, and thus to the environment.

The article on page 16 outlines Gurit's sustainable chemistry strategy that embraces bio-based options including the use of recyclate inputs and minimising material waste as well as its journey to remove all 'Substances of Very High Concern' from all standard and essential products by 2022.

Gelcoats in particular, play a critical role in protecting a composite component and extending its life span. Written by Larry Beston, Managing Director of RF Composites, our article on page 10 outlines the company's journey to developing their new swimming pool surface gelcoat CHLORSHIELD.

ATL's article on Duratec surface technology products cites user experiences from Leisure Pools on Queensland's Gold Coast and one of Australia's largest production boat manufacturers, Maritimo Motor Yacht based in the Coomera Marine Precinct.

2021 is turning out for many in the industry to be prosperous, albeit defined and frustrated by the long shadow of COVID-19 and the consequence of fractured and disrupted supply chains and material price increases. For our annual Composites Australia conference, I am hoping that the old proverb that 'the third time something is attempted is more likely to succeed than the previous two attempts' rings true and that our industry will have an opportunity to gather in Toowoomba from 8th – 9th September 2021 and discuss all things composites. Until then, enjoy reading about the fabulous activities of our composites community.

Leona Reif
President

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A cracker of a recovery

Written by Kerryn Caulfield, Executive Director of Composites Australia Inc.

Massive increases in involuntary savings, monetary and fiscal stimulus, and the targeted generosity of bailout programs are navigating Australia away from the pandemic recession that we thought we had to have. Consumer composites like recreational or pleasure boats, caravans and swimming pools – all of which, by the way, are gelcoated – are thriving. Riviera reports a $10 million expansion of the company's Gold Coast boatbuilding facility to meet the largest forward orders for luxury motor yachts in the company's 41-year history. Pool and caravan manufactures are equally busy quoting up to a 12 month delivery lead time.

But soaring prices for manufacturing inputs are threatening the economic viability of products that are locked into fixed prices. Raw material and freight prices have increased in what has been described as a 'perfect storm,' the causes of which include the pandemic, subfreezing conditions that reduced or shut down at least 28 per cent of U.S. refining capacity in February and the blockage in the Suez Canal, a vital passage for Middle Eastern oil. There are reports of a 10 to 20 per cent rise in resin prices, shipments being reassigned and price rises for global containers of up to 200 per cent. Equally, there are reports of fibreglass prices increasing by up to 75 per cent.

But the pain doesn't stop there. Production schedules are being menaced by a shortage of high-value manufacturing imported subsystems, particularly those from Europe where shut downs have stymied production. Alan Steber, General Manager and Director of Steber International, says that while he may have received a shipment with a boat engine, the gear box is yet to follow.

Taut not tight labour market

While the labour market was tight before the pandemic – it is now taut with small businesses in particular feeling the effect. The online employment agency SEEK reported that job advertisements hit an all-time high in March 2021 – the highest in the company's 23 year history - yet applications for jobs per advertisement were at their lowest level since 2012. There was an increase of 75.1% in national jobs advertised compared to March 2020, when the fallout of COVID-19 first impacted the labour market. Attracting workers has continued to frustrate productivity across manufacturing with members reporting few, if any responses to job advertisements. The pandemic also heralded the end of free movement and curtailed the go-to option of incoming workers to fill skills and labour gaps. All of which calls for innovative solutions. An indication of the urgency of the shortage is Riviera's new initiative with the Queensland Department of Employment, Small Business and Training (DESBT) that will employ and train 30 additional craftspeople for its boatbuilding team on the Gold Coast, which is in addition to the record 41 new apprentices employed earlier in the year.

Allnex

Sovereign capability in polymer solutions

Written by Kerryn Caulfield, Executive Director of Composites Australia Inc.

COVID-19 revealed Australia's vulnerability to trade disruptions in the global marketplace and galvanised us all into reassessing national self-reliance. As an island nation at the end of long global trade routes, our manufacturing sector is heavily reliant on just in time supply chains, and has little tolerance for loss and disruption. The last year has demonstrated that the Australian composite sector needs a degree of domestic-based manufacturing capability for critical components of our supply chains to ensure the lights in our businesses can remain turned on. For chemical inputs – the lifeblood of Australian manufacturing - Allnex, is not only the largest, but also the only local producer of composite resins, such as unsaturated polyester and vinyl ester resins, gelcoats and flowcoats. The team that provides Allnex's end-to-end research and product development service has worked intensely during this difficult environment to develop a number of next generation products.

Australian made pool the Vice President model, by Freedom Pools. A large elegantly designed pool with double entry steps, numerous resting ledges and add on spa. Contributed by Allnex.

Coming out of the pandemic earlier this year, Allnex launched its next generation of pool gelcoats, Aquaguard® X. It was over 20 years ago that the original Aquaguard® range of pool gelcoats was developed for the local and global composite pool markets. David Stevenson, Product Line Manager, who has followed Allnex (in its previous entities) around the country for 29 years this month, was involved with the initial development of Aquaguard®. "The Aquaguard® range has served industry well. It has high durability, outstanding UV protection and weathering and chemical resistance properties. We were the first in the world to introduce aesthetic finishes such as stunning jewel highlights and stone/granite-like finishes, all of which are enabled by our polymer chemistry."

