Ask the Experts Series

Our World is Water

Antifouling 101

A Comprehensive Guide from Interlux

At Interlux, we recognize the importance of providing high-quality technical support and advice to all our customers. To that end the *"Ask the Experts Series"* is written to provide you with knowledge that will help you make informed decisions about marine paint.

Antifouling 101

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Part 1

The choice and use of antifouling paints is one of the most complicated questions a boater will need to answer. At Interlux we help boat owners answer that question at boat shows, online and at our technical service helpline. Many boaters will just chose to let the boatyard decide "put on whatever you apply but make it blue", or they may ask their fellow boaters what they are using or they may simply go to the yacht chandlery and pick one that fits their price range. Through our experience we have noticed that many myths and misunderstandings have grown up around antifouling paints and this is an attempt to demystify those misunderstandings.

The Challenge

One of the ironies of boating, whether It's for recreational or commercial purposes is that the primary ingredient necessary for such activity – water – is also potentially the biggest cause of problems. The destructive effects of fouling marine growth have vexed man from the beginning of his use of the world's waters for relaxation and commerce.

Protecting a boat from marine growth is an unavoidable but absolutely necessary task. If you consider that the sea contains immense quantities of floating plant and animal life – what marine biologists term 'plankton' – you can readily appreciate the inevitability of the problems. In essence, the boats natural environment of water contains the seeds of diminished performance and (if unattended) eventual destruction.

Plankton is a word of Greek origin, meaning, 'to wander'. It is a biologically collective term given to all plant and animal life floating in the water. Because of its' microscopic size, plankton is generally not readily visible. But at times it can be thick enough to be seen by the naked eye in daylight. Indeed, the luminous nature of many of these organisms creates the nighttime 'phosphorescence' of the sea so familiar to many.

As a consequence the bottoms of all vessels are subject to marine growth in varying degrees. It is a known fact that the density of marine organisms is greatest in coastal waters that are **48°F** or warmer and since the run-off from the land brings a wealth of food on which plankton exists, harbors and estuaries where boats are moored are literally the breeding grounds for marine growth.

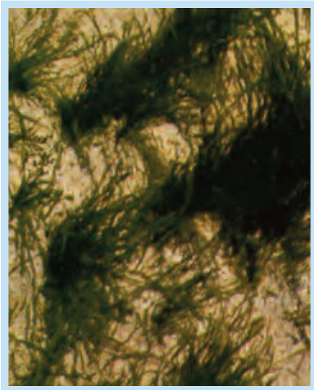
Most people when they consider fouling think of shell fouling such as barnacles or mussels but there are a host of other organisms such as algae, slime, grass, bryozoans, Hydroids, diatoms, snails and worms that would love to call the bottom of a boat home.

Fouling can be divided into two categories, weed (plant) and shell (animal). The primary difference between weed and shell fouling are their origins and appearance, but their destructive properties are equal in potential.

Weed Fouling

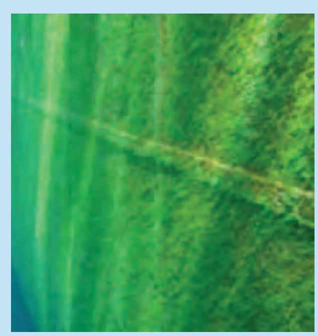
'Weed fouling' is a by-product of the seaweed family that is familiar to ail. True seaweeds are divided into three groups, by colors; Green, Brown and Red. All are fouling growths and are found around the, globe, and each has its' own common characteristic. Like ordinary house or garden plants, each of these seaweeds can only grow in the presence of light. Green weeds need more light than brown which itself needs more light than red and because of the need for light, 'weed fouling' on boat bottoms tends to concentrate itself near the waterline.

Weed growths (fouling) multiply and spread by means of tiny spores that attach themselves to the bottom of the hull. Light is important to their growth and reproduction, as explained above, but either too much or too little light can be fatal to weed growths. The moderate amount of light typically found at the waterline provides the ideal conditions for permits them to thrive, particularly, when they are attached to the bottom of a boat.

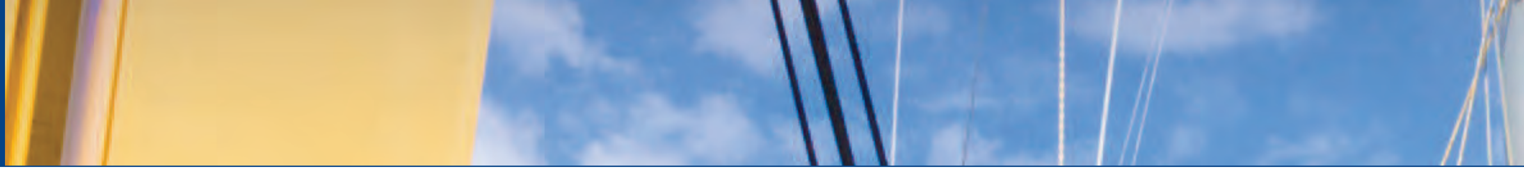


Enteromorpha:
A typical example of the green weed that is found in coastal areas throughout the world.

Ectocarpus:
The most common brown colored fouling growth. It has a branched structure Instead of the filamentous structure of the Enteromorpha and it also is found at the lower portions of the waterline.



Polysiphonia:
The red colored Polysiphonia, which has a branched structure with feathered tips.



The owner of this boat waited a little too long to apply new antifouling!

These remarks have applied to the true seaweed, but as stated above, there are various other fouling forms, that are classed as 'grass' fouling, but which are in fact animal fouling. The two most important of these are hydroids, which are related to the sea-anemone, and polyzoa which are related to marine worms. Both form soft branching growths, easily mistaken for seaweeds. If they are placed in water and examined with a lens, the branches are seen to be covered with what look to be minute daisy-like flower heads, but which are little gelatinous polyps whose tentacles move actively, expanding and contracting to capture their prey.

The color of hydroids and polyzoa varies from white and pink through buffs and browns to red.

They are never green. The minute larvae, by which they are propagated, are generally more repelled by sunlight at the time of settling than are seaweed spores. This type of fouling consequently occurs more abundantly on the lower parts of yachts.

Shell Fouling

Shell fouling is similar to seaweed growth in that the microscopic organisms are hatched in the sea, swim, disperse and ultimately, seek a resting place – such as the bottom of a boat.

The most universally known shell fouling organism is the Acorn Barnacle of which there are many species, ranging in size when fully grown from 0.75 cm or less, up to 4.0 - 7.0 cm's in diameter. There are also Stalked Barnacles or 'Goose Barnacles', the shell portion of which grows on a long, flexible stalk.

When barnacles adhere to the bottom of a boat, they continually grow and exert considerable pressure on the area where they are attached. Fiberglass hulls are very hard and tough, yet they are not impervious to the destructive nature of the barnacle. Left unattended or uncorrected barnacles can do considerable damage to the gelcoat surface. When scraped off they usually leave a ring of glue on the surface and sometimes their adhesion is so great, that the force necessary to scrape the barnacles, tears the gelcoat with it.

