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ABOUT ANTIFOULING SOLUTIONS TO PROTECT SHIP'S HULL

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ABSTRACT

Antifouling solutions are essential for protecting ship hulls from marine organisms like algae, barnacles, and molluscs, which can slow down the ship and increase fuel consumption. They are crucial for maintaining a ship's efficiency and longevity by protecting the hull from marine growth, which can slow the vessel and increase fuel consumption. Modern antifouling methods, such as specialized paints, copper-based coatings, self-polishing surfaces, silicone coatings, ultrasonic systems, and electrolytic solutions, offer effective ways to combat biofouling. These solutions not only improve operational performance but also contribute to environmental sustainability by reducing the need for frequent cleaning and minimizing the release of harmful biocides into the water. The ongoing development of innovative antifouling technologies will continue to enhance the protection and efficiency of maritime vessels.

Keywords: antifouling, paints, biocides, efficiency, environmental sustainability

1. INTRODUCTION

The hull of a ship is continuously subjected to marine environments, leading to the potential attachment of marine organisms. These algae and shells can impair the ship's speed and handling, and may also cause long-term damage to the hull. Hull protection is a crucial element for the longevity of the ship, as well as maintaining its performance, reducing maintenance costs, and also using less fuel. There are several solutions for protecting it:

- traditional antifouling paints,
- copper-based antifouling paints,
- hull varnishes,
- smooth non-stick coatings,
- fiber-reinforced non-stick coatings,
- ultrasonic antifouling systems, and
- hull protection covers.

2. SEVEN ANTIFOULING SOLUTIONS

Each of these solutions provides a distinct method for hull protection, so we will examine the advantages and disadvantages of each.

2.1. CLASSIC BIOCIDE-BASED ANTIFOULING PAINTS

Antifouling paint, a long-standing solution for preventing the growth of algae, shellfish, and other crustaceans, has been used for decades. It contains a biocide and an anti-adherent to deter marine organisms from attaching to the hull. These paints are available in hard or erodible matrices, chosen based on factors like the boat's speed, anchorage location, and navigation area.

The widespread use of antifouling paint is due to its numerous and notable benefits. It effectively prevents and eliminates barnacles and other marine organisms from attaching to the hull, thereby simplifying maintenance. This, in turn, helps preserve the ship's performance by reducing drag. Regular application of new coats ensures the ship remains efficient and durable over time.

Despite its advantages, antifouling paint is a biocide chemical product, making it highly polluting to the aquatic environment. Beyond its harmful impact on marine biodiversity, it poses health risks during application, particularly when stripping or sanding. Regulatory constraints now govern its use; for instance, cleaning the boat hull by diving is prohibited due to environmental toxicity. Additionally, the lifespan of antifouling paint is limited to 1 to 2 years at most. In waters with high algae growth, the hull may need treatment twice a year, necessitating frequent and costly removal from the water.

The most widely known brands of antifouling paint include Seatec, International, Hempel, Boero, Altex, Epifanes, Nautix, Pettit, Tikal, Yachticon, Jotun, Veneziani and Yachtcar (this list is not exhaustive).

2.2. COPPER-BASED PAINTS

Copper paints incorporate copper particles, a material known for preventing biofouling or the growth of marine organisms on a ship's hull. Historically, wooden hulls of traditional ships were clad in copper plates to deter shipworms and prevent the wood from rotting.

One of the primary advantages of copper antifouling paints is their long-lasting effectiveness. Unlike traditional biocidal paints that need yearly reapplication, copper paints can remain effective for several years, even up to a decade, significantly lowering maintenance costs and efforts. Additionally, copper antifouling paints are relatively more environmentally friendly compared to biocidal paints, as copper particles degrade more readily and are considered less harmful to the environment.

The primary drawback of using copper antifouling paint is its cost, which is substantially higher than traditional antifouling paints, representing a substantial investment. Additionally, copper is unsuitable for aluminium hulls due to the corrosion it causes. Even on other types of ships, it can lead to minor corrosion on metal propellers and rudders, as well as unprotected wooden hulls. Therefore, it is crucial to monitor the wear of anodes closely if you opt for copper paint. Lastly, copper remains harmful to the environment; in the Baltic Sea, 40% of copper pollution is attributed to hull paints.