According to CSIRO, Australia's climate has warmed over the past century, leading to an increase in the frequency of extreme heat events. Scientists at NASA analyzing 30 years of satellite data, also found that the amount of ultraviolet (UV) radiation reaching Earth's surface has increased markedly over the last three decades. The cumulative effect of what is known as 'climate change' is a challenge for all surface technologies on manufactured products.

"We're the only company in Australia that can control and change what's in the polymer chain for a given end result, such as improving existing or developing new products to withstand the harsher outdoor conditions, " says David who admits to loving the challenge of purposeful chemistry.

Having trained as a chemist, David commenced his career in the technical lab of A.C. Hatrick Chemicals Pty Ltd in Homebush, NSW. He maintains that Australia is a good place to develop polymer technology. "Our products have to be robust and durable for a multitude of applications such as swimming pools, boats, truck bodies, tanks, roof sheeting, pipelines and many more in all conditions from Antarctica to the middle of the desert. The same product could be used on the same day in a workshop at -3 Celsius in Melbourne and 45 Celsius in Darwin. We also have the home ground advantage in that shipping times tend to erode shelf life of imported products."

Producing a high performing, cost effective gel coat is not easy. A typical gelcoat formula can be made up of up to 30 different elements including resins, fillers, pigments and additives, all of which have to perform symbiotically. A gelcoat has to be manufactured to be applied using a variety of application methods in a range of temperature conditions. Mechanical properties, porosity, viscosity and physical bonding properties all play a part. But changing one chemical input to improve a particular property can adversely affect another. Balancing the chemistry and managing all the performance expectations requires considerable R&D.

Also on the 2021 agenda for Allnex is the release of a new antistatic gelcoat, the name for which is yet to be confirmed. Static electricity is a common problem that affects manufacturers around the world.

"Our new antistatic gelcoat will make statically-charged workplaces - that most likely have styrene and acetone vapor present – much safer. It eliminates the need for earthing and antistatic straps."

"Static electricity, which is a function of mechanical motion and a dry warm environment, can accumulate during fabrication. Fibreglass rovings in particular, have a tendency to become positive. The result can be unwanted accumulation of dust - by virtue of dust being attracted to a statically charged surface – which can ruin a surface finish. Demoulding can often become hazardous." advises Dan Naiker, Applications Manager at Allnex.

Dan, who has spent over 40 years in the composite sector, also admits to loving the challenge of purposeful chemistry to solve problems and to streamline manufacturing. "Our new antistatic gelcoat will make statically-charged workplaces - that most likely have styrene and acetone vapor present – much safer. It eliminates the need for earthing and antistatic straps."

Composites products in the electrically charged environments such as fuel tanks and pipes in the construction sector will also benefit from antistatic properties of the new gelcoat." Both Dan and David are committed to the chemistry of the materials used for making thermosets - the properties, composition, behavior and the changes that can be enabled to make step change composite products.

Scott Bader

Harnessing the power of chemistry as a force for good

Written by Kerryn Caulfield, Executive Director, Composites Australia Inc.

Unique in both structure and vision, the global industrial chemical giant, Scott Bader Company Limited, was founded in central London in 1921 by Quaker husband and wife team Dora Scott and Ernest Bader.

Scott Bader has a large global research and development team, with around 12 per cent of its workforce in technical roles around the world.

Profoundly influencd by their faith and the atrocities of World War II - the biggest and deadliest war in history – in 1951 the Bader family decided to reshape the business as a socially responsible 'industrial democracy', in which the workforce became trustees-in-common of the company assets. Common-ownership or 'trusteeship' was conceived "as an alternative to a war-based capitalist economy on the one hand and to communism on the other".

While we commonly know 'the Commonwealth' to describe the group of Nations that were mostly former territories of the British Empire, the genesis of the term as a political philosophy was used as early as Aristotle and simply means any body of persons united by common goals for the common good.

At the same time, the family handed over the Scott Bader Company shares to 'Scott Bader Commonwealth Ltd', which has held the shares ever since.

A registered charity, the Scott Bader Commonwealth was "founded on the belief that a socially responsible undertaking cannot exist merely in its own interests. It is part of the whole national and international community and as such it has responsibilities which extend far beyond its factory walls".

According to his biographer John G. Corina, Ernest Bader "... combined marketing energy and individualistic leadership with a flair for spotting and applying new technology, and the company eventually became the leading innovator in plastics technology, in an industry generally dominated by capital-intensive giants." Scott Bader has now grown to become a global manufacturer worth Euro 227 million employing 700 people across 6 manufacturing sites and 15 offices.

Headquartered in rural Northamptonshire, the

company has manufacturing and distribution presence for its wide range of structural adhesives, synthetic resins, gelcoats and polymers in Europe, North America, Middle East and South Africa and joint ventures in South America and India.