There are other kinds of shell growth found on yachts as well as barnacles; of these, two are frequent enough to deserve mention. The first is another member of the shell family, the Mollusk, or 'mussels', as they are commonly referred to such as the blue mussel. Non-indigenous or invasive mussel species such as Zebra Mussels and Quagga mussels were introduced into the Great Lakes in the 1980's and have spread to many bodies of water throughout the U.S. and Canada. The other common type of shell fouling is the tube worm, which appears as tangled, coral like white tubes, inside which the animals lives.

A form of fouling that is particularly deadly to wooden hulls is the teredo worm. Teredo worms are the termites of the sea. They can destroy an unprotected wooden hull in a short period of time and needless to say, their appetites are never satisfied. Although they are particularly destructive to wooden vessels they can colonize a fiberglass hull as well.

Another form of marine growth that should be mentioned is the Tunicate, sometimes called 'Sea-Squirts' or 'Jelly-Bags'. Their larva forms resemble minute tadpoles and possess a faint semblance of a backbone. When attached to the bottom of a boat, they offer an extreme amount of drag resistance.

Shell fouling is not as dependent on light as seaweeds are. During their larval or maturing state, barnacles prefer dark areas. Thus, it is not uncommon to find shell fouling on the lower portions of the hull such as the keel and rudder.

Tunicates or 'Sea-Squirts'

Mussels

A form of animal fouling that grows flat to the surface are the Bryozoans, which are made up of colonies of individuals, called Zooids. Zooids are less than one thirty-second of an inch in size and live together in an encrusting lacework 'crust', which is formed by a limestone covering secreted by the colony. They feed on plankton and bacteria by sweeping the surrounding water with cilia-covered tentacles called lophophore. Bryozoan colonies can get very large stretching a foot or more across.

Slime

Yachts frequently become coated with a slimy moss-like growth, usually more noticeable on the sides than on the bottom. Such slimes are vegetable, sometimes true seaweeds of a low order which forms a tangled mass of microscopic threads, more often organisms called diatoms. Different species of slimes vary in color; they are commonly green, greenish-brown, brownish-red or black.

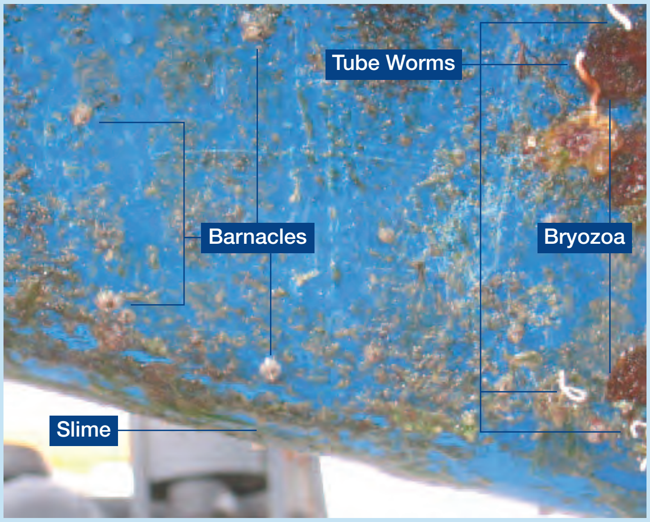
As antifouling compositions have become more efficient and have effectively cleared yacht surfaces of the major fouling organisms like shell and weed growths, this unfortunately has left the surface open to colonization by slime organisms such as bacteria, diatoms and algae, which have proved very tenacious and of all fouling types, the most difficult to control.

Tube Worms on a fiberglass hull

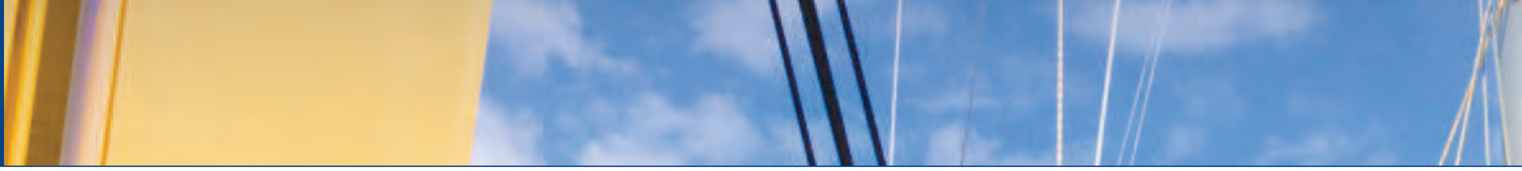
Six weeks in the BVI:
The black paint on the right is Micron and the red paint on the left is not.

A typical slime film could consist of long filaments of the alga **Ulothrix** together with **Acthnahthes** diatoms, attached by means of gelatinous stalks bound up together with silt particles. Being stalked, some of these diatoms manage to keep out of the toxic area around the antifouling surface and so are not affected. Other slime forms have their own anti-antifouling defenses, including in some cases the ability to chemically bind normally toxic materials like copper into insoluble forms and effectively inactivating them!

Slime fouling



With everything that wants to grow on the bottom of a boat what is there to do?



Part 2

How antifouling paint works

The best solution to the problem of fouling is treating the hull with an antifouling paint. Antifouling paints contain biocides that repel fouling organisms when released at a controlled rate into the water adjacent to the hull.

The rate of release of biocides is important; if it is too fast, the antifouling will fail prematurely, especially after a period of intense activity, while if it is too slow, the antifouling will be ineffective, particularly in areas with a high fouling challenge. It is at the settling stage of fouling organisms that the adhesion and growth must be prevented: once settled and firmly attached, growth is extremely rapid and the organisms are beyond the influence of antifouling paints, and can only be removed by scrubbing and scraping.

Choosing an antifouling with the correct biocide release rate does depend on the severity of the problem locally. Other requirements vary too. For instance, antifoulings with a high copper content cannot be used on aluminum vessels without being specially primed first. Some boats dry out for several hours on their moorings, at low tide, while others are permanently immersed. Some boats need to be burnished to a smooth, racing finish. Others require bright, attractive colors.

Thus antifouling compositions bear only a superficial resemblance to other paints. Whether for protective or decorative use other coatings are designed to be as permanent and as water-resistant as possible. Antifoulings look like paints, smell like paints and are applied like paints, but in order to function they require some water ingress in order to release the biocides, in a continuous and controlled manner throughout the lifetime of the composition. The antifouling film acts as a biocidal reservoir which gradually becomes depleted. All antifoulings will eventually fail when the concentration of biocide in the layer of water adjacent to the surface falls below the critical level necessary to control the larval fouling.