Within this context, Coppercoat stands out as a popular choice among ship owners. This brand of copper antifouling paint consists of "pure copper particles suspended in an epoxy resin".

2.3. VARNISHES FOR HULL PROTECTION

Hull protection varnish is a less frequently used alternative to traditional antifouling paints. It shields ship hulls from both algae and shell fouling, as well as corrosion. Composed of water-resistant polymers, this varnish creates a protective barrier on the hull against marine organisms.

In contrast to the previous options, varnish does not contain environmentally harmful chemicals or metals like copper, resulting in a more eco-friendly choice.

It's essential to highlight that varnish offers reduced effectiveness than antifouling paints in mitigating hull fouling. As a result, varnished hulls require regular maintenance, including routine cleaning and reapplication of varnish to maintain their effectiveness.

The hull is cleaned with fresh water and a mild detergent, avoiding abrasive or acid-based cleaners that could harm the varnish. Using a soft brush is recommended to prevent scratching the varnish's surface. Power tools like polishers or pressure washers should be avoided, due to the potential damage they can cause to the varnish. Regularly monitoring the hull for any signs of damage or deterioration is essential.

One notable provider of varnishes is Eco'Prisme, known for its graphene-based product, Parafouling.

2.4. SMOOTH ANTI-ADHESIVE COATING

Smooth films offer a substitute for antifouling paint to safeguard ship hulls. This method involves applying a silicone adhesive film to the hull's surface, creating a non-adhesive barrier that prevents marine organisms from attaching.

The primary benefit of this solution is its lack of toxic substances, making it environmentally friendly. Additionally, it conserves water and energy during dry-dock maintenance. It also has a longer lifespan than traditional antifouling paint, saving money on hull protection. The non-stick coating only needs renewal every five years, unlike traditional antifouling, which typically requires annual reapplication. Unlike biocidal antifouling paints, cleaning by diving is permitted and can be accomplished with simple brushing.

However, this solution has its downsides. Firstly, the adhesive film costs more compared to traditional antifouling paint, which can be a barrier for some boat owners. Additionally, proper installation can be challenging and requires specific expertise. Removing the film generates plastic waste, contributing to environmental concerns. Finally, its effectiveness may be constrained in regions with a dense population of marine organisms, necessitating more frequent monitoring of the hull's condition.

On the market, notable solutions include Flow Silikon by Uniflow and MacGlide by Mactac.

2.5. FIBER-REINFORCED FILMS

These films offer another environmentally-friendly coating alternative, distinct from other non-stick coatings in their superior performance in regions with a dense population of marine organisms. The secret lies in their unique technology, which mimics the spines of sea urchins, giving them a carpet-like appearance. They are anti-fouling, durable, and high-performing. According to the manufacturer, their design protects ship hulls from harmful marine organisms while boosting overall performance.

One of the significant advantages of this type of adhesive is its positive ecological impact, as it does not contain toxic substances detrimental to the marine ecosystem. They offer exceptional durability and UV resistance, allowing them to outlast traditional paints. These adhesives can be easily cleaned by diving or using a high-pressure wash. Additionally, some ports are beginning to permit the use of fairing chocks for boats equipped with these adhesives, offering a cost-saving benefit.

Despite their benefits, these adhesives have some drawbacks. They are initially more expensive than traditional paints, although they can offer savings in the long run. Their application requires professional expertise, and the drying time can be extended. Additionally, our research indicates that color options are limited and removal can be challenging if needed.

One of the top products available on the market is the Finsulate range.

2.6. ULTRASONIC TECHNOLOGY

Ultrasonic antifouling represents a sonar technology that employs sound waves to control and monitor the proliferation of marine organisms on ship hulls.

This technology is eco-friendly, nontoxic to marine environments, cost-effective in the long run, simple to install, and suited to the majority of hull types, except for those that extend to great depths.