Scott Bader's range of high-performance resins, gelcoats and adhesives were distributed to the Australian composites market by Summit Composites Pty Ltd. But in June 2020, Summit Composites Pty Ltd was fully acquired by Scott Bader Australia and Queensland-based resin supplier, Composites Fibreglass International (CFI) (formerly NCS Composites), was appointed as its Queensland and NSW distributor.

Scott Bader has a large global research and development team, with around 12 per cent of its workforce in technical roles around the world. Its investment commitment in R&D is running at around 2 per cent of the company's turnover which equates to nearly A$8M annually.

Kevin White, National Sales Manager for Scott Bader Australia, says that the company's extensive product range was developed over 70 years of dedicated R&D. According to Kevin, "Across our Crystic®, Crestapol®, Crestabond®, Crestamould® and Crestafire® brands, our customers have a massive choice of resins, gelcoats and adhesives from all around the world. The Crystic® brand for example, is one of the company's first brand names that includes close to 100 standard polyester resins and gelcoats. The Crestapol® intelligent resin technology of low viscosity urethane acrylate-based resins designed for infusion, pultrusion and closed mould applications is also unique."

He also believes that fire is one of the key safety challenges in transport vehicles and rolling stock, workplaces and public spaces. "Needless to say, the best way to prevent fires is to control the type of combustible material in the first place. Our Crestafire® range of resins, gelcoats and adhesives across nearly 30 products is specifically designed to offer systems that meet European and global flame, smoke and toxicity (FST) standards in the rail industry – which are now the benchmark for the world. Being part of a large global company has also enabled us to service the Australian market more efficiently. We now keep stock of our Crestabond® range of adhesive in refrigerated warehouses as well as others."

Scott Bader's charitable status and socio-economic vision brings an obligation to the wider community, and thus to the environment. By 'harnessing the power of chemistry as a force for good', the company is realising its vision to become a fully sustainable company by 2036 - manufacturing and distributing products that are compatible with the European Union's green ambitions and circular economy.

Two strategic R&D partnerships helping the company to achieve this vision are with the University of Liverpool and the University of York in the UK. Polymer Mimetics is a joint venture company with the University of Liverpool, through which Scott Bader aims to bring the next generation of sustainable high-performance polymers to the market. The technology takes widely available chemical building blocks and, in a facile, highly scalable process, transforms them into high-performance polymeric products with the potential to engineer in degradability. It is envisaged that this new generation of materials will have broad applicability in several markets including coatings, composites and speciality additives.

Scott Bader is also one of fourteen partners to have joined the CHAMPION project at the University of York, which undertakes research into novel bio-based polymers. 'CHAMPION' is an acronym for 'Circular High-performance Aza-Michael Polymers as Innovative materials originating from Nature'. The project is one of a number that hope to end the reliance on fossil-derived chemicals and aims to improve the sustainability credentials of polymer-based products.

At the end of April 2021, Scott Bader will turn 100. The milestone is being celebrated by accelerating its commitment to pioneering and harnessing the power of chemistry to make a positive difference in the world.

Scott Bader investment commitment in R&D is running at around two per cent of the company's turnover which equates to nearly A$8M annually.

Developing the next generation of swimming pool surface gelcoat technology

Laurance Beston, Managing Director of RF Composites

Functionally, a gelcoat is a high quality finish designed to provide great aesthetics including depth of colour, gloss and opacity, as well as UV protection and water / chemical resistance to an FRP composite. For external end use applications where the composite part is exposed to aggressive environmental elements for extended periods of time, gelcoats play a critical role in protecting a composite component and extending its life span.

There are many elements to the final gelcoat formulation - including its base resin - that influence its application and in-service performance characteristics. Ultimately, a gelcoat's performance relies on material selection and formulation. Flow, cure and adhesion properties are all critically designed into a commercial gelcoat.

Over four years ago, the RF team set about using its expertise in novel resin design, formulation and blending to develop a completely new gelcoat that will outperform existing products on the market, particularly those for fibreglass swimming pools. Our aim was to develop-out susceptibility to corrosion from sanitising agents such as chlorine - which all too often whiten pool surfaces through oxidization - and the likelihood of pigment degradation.

CHLORSHIELD

After analysing legacy technology, our team of polymer chemists investigated and developed

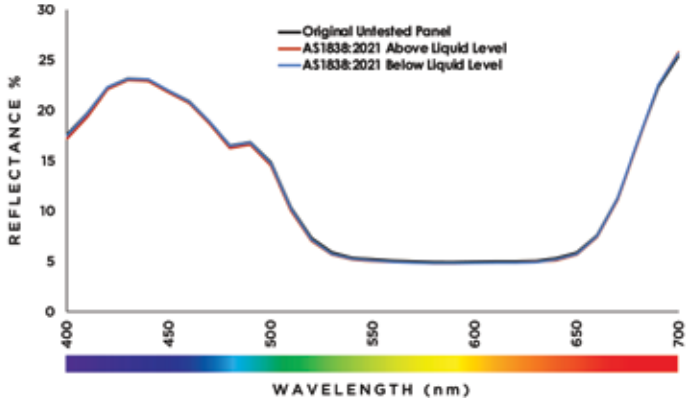
new resins, identified novel monomers and fundamentally changed the building blocks of traditional gelcoat formulations. We completed extensive internal testing and commissioned external tests against recognised standards. The resulting product is now trademarked as CHLORSHIELD, in Australia, NZ, USA, EU & UK and it has a patent well under way.