The dissolution process which allows removal of biocide is called ‘leaching’ and the rate of removal the ‘leaching rate’. The problem in antifouling development is to produce products which will maintain an adequate leaching rate of biocide for extended periods of time. This must be combined with all the other necessary properties of application, flow, leveling, drying, adhesion and film integrity necessary in a film which is subjected to repeated immersion in sea water, and subsequent drying out.

Failure of the biocide to leach adequately, or alternatively to be released too rapidly, will lead to premature fouling. The thinner the antifouling the less biocide reservoir it contains and too thin a film will lead to rapid failure once all the biocide has gone. On the other hand, application of five coats of antifouling will not give five times the lifetime except in the case of copolymers. Other antifouling systems get ‘clogged’ with insoluble materials at the surface, before the biocide in the lower coats can be utilized.

The effectiveness of the antifouling and its lifetime will depend on the types and level of biocide(s) it contains, along with the types of resin, natural or synthetic, used as binders. Very few biocides have found use in antifouling compositions since very precise properties are required, particularly in terms of toxicity and solubility in sea water. Many are too soluble in sea water, while others are too toxic to be handled safely.

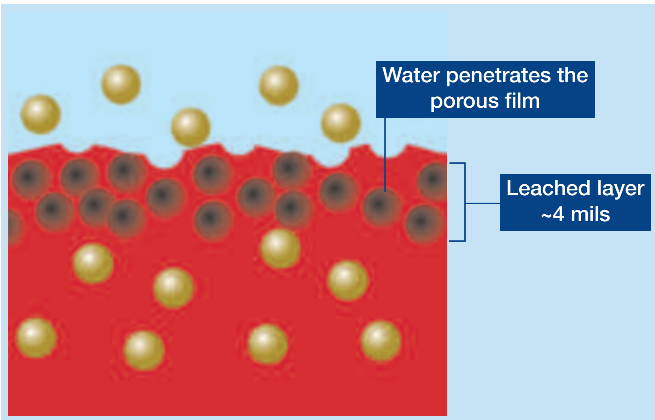
As you can see the delivery system of the biocide is a major determining factor in how well the antifouling paint works and for how long it works. In simple terms there are two methods of delivering biocide to the paint film surface so that it can discourage growth, hard and ablative. These terms refer to the way the resin interacts with the water.

Hard Paints

The technical term for these types of antifouling paints is ‘contact leaching’. The paint dries to a porous film that is packed with biocides, and these leach out as they come into contact with water. This leaching is designed to release biocide throughout the season, but it is a diffusion controlled process that starts at a high level and steadily decreases until there is not enough biocide coming out of the paint film to maintain fouling protection. Once the biocide is exhausted, the remaining hard paint film remains intact.

Hard antifoulings do not retain their antifouling ability if kept out of the water, and cannot be hauled and relaunched without repainting. However one of the main benefits of this type of antifouling is its resistance to abrasion and rubbing. This makes it ideal for fast powerboats, racing sailboats or boats where the owners have the bottoms scrubbed regularly. Most hard antifouling paints can be wet sanded and burnished prior to launch in order to reduce drag and improve hull speed.

The paint film of hard bottom paints continually builds up year after year, and eventually becomes brittle, and starts to crack and flake off. It is at this point that it will need to be removed.



Hard antifoulings will eventually leave biocide trapped within a rough, honeycombed paint film that will need to be removed by sanding or scraping.

Ablative Paints

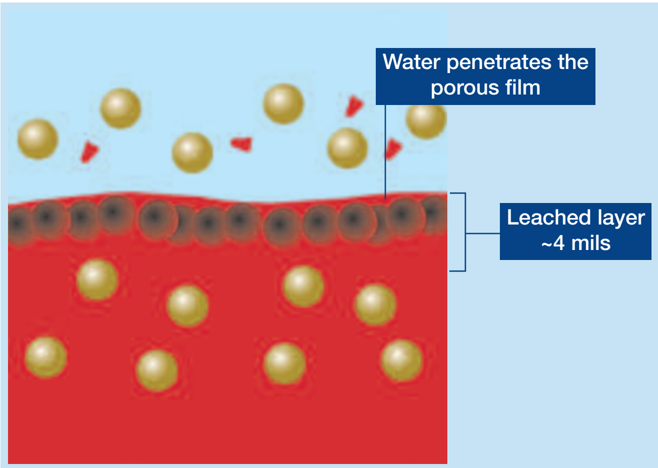
Ablative types of antifouling are more efficient at delivering biocide than Hard antifoulings and use less biocide to provide more antifouling protection. To ablate means to 'wear away' or 'erode', and there are many antifouling paints that work by wearing away, but there are several different ways that the paints wear away.

Soft Rosin-Based Sloughing Antifouling Paints

These paints are made with natural rosins and are the softest type leaching paints. They were originally developed so that a boat could be painted between tides so they dry quickly. The older formulas required they be launched within 72 hours of painting. These paints erode quickly and are least expensive antifouling paints offered. This type of paint is used on boats with displacement hulls and commercial workboats.

Controlled Solubility Copolymers and Controlled Depletion Polymers

These types of antifoulings are partially soluble which means that as water passes across the surface of the coating it wears the surface away, much like a bar of soap would wear away. The physical action of the water over the surface steadily reduces the thickness of the paint, which results in always having fresh biocide at the surface throughout the season. For this reason these types of antifoulings have the capability to perform well in the areas of highest fouling challenge, and the longevity is directly related to the thickness of the paint applied.



Release of biocide is slowed until the leach layer is worn off.

These types of antifoulings are formulated using a blend of natural rosin and man-made synthetic resin, and by varying the ratio of synthetic resin to natural rosin the chemist can control the rate at which the paint will wear away, and this also determines the cost. Rosin is much less expensive than synthetic resin, so a coating that contains more of the latter will be more expensive, but wear more slowly, than one that contains more rosin but wear away more quickly.

Boats painted with Controlled Solubility Copolymers can be hauled and relaunched without repainting since the biocides are chemically bound to the paint film and are only active when in the water.

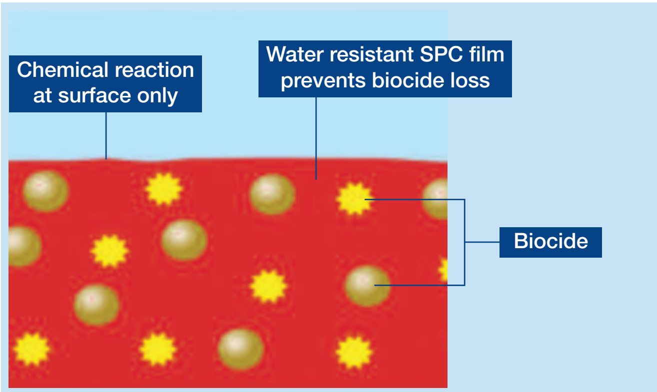
Sometimes Controlled Solubility Copolymers, or Controlled Depletion Polymers, are called 'self-polishing' because the action of the boat physically moving through the water wears away the leach layer, and so exposes fresh biocide. But true Self-Polishing Copolymer (SPC) antifoulings are superior since their biocide release is controlled by an initial chemical reaction at the surface, prior to then physically wearing away.