However, this method may be less effective for non-moving boats, necessitates electrical power to operate, and involves a higher initial investment compared to traditional antifouling. Its performance might be limited in certain geographic areas or under specific weather conditions. Additionally, it requires regular maintenance and might not deliver optimal results for ships with deep drafts as traditional antifouling solutions.

Furthermore, living on board or mooring your ship in a marina with populated vessels can lead to noise pollution, whether audible or not. Additionally, considering the significance of ultrasound for many marine species, this solution might be less environmentally friendly than it appears.

This technology has been discussed for decades, but today it is commercially available, particularly from companies like Sonihull and Hasytec.

2.7. PROTECTIVE SHIELDS

The final solution in our comparison shields the ship's hull from dirt by inhibiting the growth of microorganisms due to the lack of light.

One of the primary advantages of this solution is its cost-effectiveness. It eliminates the expenses associated with annual careening, which can be substantial for ship owners. Additionally, the cover is fully recyclable and eliminates the need for toxic antifouling that harms the marine ecosystem, thereby reducing the ship's ecological footprint.

The cover is fairly easy to use and transport, with a lifespan of around ten years, making it more practical and cost-effective than the annual task of reapplying antifouling.

Despite these advantages, it's important to note that some hull shapes may be better suited for this solution than others. Although covers have been designed for various types of pleasure boats, they need to be custom-made, which can make them more expensive than other hull protection options.

Moreover, while the hull remains clean, the exterior of the cover is prone to fouling, which raises the issue of cleaning it. Additionally, the cover needs to be handled each time the boat departs from or arrives at port to ensure proper protection when the boat is docked.

Innovative protective covers can be found at K-Ren or ProtecMarineNC, for instance.

3. ANTIFOULING PAINTS AND THEIR ENVIRONMENTAL IMPACT

Advancements in hull coatings allow ships to enhance fuel efficiency, lower air and underwater noise emissions, and curb the spread of invasive species.

Each day, thousands of merchant ships traverse the globe, facilitating the movement of goods and ensuring access to essential items. With lifespans averaging 20 to 25 years, these commercial vessels spend extensive time at sea, covering tens of thousands of nautical miles and passing through numerous marine ecosystems.

Without special coatings, tiny marine creatures can gather on the hull, increasing the ship's resistance in the water. This results in higher fuel consumption, increased air emissions, and elevated underwater noise levels. Additionally, the submerged areas of ships facilitate the dissemination and proliferation of aquatic invasive species, including barnacles, zebra mussels, and tunicates.

Prior to exploring the benefits, environmental impacts, technological advancements, and regulations of hull coatings, it's important to understand why they are necessary in the first place.

3.1. BIOFOULING AND ITS IMPACT ON SHIPPING AND THE MARINE ENVIRONMENT

Have you observed algae or crustaceans accumulating on the underwater parts of waterfront structures, like dock pillars? If so, you've observed biofouling. Also known as marine fouling, this process involves marine species and organisms settling and accumulating within numerous hidden crevices of underwater structures. When biofouling develops on hulls, propellers, water inlets, and various ship components that come into contact with water, marine species can migrate from their original ecosystem to a different one. These species are then considered invasive because they disrupt the balance of the new ecosystem, potentially threatening the viability of indigenous species.

Fig.1. Mussels and barnacles are among the numerous species that can attach to ship hulls and accumulate over time. This buildup reduces transit efficiency by increasing resistance in the water and can potentially lead to these species becoming invasive in different ecosystems.

In addition to spreading invasive species, biofouling negatively impacts fuel efficiency and the overall environmental footprint of ships. The accumulation of marine organisms on submerged surfaces increases resistance, requiring more fuel for movement. Just as a car's streamlined design enhances road efficiency, a streamlined hull enables ships to travel more smoothly through water.

When aquatic species adhere to the ships, they create a rough texture on the hull, which creates friction and resistance in the water. This resistance leads to higher fuel consumption and increased emissions of atmospheric contaminants and greenhouse gases during voyages. Biofouling, such as the build-up of crustacean species such as barnacles, is capable of amplifying a vessel's water resistance with 20 up to 60%, reducing its speed and raising its fuel consumption by 40%.