CHLORSHIELD is now available as the next generation of swimming pool surface gelcoat technology. It is designed to provide unparalleled protection for a swimming pool's cosmetic surface from chemical attack, particularly in our unique Australian outdoor environment.

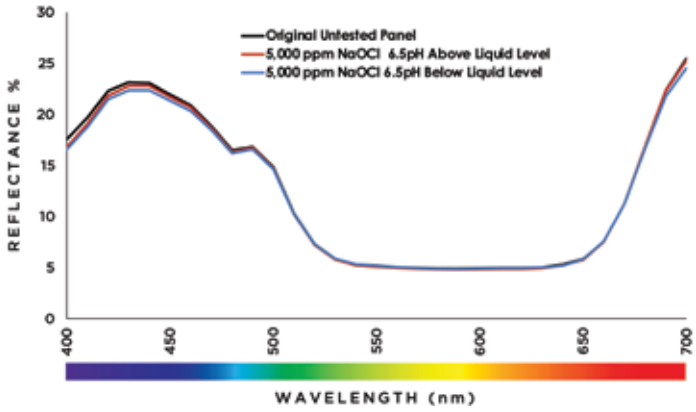
The test results exceeded expectations by easily surpassing Australian Standard AS1838:2021 for pre-moulded fibre-reinforced plastics. Our licensed manufacturing partners are now able to offer an extraordinarily wide range of vivid colours and highlights.

In summary, the process for testing against the new Australian Standard AS1838:2021 is quite simple. Heat one litre of water to 70C. Dissolve 0.75g of Calcium Hypochlorite in the water and then place the test panel - half submersed - into the sealed container at 60C. Leave for 24 hours at that temperature. This equates to approximately 488ppm Calcium Hypochlrite Ca(OCl)2.

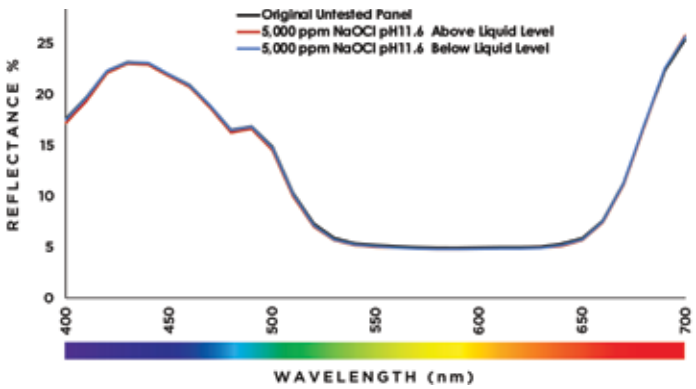
Rather than use a simple grey shade comparison RF uses spectrographic graphic colour analysis. The graphs below show the "shape of the colour" in a light reflectance versus light wavelength over the visible spectrum. Whitening (bleaching) of a panel under test as an upward shift in the graph; as white surfaces have higher reflectance.



Here we show various tests and the reflectance curves of CHLORSHIELD colour Cobalts Sea, under harsh test criteria. Australian Standard AS1838:2021 as stated above.



RF Also tests at 5,000 ppm of Sodium Hypochlorite (NaOCl) @ pH 6.5, 60C for 24 hours, which is analogous to salt water pool chlorination. Greater than 10 times the concentration of AS1838:2021



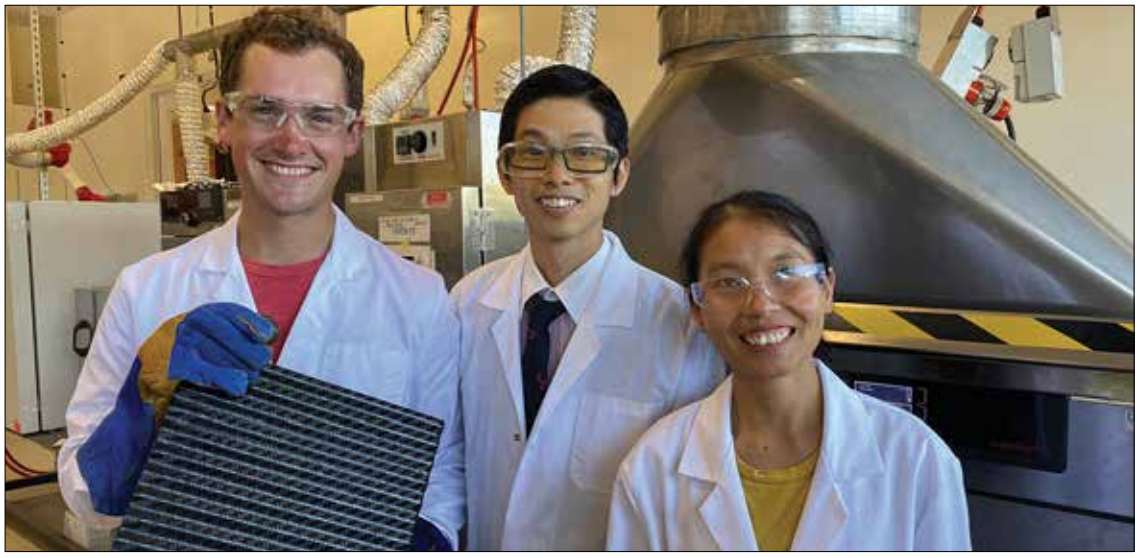
Further, RF tests at 5,000 ppm of Sodium Hypochlorite (NaOCl) @ pH 11.6, 60C for 24hours, as "bad" pools often have high pH's of 8-9. This test again is greater than 10 times the concentration of AS1838:2021 and >1,000 more alkaline than a bad pool.