Self-Polishing Copolymers

SPC technology antifoulings work because the film contains an acrylic copolymer that reacts with saltwater and this only occurs at the surface. As a result, this chemical reaction controls and sustains the release of biocides, not diffusion. Because this reaction is chemical rather than physical it takes place at the same rate whether the boat is underway or sitting at the dock, throughout the lifetime of the antifouling, without decline. This technology is what made the tin-based (TBT) copolymer coatings last as long as they did, but since the demise of tin-based coatings the only coating in the yacht marketplace that uses an acrylic SPC copolymer is Micron 66.

Why does the biocide release remain constant for SPC antifoulings?

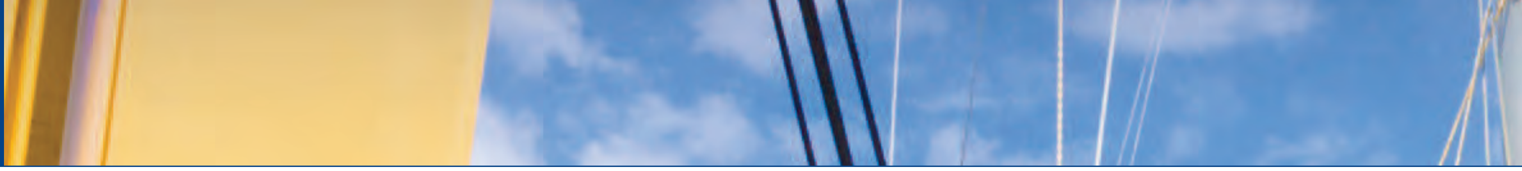
- Salt water cannot penetrate the SPC film because it is hydrophobic (very water resistant)
- The chemical reaction between SPC copolymer & salt water occurs at surface only



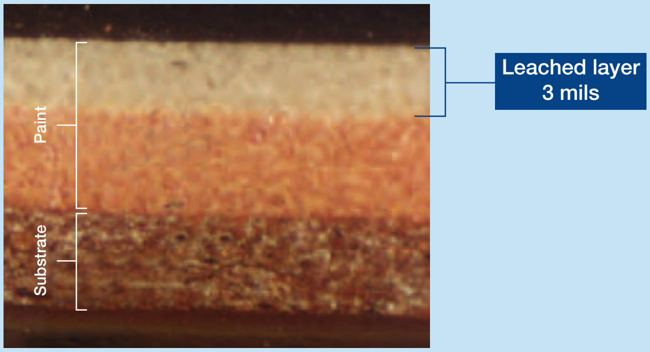
As the chemical reaction takes place at the surface it releases the biocide from the paint film and no leach layer is formed.

Dual Resin Technology

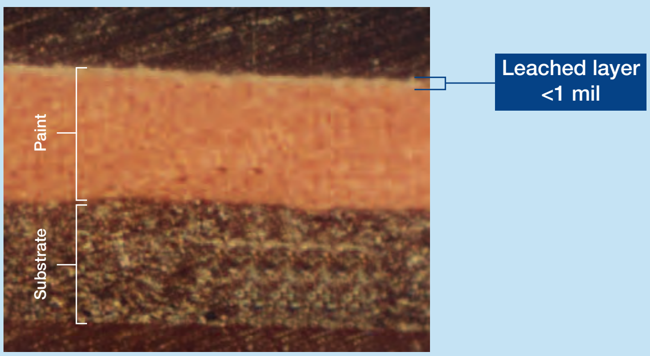
This resin system delivers the benefits of both hard and ablative antifouling paints for use on all boats. It has the durability of a traditional hard paint but has a slow polishing mechanism built-in that continuously smoothes and renews the active surface avoiding the heavy build-up of paint layers much like an ablative paint.



Part 3



Traditional hard antifouling
Cross-section



Micron® 66 SPC antifouling
Cross-section

Antifouling paints must be registered with the Federal EPA as well as each State where it is intended it to be sold. In the U.S antifouling paints must contain a biocide that is registered with the Federal EPA. All of the ingredients used in an antifouling paint must either be a biocide or on the E.P.A.'s list of inert ingredients. Paints that do not contain a biocide cannot be registered as antifouling paints so always look for the EPA registration number.

It takes approximately five years to fully research an antifouling before its launch into the market. Much of this time is spent testing the product outside the laboratory, in the actual environment in which boats are used.

Interlux® prides itself in utilizing innovative products that meet or exceed technical and environmental requirements.

Significant work has been carried out to determine the optimum levels of biocides required in our antifouling paints in order to achieve the industry-leading performance that our customers expect. This work ensures that formulations are properly engineered, rather than over engineered, and that the environmental impact is minimized. At the same time, Interlux is actively funding work developing efficient new biocide delivery systems to ensure that the 'right' amount of biocide is released into the environment when it is needed. Together, these two activities will ensure that we continue to offer our customers the most effective antifoulings with the least environmental impact.

What goes into an antifouling paint?

An antifouling paint is a combination of four basic ingredients:

Resin: Holds the product together and forms the coating film and controls the release of the copper or other biocide. This dictates the type of antifouling performance achieved.

Pigment: Provides the color and thickness of the antifouling.

Solvent: Dictates the application on characteristics, flow and drying speed.

Biocides: the active compounds that repel fouling. The most common types are copper compounds such as cuprous oxide or metallic copper.

Biocides

Cuprous Oxide

Cuprous oxide and metallic coppers have been in common use for 100 years or more and they still are the basic biocides used in many antifouling paint formulations. Cuprous oxide works in an antifouling paint by discouraging the attachment of the larval forms of shell fouling such as barnacles and mussels. It is also an excellent antimicrobial and will work against slime and grass growth but requires a much higher release rate to control this type of fouling. The best antifoulings also contain a boosting biocide combined with the cuprous oxide to help control weed fouling. Cuprous oxide is available in many colors ranging from dark red to dark purple. This limits the color selection of antifouling paints to the darkest shades.

Cuprous Thiocyanate or Copper Thiocyanate

While not a powerful as cuprous oxide, cuprous thiocyanate is a copper compound that works in the same manner as cuprous oxide, by discouraging the attachment of the larval forms of shell fouling. The copper content of cuprous thiocyanate is considerably less than in cuprous oxide which enables it to be used in antifouling paints for aluminum. Cuprous thiocyanate is a white powder which means it is possible to make antifouling paints with bright, crisp colors, including

white. Boosting biocides are commonly used with cuprous thiocyanate in order to boost performance.