Higher fuel consumption is not only detrimental to the environment but also raises operational costs for vessel operators, ultimately impacting consumers who depend on shipping for access to goods and merchandise. Furthermore, the friction caused by fouling on hulls and propellers can affect the underwater noise levels emitted by vessels, disrupting the frequencies used by marine mammals like whales for communication, feeding, reproduction, and hazard avoidance, thus threatening their survival.

Fig.2. Cleaning the hull underwater (Source: Marine Tankers).

Can biofouling be prevented just by scraping marine organisms off ship surfaces through hull cleaning? While hull cleaning contributes to the solution, it is costly, time-consuming, and needs to be repeated. Additionally, if not done correctly, hull cleaning can expedite the spread of invasive species. That's where antifouling paints play a crucial role.

3.2. ANTIFOULING PAINTS AND THEIR ROLE IN PREVENTING BIOFOULING

One of the most crucial and effective methods to combat the environmental and economic impacts of biofouling on ships is the use of antifouling coatings. These specialized paints are applied to the hull to prevent marine organisms—such as barnacles, zebra mussels, and algae—from adhering to the submerged surfaces. Antifouling paints are vital in preventing the spread of invasive species by ships, guaranteeing that commercial ships can sail without unwanted drag, thereby enhancing their fluidity in the water and improving the overall efficiency and the long-term viability of their voyages.

Hull coatings have a long history. For centuries, sailors and navigators have sought to stop marine organisms from thriving on ships using various coatings, including copper sheeting affixed to the hulls. Copper, favored for its harmful effects on aquatic life, was the preferred solution to combat biofouling in the early days of shipping. However, with the transition from wood to iron in ship construction, copper became less viable due to its propensity to accelerate corrosion. This shift led to the development and use of antifouling paints as the preferred solution for hull coatings.

While these paints, composed of compounds like copper, arsenic, and other biocides, are effective in preventing bioaccumulation, they eventually degrade or seep into the water, discharging toxic chemicals into the marine ecosystem. These toxic compounds are consumed by marine organisms, tainting the food chain, and hindering marine life growth. Despite the ban on harmful biocides like tributyltin (TBT) beginning in 2008, coatings based on copper, which make hulls inhospitable for marine life, are still in use today.

Low-friction antifouling paints present an alternative by making it difficult for marine life to adhere instead of removing them. Teflon-based antifouling paint is one such option; similar to its application in the kitchen, Teflon inhibits anything from adhering to the ship's surface and being transferred across regions. However, similar to other hull coatings, coatings containing Teflon ultimately flake away, leading to plastic residue entering the ocean.

Although antifouling technologies have made substantial progress in recent years, there is still potential for improvement to eliminate the toxicity and plastic pollution caused by peeling coatings. Canadian innovators are actively working on developing and refining these technologies.

3.3. ANTIFOULING SYSTEMS AND THEIR MODE OF ACTION

Hard antifouling

The biocides are bound in a resin system. It is mechanically very resistant and suitable for trailer boats and tidal areas. During the season, the active substances are washed out, which leads to a slow decrease in protection. The empty resin matrix remains on the hull and must be sanded in winter.

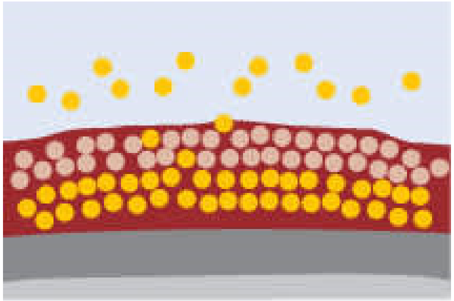

Fig.3. Hard antifouling

Self-polishing or self-erosion

A water-soluble resin system is mixed with biocides. When sailing, the paint and active substances degrade evenly. If the yacht is moved regularly, there is always a new layer of active substance on the surface. In principle, the protection works as long as there is paint left. Can be repainted without sanding.