Functional, processable & smart resins

The next generation of composites & coatings

Written by Prof Russell J. Varley, Professor of Composites Carbon Nexus at the Institute for Frontier Materials Deakin University, Victoria

The polymer matrix, despite its importance is almost forgotten when discussing the merits of carbon fibre composite materials, often being seen as simply the glue that binds the much stronger carbon fibres together. Yet, it is the polymer matrix that determines the ease of processability, the service temperature and durability, it is the constituent that will fail first under load and is from where virtually all functional properties originate. At Carbon Nexus at Deakin University, we are using our knowledge of polymer chemistry, structure property relationships and composite fabrication methods to develop the next generation of polymer matrices that address some of these challenges of functionality, durability, performance and processability.



Principle researcher, Mr Samuel Swan, PhD candidate; Dr Jerry Gan, Associate Research Fellow and Dr Jane Zhang, Research Fellow in the Carbon Nexus research facility.

Three examples of current research projects that focus directly upon the matrix are described here to illustrate the scope of research undertaken on resins at Carbon Nexus. The first involves the development of fire resistant rapid curing epoxy resins for High Pressure Resin Transfer Moulding (HP-RTM), the second is using self-healing technologies to extend the service life of coatings while the third uses novel modifiers to enable the fabrication high temperature epoxy resin via resin infusion.

Rapid Manufacture of Fire Retardant Composites

As composite applications become more closely intertwined to the everyday lives of people, increasingly high levels of fire retardancy are required. This, in turn, requires the development of fire resistant polymer matrices that are fire resistant and processable using High Pressure Resin Transfer Moulding (HP-RTM) which is ideally suited for the rapid manufacture of carbon fibre composite materials for the automotive industry, particularly for medium volume manufacturing of complex components.

HP-RTM requires highly reactive and low viscosity resins which are fully infiltrated into the preform prior to cure to facilitate high quality composites. Unfortunately, the aliphatic nature of these resins results in very poor fire-retardant properties. Despite the availability of effective fire-retardant additives, they are not suitable for HP-RTM resins because they invariably increase viscosity, reduce reactivity and are likely to be filtered unevenly throughout the preform, greatly reducing effectiveness. Our approach at Carbon Nexus therefore has been to design and synthesise new fire-retardant additives and resin systems that remain miscible, have a low viscosity and remain sufficiently reactive for medium volume manufacturing using HP-

RTM. Our resin system has been able to achieve a V-0 industry UL-94 rating (Fig 1a) and an oxygen index (OI) of about 37%. Commercially available HP-RTM resin systems tend to drip continuously during combustion and do not self-extinguish while the OI for these resin systems is often around 20%. Importantly the viscosity (Fig 1b), reaction rate, glass transition temperature (Fig1c), thermal and mechanical properties are either mostly unaffected or in the case of fracture toughness, actually improved by about 20%.

The overall strategy used in this research was to synthesise a monomer that fully incorporated into the crosslinked network enhancing efficiency of fire retardancy and minimising any reduction in properties. Furthermore, the reactive monomer was designed to take advantage of the synergistic mechanisms promoted by silicon and phosphorous elements during combustion. Phosphorous oxides are well known to promote decomposition of the network creating a char layer but also emit radicals which act as radical scavengers in the gaseous phase terminating chain reactions and reducing combustion. In the condensed phase, both phosphorous and silicon act together to produce a strong and stable char layer which inhibits the transfer of combustible products further reducing combustion.

Drs Houlei Gan and Mohsen Seraji,
Associate Research Fellows

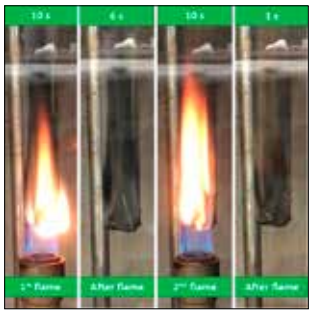


Figure 1a. Flame self-extinguishes after 6 and 1 seconds after flame.

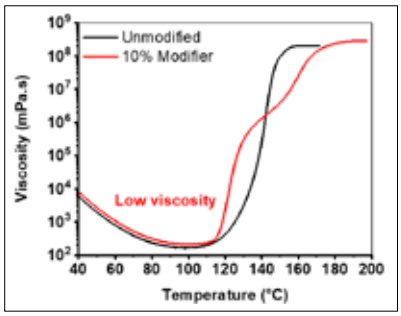


Figure 1b. Similar minimum viscosity and rate of reaction using FR modifier.