Irgarol®

Irgarol® 1051 is an organic algaecide specifically designed for use in marine antifouling coatings. It is a highly specific and effective inhibitor of photosynthesis which can control fouling of marine surfaces caused by algae. Its very low water solubility contributes to very slow leaching rates and therefore extended antifouling action. On the label of an antifouling paint look for this name N-CYCLOPROPYL-N'-(1,1-DIMETHYLETHYL)-6-(METHYLTHIO)-1,3,5-TRIAZINE-2,4-DIAMINE

Zinc Pyrithione or ZPT and Zinc Omadine®

As stated previously cuprous oxide is very effective biocide against shell fouling and to improve the spectrum of fouling control a boosting biocide that is effective against soft fouling organisms is used. Zinc Omadine® has the necessary broad spectrum of activity against algae, bacteria slime, fungi and diatoms and does not persist in the environment. These biocides help keep the surface clean of slime and grass and help the cuprous oxide be more effective.

On the label of an antifouling paint look for this name ZINC 2-PYRIDINETHIOL 1-OXIDE

Econea™

Econea™, an organic metal-free antifouling agent, protects boat hulls without accumulating in the marine environment. Econea™ is most effective against shell fouling but it is compatible with most major booster biocides that help control weed fouling. Econea™ degrades rapidly after it has left the coating and is the water column.

Once in the aquatic environment, Econea™ has extremely low impact as it hydrolyses rapidly when in solution to form very low toxicity breakdown products that are biodegradable.

On the label of an antifouling paint look for this name 1 H-PYRROLE-3-CARBONITRILE, 4-BROMO-2-(4-CHLOROPHENYL)¼-5-(TRIFLUOROMETHYL)¼

The Antifouling Paint Label

On the label you will find the following information which gives you some information about the paint:

ACTIVE INGREDIENTS:	PERCENT
CUPROUS OXIDE	38.62%
N-CYCLOPROPYL-N'-(1,1-DIMETHYLETHYL)-6-(METHYLTHIO)-1,3,5-TRIAZINE-2,4-DIAMINE	2.00%
INERT INGREDIENTS	59.38%
	100.00%

This particular paint has 38.62% Cuprous Oxide by weight and 2.00% by weight of a co-biocide. The biocides are always listed by their chemical names so you see N-CYCLOPROPYL-N'-(1,1-DIMETHYLETHYL)-6-(METHYLTHIO)-1,3,5-TRIAZINE-2,4-DIAMINE not Irgarol® as Irgarol is a trade name owned by Ciba-Geigy. The rest of the ingredients are listed as inert. For an antifouling paint to gain registration with the EPA all ingredients must be either registered biocides or listed with EPA as an inert ingredient.

What do the numbers mean?

One of the biggest misconceptions people have about antifouling paints is that the numbers in the Active Ingredient Statement on the antifouling paint label are the volume of biocide in the paint. They do not refer to the volume of biocide in the can but they refer to the percentage of the weight per gallon. In other words if the label refers to 40% cuprous oxide that means that 40% of the weight of the gallon is cuprous oxide and that the other 60% of the weight is solvent, resin and pigment. So if the weight per gallon is 15 pounds and the percentage of cuprous oxide is 40% there are 6 pounds of cuprous oxide in the gallon can.

Does the Amount of Biocide in an Antifouling Paint affect the Performance?

The level of biocide is not the only determining factor of how an antifouling paint will perform. The resin system, the material that holds the paint together, is equally important since it is the mechanism that determines how fast the biocides will be released. The resin system must be carefully tailored for the amount and type of copper and other biocides used to obtain maximum efficiency. The amount of copper or other biocide may affect the life of an antifouling paint but the sophistication of the resin system to hold and release copper or other biocide at the proper rate is far more important to the effectiveness of the antifouling. A copolymer or ablative antifouling will release biocide at nearly constant rate throughout its life. For this reason, highly efficient antifouling paints like Micron are less dependent on large amounts of copper and other biocides and deliver the best possible performance.

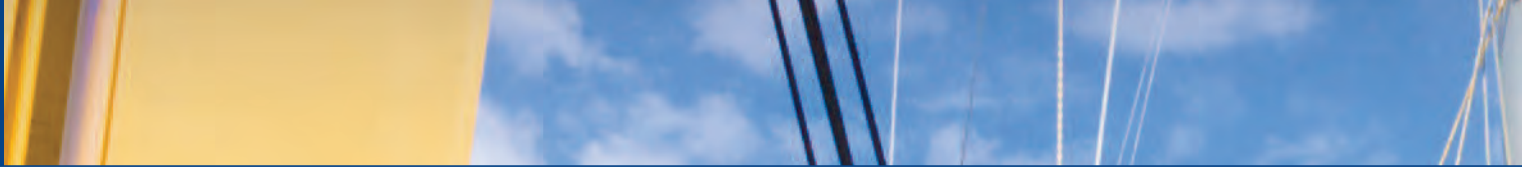
The use of boosting biocides in combination with Biolux® Technology keeps the bottom clear of slime and makes the copper more effective.

Remember: The most important number when talking about antifouling paints is the number of barnacles on the hull at the end of the season.

Use of Natural Products as Antifouling Agents

You may have read recently about the alleged benefits of 'natural' ingredients in yacht antifouling paints.

The term 'natural' is frequently used to denote or indicate that the identified material is safer for both the environment and end-users. The use of that term for active ingredients used for fouling deterrence is no different. The inference is that as the product is derived from a natural source (typical examples include seaweed extracts, tea tree oil, capsaicin extracts) then it must also be safe for the environment.



In terms of a material being 'environmentally friendly' it needs to be considered as a whole process, i.e. examine all of the aspects of the material, how it is obtained, how it is used and what happens to the material when it is released into the environment. As part of this, the methods used to extract the natural products from their source need to be considered. The most common source of natural products are plants; leaves, bark, flowers are all used.

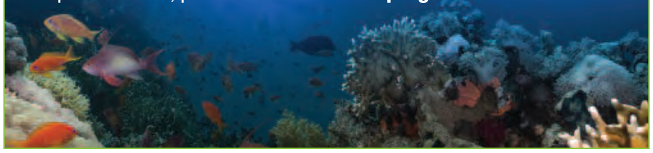
The process to extract material from a plant is usually two or three steps; often involving mechanical crushing (for example olives are crushed in order to obtain the oil), distillation (usually steam distillation) and purification. Each step uses energy and generates by-products that require disposal. Extracting materials uses resources in the same manner as do pure synthetic manufacturing techniques. Quite often the final stage of extraction of natural products is a further synthetic step in order to modify the product slightly in order to give the desired properties.

In the case of fouling deterrence, the term 'natural' is often used to imply that the ingredient will not require any formal registration to allow its use as an active ingredient in a formulation. This is not the case as any ingredient in any formulation (whether antifouling paint for boats, anti-fungal paints for masonry or wood preservatives) that exhibits an activity towards a fouling species must be registered as a biocide under many countries' regulations (e.g., the Environmental Protection Agency in the USA and the Biocidal Products Directive in the EU member states). Approval through these legislative systems involves assessments of human and environmental exposure risks. Compounds that exhibit rapid degradation to non-active species in the environment are more favorably considered than those that do not.