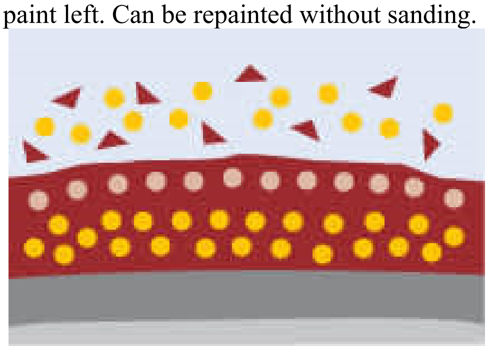

Fig.4. Self-polishing or self-erosion

Thin layer

Also called Teflon antifouling. This is a kind of hard antifouling. Only a very thin and very smooth layer of paint is applied, which is why there are hardly any layers that form. The antifouling is a combination of non-stick surface and biocides bound to the paint. Sanding is not necessary.

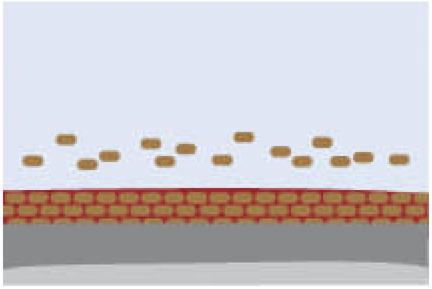

Fig.5. Thin layer

3.4. REGULATIONS GOVERNING ANTIFOULING PAINTS AND BIOFOULING PREVENTION

Acknowledging the environmental impact of biofouling and its treatments, the International Maritime Organization (IMO) has established an antifouling convention and guidelines to manage biofouling. As the organization tasked with ensuring the safety and security of global maritime operations and preventing marine pollution from ships, the IMO is also committed to ongoing research in these areas.

The International Convention for the Control of Harmful Anti-Fouling Systems on Ships, in 2001, was established to prohibit the application of hazardous materials, such as metallic compounds and tributyltin, in antifouling paints. This convention was amended in 2021 to further restrict the use of antifouling paints containing cybutryn, another chemical known to be harmful to marine organisms.

The IMO published in 2011 the Guidelines for the Control and Management of Biofouling on Ships to minimize the transfer of invasive aquatic species. These guidelines offer ship owners and operators suggestions to inhibit bioaccumulation and mitigate associated risks, including:

• Applying antifouling paints to the ship's hull and other submerged areas;

• Regularly inspecting and cleaning the hull and submerged areas;

• Creating a management strategy and documenting the measures taken to prevent biofouling, such as the type of coating applied and the date of application;

• Taking into account the ship's type, configuration, and speed when choosing the antifouling system to be applied.

In 2019, the IMO conducted an assessment of microplastic pollution resulting from hull coatings. Additional research is required to comprehend the contributions of microplastics from the cleaning and maintenance of these coatings.

4. CONCLUDING REMARKS

Traditional antifouling methods effectively prevent marine organisms from fouling boat hulls. However, they also have detrimental effects on the marine environment. As a result, more environmentally friendly and sustainable alternatives are being introduced, including biocide-free antifouling paints, smooth non-stick coatings, fiber films, ultrasonic antifouling, and protective covers. All of these approaches offer unique benefits and drawbacks.

With this advice, you'll be well-equipped to select the most suitable approach for maintaining your boat. Although alternative solutions can be more costly upfront compared to traditional annual antifouling, they often provide better protection, have extended durability, and are more environmentally friendly. It's crucial to consider long-term options to safeguard our boat hulls while preserving our delicate oceans.

Antifouling coatings seem to offer a dual benefit by curbing the spread of invasive species and lowering ships' atmospheric emissions. However, many measures and solutions aimed at addressing specific problems often bring about unforeseen effects and ecological compromises. Hull coating technologies follow the same trend.

As we navigate towards a more sustainable future, it's crucial to continue researching and refining antifouling technologies to minimize their ecological footprint and support the health of our marine ecosystems.

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