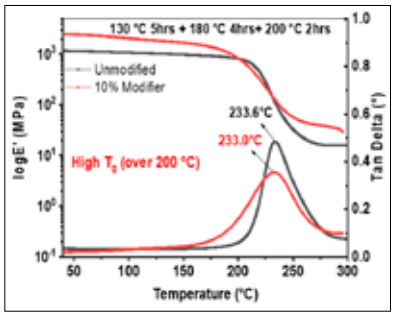


Figure 1c. High Tg is maintained despite FR additive.

Self-Healing Polyurethane Boronic Ester Coatings for Extreme Environments

Degradation is an unavoidable reality of materials in the environment, whether from corrosion, UV weathering, moisture resistance, or through various other chemical, environmental and mechanical degradation mechanisms. Nowhere is this more relevant in the Oil and Gas industry where petrochemical infrastructure, such as pipelines and off-shore platforms are in a constant war against corrosion and harsh damaging environments. Avoiding failure or extended down time requires comprehensive monitoring and maintenance programs that are complex, time consuming and costly, particularly in situations where repair may be too difficult or impractical such as offshore platforms or underwater pipelines. The emergence of self-healing materials where damage is repaired or restored autonomously or through some remote activation, therefore has enormous potential to extend the service life of assets, reduce maintenance programs and greatly increase the efficient use of resources.

At Carbon Nexus and in collaboration with PETRONAS (Malaysia) we are developing a new family of polymer coatings that repair and restore surface cracks and scratches that inhibit corrosion and add another layer of protection to increase service life. Importantly, this technology is entirely autonomous not requiring any external intervention, only utilising moisture from the surrounding air or water if submerged.

The technology takes advantage of the inherently reversible chemistry of boronic ester groups which can hydrolyse or re-esterify depending upon the environment. When the surface is broken via a scratch or a crack, the boronic ester groups are initially hydrolysed when exposed to the surface, but can then progressively reconnect via re-esterification in the presence of moisture restoring the polymer to its original state. In zipper like fashion a scratch or damaged region is therefore closed from the bottom up, expelling moisture and stabilising the polymer as also shown in Figure 2a.

At Carbon Nexus, we have demonstrated this healing for a range of temperatures from room temperature to 80 °C and for a variety of environmental conditions from ambient to 86% RH. Figure 2b shows a typical example of the type of healing observed for coatings. All of the conditions demonstrated excellent healing, apart from low humidity atmospheres which showed little, if any healing. Indeed, even when placed underwater any visible evidence of a scratch was entirely eliminated. However, a major disadvantage of this technology is that despite its excellent healing

Functional, processable & smart resins
Continued

ability as shown, the polymer networks degrade during long term exposure. Our research has been to overcome this disadvantage by copolymerising the boronic ester networks with more durable and ductile polyurethane polymers to create hybrid networks that are able to maintain high levels of healing, while at the same time are durable and ductile enough to withstand harsh environments.

Principle researcher – Dr Jane Zhang, Research Fellow

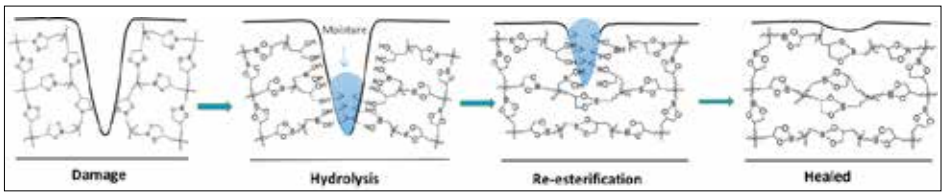


Figure 2a. Boronic ester self healing mechanism

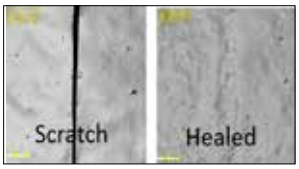


Figure 2b. Example of self-healing hybrid coating, before and after healing.

Resin Infusion of High Temperature Polymer Networks

As the adoption of polymer composites becomes more widespread, they are becoming increasingly important in applications requiring long term durability at elevated temperatures. From hypersonic re-entry aircraft and near engine applications, to high pressure pipes in petrochemical facilities, the demand for structures which can survive long term exposure at elevated temperatures or continuous and intermittent spikes in temperature grows. A particular advantage of polymer composites is that there is a wide range of matrices to choose from to meet many of these challenges, from aerospace epoxy resins which typically have a maximum service temperature of about 180 °C, through to more niche polymers such as polyimides and cyanate ester resins that can have maximum service temperatures in excess of 250 °C.