Yacht paint companies routinely test compounds for antifouling properties, both compounds derived from natural sources and synthetic compounds. Combining them with technical expertise on delivery mechanisms, yacht paint companies aim to develop and test materials that have good antifouling efficacy at low levels and which degrade rapidly in the environment so that they do not persist and cause long-term environmental issues.

It is the combination of properties of a material that makes it worthwhile developing an antifouling product from it. Firstly it needs to be efficacious and deter the settlement of fouling organisms and secondly, it must degrade rapidly into non-active materials so that it does not persist in the environment. Unfortunately, neither of these properties is guaranteed just because a material is from a natural source.

If you are interested to read more about our environmental ratings and performance, please visit **www.echoprogram.com**



Part 4

Non-Biocidal Coatings

The control of surface roughness and of fouling is essential to keep hulls as smooth as possible, and to help minimize drag. Controlling fouling using an antifouling paint containing biocides is the most common way of keeping hulls as efficient as possible, but there are coatings that can do this without the use of biocides and here at Interlux® we refer to these paints as 'Foul Release' coatings, with the brand name 'Intersleek'.

Foul Release coatings do not contain active biocides and cannot actively repel the attachment of fouling organisms. The purpose is to create a surface which proves to be extremely difficult for growth to attach. Once fouling has begun, the adhesion is weak and the sooner that it can be removed the easier it will be to remove. These coatings will work best on boats that are used regularly or are cleaned by a diver on a regular basis.

Foul Release Coatings: The History

- In 1999 the revolutionary Intersleek® 700 was introduced, for deep sea scheduled ships with speeds in excess of 15 knots.
- These silicone based technologies work by providing a very smooth, slippery, low friction surface onto which fouling organisms have difficulty attaching. Any which do attach, normally do so only weakly and can usually be easily removed.
- With proven average fuel savings of 4% and a corresponding reduction in emissions, Intersleek® 700 has become firmly established as the commercial industry benchmark in Foul Release technology.
- After customers became used to the level of performance from Intersleek® 700 they began to ask for improvements. Intersleek® 700 took silicone technology as far as it could go and the characteristics on the 'wish list' were not possible using Silicone foul-release technology. So the Chemists at Interlux began to look into fluoropolymer chemistry, and came up with Intersleek® 900.
- The fluoropolymer chemistry used in Intersleek® 900 represents the very latest advances in foul release technology, significantly improving upon the performance of silicone based systems. Including the following:

  25% smoother
  38% better coefficient of friction
  80% better static fouling resistance
  40% better foul release properties
  50% reduction in slime
  100% better hold-up
  35% higher gloss
  60% reduction in overspray
  60% better abrasion resistance

Intersleek 900: The Technology

Intersleek 900 has been formulated to make it very difficult for fouling organisms to adhere to the coated surface. The surface energy has been engineered in such a way that a very unattractive surface is presented to the fouling organism.

Average Hull Roughness (AHR)

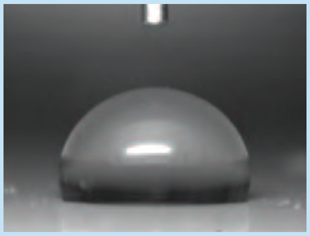
Average Hull Roughness (AHR) is of critical importance. Vessels' hulls need to be as smooth as possible for maximum efficiency. As hull roughness increases, more power is required to push the vessel through the water – more power means more fuel – more fuel means more money and more emissions. Those vessels which are unable to increase power to compensate for increased roughness will lose speed resulting in slower transit times or late arrivals.

Surface energy

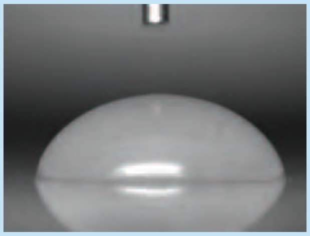
Surface energy quantifies the disruption of chemical bonds that occur when a surface is created. It is the interaction between the forces of cohesion and the forces of adhesion which determines whether or not wetting occurs i.e. the spreading of a liquid over a surface. If complete wetting does not occur, then a bead of liquid will form with a high contact angle that is a function of the relative surface energies of the system. If the surface is more hydrophobic then the contact angle of a drop of water will be larger. If the surface is more hydrophilic then the contact angle will be smaller.

Polar and dispersive forces

By measuring the contact angle with two liquids, one polar liquid (such as water) and one apolar liquid (such as methylene iodide), the surface energy can be divided into two components, dispersive and polar. This gives a measure of how many polar and dispersive (non-polar) groups there are at the surface. The introduction of polar groups into an otherwise non-polar surface will produce a surface that is amphiphilic i.e. the surface combines both hydrophilic and hydrophobic properties. Intersleek 900 provides such an amphiphilic surface. It has been established that marine fouling organisms secrete an adhesive, either of a hydrophobic or hydrophilic nature depending on the fouling species. By having a balanced amphiphilic surface we can minimize the chemical and electrostatic adhesion between the surface and a wide range of fouling organisms.



Hydrophobic:
Water on Silicone



Amphiphilic:
Water on Intersleek 900

Surface energy: Foul release

To fully understand how fouling adheres to submerged surfaces and what force is required to remove them, at International Paint we grow our own barnacles and have developed a sophisticated computer controlled system to apply force to the barnacle (cleverly named the Barnacle Push Off Apparatus) and record the force required to effect removal. It takes 40% less shear force to remove barnacles from Intersleek 900 when compared to other silicone systems. Foul Release properties are particularly important for pleasure craft that spend long periods at the dock. The excellent Foul Release properties of Intersleek 900 means that even during long periods of inactivity, fouling attachment can be either removed when the vessel gets under way, or if underwater cleaning is the option selected then less force is required to remove the fouling growth so less damage will result. Slime build-up can occur on all foul release coatings but Intersleek 900 technology combines advanced surface energy characteristics and an ultra smooth surface to reduce slime build-up by 50% over previous silicone Foul Release systems.