Given the inherently greater thermal stability of carbon fibre, the durability and thermal stability of a polymer composite is again controlled by the resin and the network structure after cure. More specifically, the level of aromaticity compared to aliphatic structures, the molecular packing and cohesive interaction between polymer chains and crosslink density all play an important role in maximising thermal stability. Cyanate ester and polyimide networks for example, both produce highly stable polymer networks able to withstand service temperatures sometimes well above 250 °C, courtesy of the highly stable triazine ring and aromatic imide groups produced after cure respectively. Unfortunately, high levels of aromaticity within a polymer tend to cause a significant reduction in the processability of polymer networks, requiring sophisticated and costly fabrication which ensures their use remains restricted to niche applications. Similarly, epoxy resins, typically known for their processability, can be challenging the more highly aromatic they are. An example of this is the commercially available tetra-functional glycidyl ether bis-naphthalene epoxy resin, reported to exhibit very high glass transition temperatures of at least 250 °C depending upon the curing agent used.

Its high melting point and high melt viscosity make it difficult to process, again restricting its wider application. At Carbon Nexus, we have improved the processability of this highly aromatic, high temperature epoxy resin, enabling it to be fabricated into a composite using simple and affordable infusion methods. In this way, its advantageous thermal stability, glass transition temperature and mechanical properties may be more widely applied. Our approach has been to use a simple non-reactive and miscible aromatic additive that reinforces the highly crosslinked network at the molecular level without impacting the thermal stability of the network. It was found that only 10 wt% of additive was required which greatly reduced the viscosity and widening the rheological processing window necessary for infusion methods as shown in Figure 3a. Importantly, this additive also improved modulus, strength and fracture toughness whilst having very limited impact upon glass transition temperature at only 10 wt% of additive.

Principle researcher – Mr Samuel Swan, PhD candidate

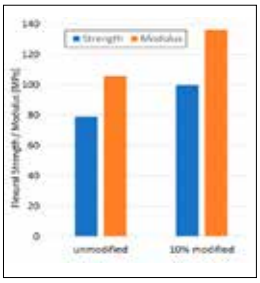


Figure 3a. reduction of viscosity improving processability and b) increased modulus and strength after cure using only 10% modifier.

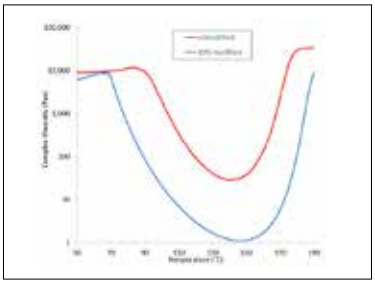


Figure 3b

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Gurit

The process of developing environmentally considerate technologies

For a company with three-quarters of its business engaged in enabling and supplying the global wind energy industry, it stands to reason that Gurit has a heightened comprehension and commitment to environmental sustainability across all disciplines.

Gurit's unique Light Reflecting Technology (LRT) allows the user to detect the presence of contamination on clothing.

One of the key targets set out by Gurit in 2017 was to remove all SVHCs (Substance of Very High Concern) from all standard and essential products by 2022. This is no small task given that the European Chemicals Agency are designating more SVHC's every year. Of specific note for the composites industry was the inclusion of Bisphenol A and Nonyl Phenol. These substances are present in many amine-based hardeners and, although they can provide very effective technical benefits, the hazard profiles of endocrine disruption and bio-persistence mean that removal of such substances is of paramount importance. The removal of such substances not only eliminates these harsh chemicals from the supply chain, but also reduces reporting requirements for its customers. The company is currently on track for this target with a large reduction in the number of materials affected – from 65 per cent in 2017 to currently 11 per cent of products (in standard and essential ranges within the Formulated, Prepreg and Core product offering). The number of SVHCs used in Gurit products has been reduced from a maximum of 10 substances in 2019 to only three in 2020.

Gurit's drive to reduce the hazard profile of products has resulted in a number of new product developments. "The formulated product portfolio was complex and filled with legacy systems with a number of health & safety related issues. We are now in the final year of the formulated product rejuvenation project which started with Ampreg™ in 2018, then AMPRO™ last year and completed with PRIME™ & Spabond™. To date, two-thirds of our formulated portfolio has been replaced with safer, higher performing products and this will increase

to over 90 per cent by the end of 2021. We believe our ecological approach to formulations to be unique," advised Kevin Cadd Formulated Product Manager.

These new products also incorporate Gurit's unique Light Reflecting Technology (LRT) as standard, allowing the user to detect the presence of contamination on clothing and around the work environment in order to monitor exposure with the support of a simple UV light.

Sustainable chemistry at Gurit also embraces bio-based options including the use of recyclate inputs and minimising material waste. The newly introduced AMPRO™ BIO has an accredited 40-60 per cent bio-based content and is a simple to use, all-purpose epoxy. AMPRO™ can also be used for gluing, coating, laminating and filling for a very wide range of tasks, most typically for the manufacture and repair of wooden boats.

Along with traditional glass-and carbon-fibre products and hybrids, Gurit recently commenced offering a range of sustainable fibre alternatives for reinforcements suitable for composite component manufacture and repair with natural flax fibre products. Thanks to these flax-based reinforcements, the CO2 footprint of semi-structural composite parts such as exterior panels, can be reduced by 75 per cent when compared to carbon fibres while matching performance. For interior panels, weight can be reduced by up to 50 per cent and plastic by up to 80 per cent at matching performance. The combination of Gurit's low toxicity bio resin with natural fibre solutions now provide an important first step for a bio-based composite panel solution for multiple industries.