Fouling: What to Expect

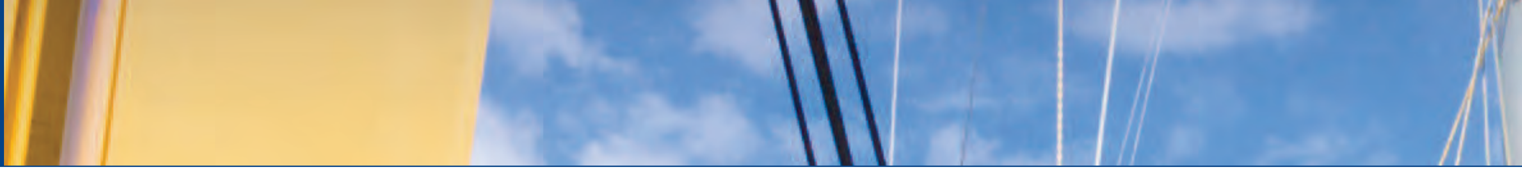
Foul release coatings do not contain active biocides and cannot actively repel the attachment of fouling organisms. The purpose of the Intersleek 900 System is to create a 'low surface energy' which proves extremely difficult for growth to attach. When fouling begins, the adhesion is weak and the longer it remains on the surface the harder it will be to remove. For example, a barnacle that has begun to grow on the Intersleek 900 surface and is less than the size of a pencil eraser can easily be removed. The smooth, 'low surface energy' coating of Intersleek 900 surfaces provides a weak platform for growth to permanently adhere. The more the boat is used the cleaner it will stay with minimal underwater cleaning. With power boats, higher running speeds will also contribute to the self-cleaning properties of the coating.

Inspection and cleaning

As there is no active biocide in the Intersleek 900 System, its ability to protect the boat from fouling is dependent upon how frequently the boat is used, how fast the boat goes, the severity of the fouling conditions in the docking area and the amount of frequency of underwater cleaning. Both the method of underwater cleaning and its frequency will greatly influence the long term success of the performance of the Intersleek 900 system.

Other Non-Biocidal Bottom Coatings

There are other coating that are used on the bottoms of boats that do not contain biocides but are not designed to be 'Foul Release' coatings such as the Intersleek. One such coating is VC® Performance Epoxy. VC Performance Epoxy is an extremely hard two-component epoxy that contains a flouro microadditive.



Originally developed to be applied to high performance powerboats and racing sailboats, and then wet sanded and burnished for a super smooth finish, it has proven to be ideal for any boat that does not require antifouling protection, such as trailered or rack stored boats or boats that are permanently moored in the water. The hard durable finish holds up to frequent cleanings.

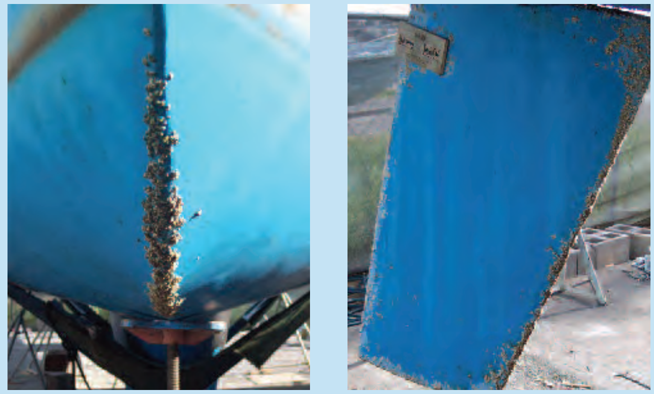
What does a flouro microadditive do?

- It helps to reduce drag by delivering a slick film
- It makes it easier to wet sand
- It makes VC Performance Epoxy easier to clean and better able to resist staining
- It increases the abrasion resistance

Part 5

Common Antifouling Problems

Barnacles growing over a layer of slime:
The slime has prevented the biocide from releasing out of the paint film and has allowed the barnacles to grow on the slime.



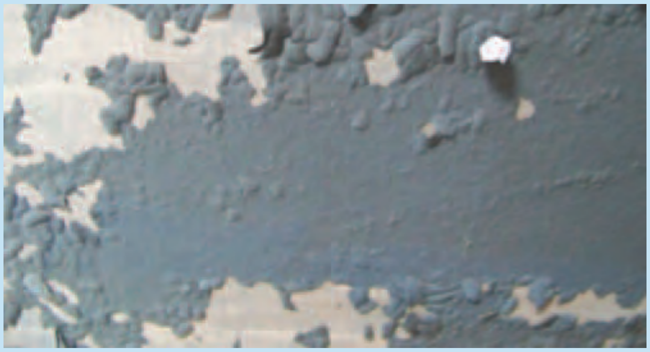
Fouling on Leading Edges:

- When using any type of ablative paint always put an extra coat of paint on the leading and trailing edges.
- When using a roller the tendency is to push too hard on the surface of edges like this so these areas should be done with a brush rather than a roller.

Fouling:
Strut was not properly primed and electrolysis developed between the bronze in the strut and the copper in the antifouling paint.

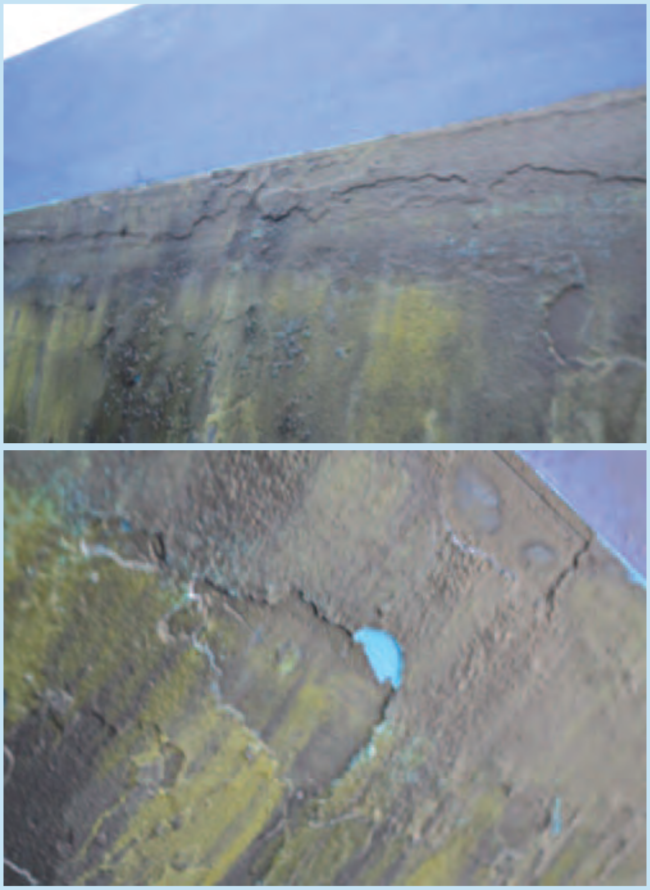
Antifouling paint cracking over the primer:
This is caused by applying the antifouling paint to the primer before the primer has cured.

Burnback:
This is caused by improperly priming the underwater metal. The copper biocide is eroded away due to electrolysis and no antifouling protection is left. This will continue on the fiberglass in concentric circles away from the metal. While this most commonly happens with paints that have an acrylic resin it can happen with any antifouling paint.