Gurit's commitment to sustainability, responsible manufacturing methods and expertise in epoxy formulations will continue to provide market-leading environmentally responsible products for a wide range of markets including wind energy, aerospace, marine and industrial applications. The company provides a full range of composite materials and formulated products for wet laminating, infusion and multi-purpose systems from the new Gurit facility in Queensland (gurit.com/australia) and is currently establishing a regional reseller network across Australia.

A full report on Gurit's commitment to sustainability, health and safety and climate neutrality can be found by visiting gurit.com/en/about/sustainability.

Duratec the surface saviour

The Duratec comprehensive range of surface technology products are used in the preparation and maintenance of composite plugs, patterns and moulds in the automotive, architectural, leisure products and marine and transportation industries. Duratec is the preferred range of products for many composite fabricators because of its ease of application, rapid coat build-up, low porosity, increased gloss and quick cure. It also saves time and labour, while ensuring a superior, smooth mould surface.

Duratec vinyl ester topcoats are easily applied, durable coatings for patterns, and in-mold applications – Black HI Gloss TopCoat 1902-054.

The Duratec range was developed over thirty years ago by Hawkeye Industries Inc in the USA which has continuously invested in R&D to expand the offering of putties, primers, sealers and topcoats. Duratec Polyester and Vinyl Ester products are trusted for their ability to cure completely when applied to plug/pattern surfaces. The thin-film air-cure capability makes Duratec ideal for the composites industry. ATL Composites has been the sole distributor for Duratec products in Australia since 1987. It's sister company, Adhesive Technologies NZ Ltd covers New Zealand.

For Neil and Neville Savage, in charge of production for Leisure Pools on Queensland's Gold Coast, Duratec products have performed consistently and reliably for the 18 years the business has been in operation. "We build the plug for the moulds of the pools out of plywood and MDF," Neil explains. "We then use auto body filler in areas and then seal the plug with Duratec 823A Sealer. We then spray it with Duratec 707-051 Base Primer and sand it fair, then follow through and spray it with Duratec 707-061 EZ Sanding Primer prior to sanding, buffing, polishing and waxing to produce a nice, smooth glossy surface.

"Duratec 823A Sealer, 707-051 Base Primer and 707-061 EZ Sanding Primer are easy to use and sand and create an extremely durable finish. We can get several moulds out of one plug, which is great when you consider some of our pools are 12-metres in length and 4.5-metres wide. "If there are any small repairs to make, we use Duratec 1910-045 Red Vinyl Ester Top Coat for all the small touch ups as well."

As Neville affirms "The best part is that Duratec products stay strong. We can get up to 12 moulds off the same structure and not have any major repairs. It saves time and labour not having to commission new plugs each time. A few years ago we tried something else and it was nowhere near as good as the Duratec system. It's by far the most durable and works well with our release system. The range of Duratec products work perfectly together."

In the marine sector, Maritimo Motor Yachts is one of Australia's largest production boat manufacturers based in the Coomera Marine Precinct. Maritimo's fibreglass contractor, Neil Parsons who has been in the industry for close to 30 years has been using products from the Duratec range for most of that time. "We have rarely strayed," he states. "Duratec 707-051 Base Primer, 1794-006 White Vinyl Ester Primer and 1902-045 Vinyl Ester Black Top Coat are spray-painted onto the timber plug before it's buffed and polished to a super high gloss. It gives a great finish to our constructed moulds."

Just as pools are enjoying a surge in demand, motor yachts too are enjoying strong sales. "We are going through a growth period, both locally and our boats for export," says Neill. "It's all hands-on deck at the moment."

Unlike pools though, Maritimo motor yachts are highly customised and each plug is "sacrificial", as Neil explains. "Our boats are composed of complex shapes. The Duratec system is easy to work with in tight areas and to sand. It buffs up to a good shine

Sand and polish to a non-wax, tack free high gloss finish. Transfers a brilliant gloss to tooling gelcoat.

at the end. We also use Duratec 1910-045 Red Vinyl Ester Top Coat as a tooling product."

The Duratec vinyl ester primers and high gloss topcoat range provide a hard mould surface with great adhesion to the original polyester, Vinyl Ester or epoxy-based tooling gelcoat.

They can be used to modify, repair and resurface existing composite moulds to recover shine, eliminate marks from repairs, and to improve vacuum integrity. Duratec vinyl ester resurfacing products will eliminate sub-surface porosity, and provide greater gloss retention, improved heat distortion temperature, and superior impact resistance to create a "better than original" tooling surface.

Duratec 1794-006 White Vinyl Ester Primer and Duratec 1910-045 Red Vinyl Ester Top Coat can be used to resurface composite moulds built with a tooling gelcoat surface and epoxy moulds built with an epoxy face coat.

ATL Composites Director, Nicholas Cossich said "We are very proud to have represented the Duratec range in Australia for more than 20 years. We appreciate the support we have amongst the specialist applicators who have a justified reputation in achieving superior finishes."

For information Visit http://atlcomp.icmsdemo.com/category/33/Plug-and-Pattern-Surfacing www.atlcomposites.com

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