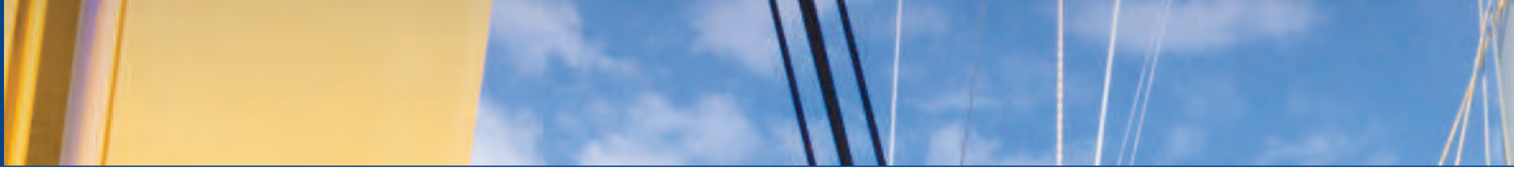


Detachment:
The time window was missed between the no-sand primer and the antifouling paint.

Detachment:
Antifouling peeling from improperly primed aluminum.



Detachment:
Improperly prepared surface resulting in excessive paint build-up, and a very rough surface.



Part 6

Glossary of terms/technology explained

A

Ablative

To ablate means to 'wear away' or 'erode', and there are many antifouling paints that work by wearing away, but there are several different ways that the paints wear away.

Average Hull Roughness

The mean value of all hull roughness measurements on the underwater hull.

C

Controlled Depletion Polymers (CDP) or Controlled Solubility Copolymers

Controlled Depletion Polymer antifouling are formulated with high Rosin content enabling polishing to occur. These types of antifoulings are partially soluble which means that as water passes across the surface of the coating it wears the surface away, much like a bar of soap would wear away. The physical action of the water over the surface steadily reduces the thickness of the paint, which results in always having fresh biocide at the surface throughout the season. For this reason these types of antifoulings have the capability to perform well in the areas of highest fouling challenge, and the longevity is directly related to the thickness of the paint applied.

Sometimes Controlled Solubility Copolymers, or Controlled Depletion Polymers, are called 'self-polishing' because the action of the boat physically moving through the water wears away the leach layer, and so exposes fresh biocide. But true Self-Polishing Copolymer (SPC) antifoulings are superior since their biocide release is controlled by an initial chemical reaction at the surface, prior to then physically wearing away.

D

Dual Resin Technology

This resin system delivers the benefits of both hard and ablative antifouling paints for use on all boats. It has the durability of a traditional hard paint but has a slow polishing mechanism built-in that continuously smoothes and renews the active surface avoiding the heavy build-up of paint layers much like an ablative paint.

H

Hybrid SPC

An antifouling with both SPC and CDP features.

L

Leached Layer

A biocide depleted 'spent' layer at the surface of the coating. In SPC antifoulings the leached layer is always thin, <15µm (0.6 mils), providing a smooth surface, conversely, CDP leached layers can become very thick, >75µm (3 mils), resulting in increased surface roughness plus removal and overcoating difficulties.

Leaching Rate

The release of biocide per unit time. There are three technologies or delivery mechanisms available to control biocide release – SPC, CDP and a combination of the two, known as Hybrid SPC.

M

Modal hull roughness

The most commonly occurring hull roughness measurement on the underwater hull.

P

Polishing

Polishing is the overall reduction of film thickness. Polishing is a bulk film effect and can occur without smoothing (but not vice versa).

Polishing Rate

Film thickness reduction per unit time. For SPC antifoulings, polishing rate is directly proportional to vessel speed.

R

Rosin

Naturally occurring resin extracted from trees. Rosin is soluble in seawater.

S

Self Polishing

The paint polymer or binder system is soluble in sea water. Solubility can be achieved either by a chemical reaction e.g. Hydrolysis, as in SPC technology or by the use of Rosin e.g. in CDP technology.

Self Polishing Copolymer (SPC)

The paint polymer or binder system is made soluble in seawater by 'Hydrolysis'. This is a controlled chemical reaction and only occurs at the surface of the coating. SPC technology combines controlled polishing rate and optimum biocide release with inherent self smoothing for hull roughness control and maximum fuel efficiency. Leached layers are always thin, <15µm (0.6 mils.) providing a smooth surface.

Smoothing or Self Smoothing

A reduction in surface roughness of Self Polishing Copolymer antifoulings resulting from the removal of 'surface peaks'. The smoothing benefit from the use of SPC antifoulings should not be confused with a general reduction in hull roughness from abrasive blast cleaning or hydroblasting.

Haul & Relaunch versus Multi-Seasonal

These terms mean different things to different people and it depends on where those people keep their boat. Multi-seasonal to a boatowner in the New Jersey may mean that the boat can be hauled in the fall as one boating season ends and then relaunched the next spring without repainting as the antifouling paint will still be effective. To a boatowner in Florida the term multi-seasonal means that the paint will be effective in the water for 15-18 months or more.

Hard Antifoulings

Antifoulings with low Rosin content are referred to as Hard or Contact Leaching antifoulings and do not polish.

Hard paints may be multi-seasonal as they can last for long periods of time in the water but they cannot be hauled for long periods of time and relaunched without repainting.

Hard antifoulings from Interlux® include:

 **Ultra®**	 **Fiberglass Bottomkote®**
 **Trilux® 33®**	 **Fiberglass Bottomkote® Aqua**
 **VC® Offshore**	**Epoxycop® and Baltoplate®**

Storage and launching Instructions for boats painted with hard antifoulings

Hard or contact leaching antifouling paint dries to a hard but porous film that is packed with biocide. The biocide begins to leach out on contact with water to prevent fouling growth. This leaching is chemically designed to release biocide while the boat is in the water. Out of the water the paint film will oxidize and slow the release of the biocides to the point where there may not be enough biocide coming out of the paint film to maintain fouling protection. One of the main benefits of this type of antifouling is its resistance to abrasion and rubbing. This makes it ideal for fast powerboats, racing sailboats or boats where the owners have the bottoms scrubbed regularly.

- Initial maximum time before launch – follow label instructions
- Boats that have been painted and are past the maximum time before launch on the label but no more than 12 months past their launch date – scuff sand with 220 grit sandpaper or a maroon Scotch-Brite™ pad prior to launch.
- Boats painted more than 12 months prior to being launched – sand with 80 - 100 grit sandpaper and recoat prior to launch
- Boats that have been launched but are in the water for less than 24 hours – lightly pressure wash to remove surface contamination (salt and dirt etc.). Follow label instructions for maximum launch time from date of painting.
- Boats that have been in the water for more than 24 hours but less than 30 days – pressure wash immediately after hauling. No additional work is needed if the boat is relaunched with 72 hours. If the boat will be out of the water for more than 72 hours will need to be sanded with 220 grit sandpaper immediately prior to relaunching.
- Boats that have been in the water for more than 30 days – pressure wash when hauled, sand with 80 or 100 grit sandpaper and recoat. Recoating is necessary even if the boat will be out of the water for less than 72 hours.

Antifouling 101 Edited by Jim Seidel (January 2012)

Our World is Water

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