The Benefits of Foul Release Coatings

Iain Walker – International Paint Japan K.K.

As international trade booms, the global shipping industry keeps pace by expanding its fleet and building ever bigger and more powerful ships.

Whilst the industry is more energy efficient than other forms of transport such as air, rail and road, with an estimated 300 million tons of fuel consumed annually by the world’s fleet, there is an ever increasing focus on shipping’s environmental impact. At this level of consumption the industry currently emits some 960 million tons of CO₂ and 9 million tons of SO₂ annually. The International Maritime Organization estimates that without corrective action and the introduction of new technologies, air emissions, due to increased bunker fuel consumption by the world shipping fleet, could increase by between 38% and 72% by 2020.\(^1\)

\(^1\) IMO ‘Study of Greenhouse Gas Emissions from Ships’ (The GHG Study), MEPC 45/8, 29th June 2000

The industry has tried to find viable means of energy saving for decades. One way to do this is through the use of antifouling coatings. Antifouling coatings are used to improve the speed and energy efficiency of ships by preventing organisms such as barnacles and weed building up on the underwater hull, restricting the ships movement through the water.

If ships didn’t use antifouling coatings, fuel consumption could be increased by as much as 40% - with current fuel use consequently rising by 120 million tons per year to a total of 420 million tons per year. It is estimated that antifouling coatings provide the shipping industry with annual fuel savings of US$30 billion and reduced emissions of 384 million tons and 3.6 million tons respectively for CO₂ and SO₂ annually.

Coating suppliers have supported the shipping industry with pioneering antifouling technology since the introduction of the first self polishing copolymer (SPC) antifoulings in 1974 and their contribution to the fuel efficiency of the global fleet has been hugely significant.

However, concerns regarding the effect of tributyl tin (TBT) on certain marine species led coatings suppliers to develop more environmentally responsible solutions and, in 1996, the first commercially available biocide free foul release technology was introduced for fast craft and in 1999 for deep sea, scheduled ships.

This biocide free, silicone based technology works on a foul release basis 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, this original silicone development has become firmly established as the industry benchmark in foul release technology.

Now, in 2007, the next generation of foul release technology, which is based on new, unique and patented biocide free fluoropolymer chemistry represents the very latest advances in foul release technology, significantly improving upon the performance of the best silicone based systems.

Foul Release

Foul Release is the name given to technology which does not use biocides to control fouling but relies on a “non-stick” principle to minimise fouling adhesion. Most Foul Release products...
currently available are based on silicone technology and they are typically split into two general categories – those for high-speed coastal vessels operating above 30 knots and those for deep-sea, high activity scheduled ships with speeds greater than 15 - 18 knots.

**Fluoropolymer Technology**

Fluoropolymer chemistry represents the very latest advances in foul release technology, significantly improving upon the performance of the best silicone based systems.

Exceptionally smooth with unprecedented low levels of Average Hull Roughness (AHR) combined with excellent foul release capabilities and good resistance to mechanical damage means that for the very first time, all vessels above 10 knots can now benefit from foul release technology e.g. Tankers, Bulk Carriers, General Cargo Vessels and Feeder Containers.

Benefits include a predicted 6% reduction in fuel consumption and emissions, reduced paint consumption at the next docking, reduced risk of fouling during loading delays and enhanced Corporate Social Responsibility through an improved environmental profile.

Fluoropolymer technology also provides excellent performance on high speed / high activity scheduled ships which typically consume significantly more fuel per day (and therefore have higher emissions) than slower vessels. The low surface roughness, good coefficient of friction and advanced surface energy characteristics improves fuel efficiency and reduces slime build-up on Container Vessels, Reefers, LNG/LPG Carriers, Cruise Liners, Ro Ro's and Vehicle Carriers.

Launched in March 2007, fluoropolymer technology has already built an impressive track record of over 40 vessels with in-service data validating the fuel and emission savings on a range of vessel types.

**Average Hull Roughness**

The Average Hull Roughness (AHR) of ships is of critical importance. Underwater hulls need to be as smooth as possible for maximum efficiency. If hull roughness is allowed to increase, 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 unable to increase power to compensate for increased roughness will lose speed resulting in slower transit times or late arrivals. Operators able to quote higher speeds during charter contract negotiation may be able to command higher rates.

From measurements carried out on hundreds of vessels, the industry is aware that typical SPC antifoulings have an AHR of around 125 microns whilst silicone based systems are better with an AHR of 100 microns. However, measurements on a number of full vessel fluoropolymer applications have shown that this can be further reduced to around 75 microns providing additional savings for vessel operators.

**Static and Kinetic Coefficient of Friction**

Friction is the force that resists the motion of two surfaces in contact e.g. a coated hull in water. The coefficient of friction can be static or kinetic and is defined as the ratio of the ‘friction force to the normal force’. The coefficient of friction is an important measure for foul release coatings. The coated hull that offers the least resistance through water will reduce the power required by the vessel to maintain desired speed.
When the static and kinetic coefficients of friction are measured and compared (both wet and dry) for silicone and fluoropolymer based systems, the fluoropolymer systems show an average improvement of 38%.

**Surface Energy: Static Performance**

Fluoropolymer systems have 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.

Surface energy quantifies the disruption of chemical bonds that occurs 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, i.e. the spreading of a liquid over a surface occurs. If complete wetting does not occur, then a bead of liquid will form with a contact angle which is a function of the surface energies of the system. If the surface is hydrophobic then the contact angle of a drop of water will be larger. If the surface is hydrophilic then the contact angle will be smaller.

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 – polar and dispersive.

This gives a measure of how many polar and dispersive (non-polar) groups there are at the surface. The introduction of polar groups in an otherwise non-polar surface will produce a surface that is amphiphilic i.e. the surface combines both hydrophilic and hydrophobic properties.

Fluoropolymer systems provide 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 fluoropolymers can minimise the chemical and electrostatic adhesion between the surface and a wide range of fouling organisms.

**Surface Energy: Foul Release**

Foul release properties are particularly important when considering slower speed vessels (<15 knots). These vessels often trade on the spot market and may have static periods awaiting a charter or waiting to discharge/load cargo. The excellent foul release properties of fluoropolymers means that even during exceptionally long periods of inactivity, any fouling attachment can be removed either by the vessel getting under way, or if underwater cleaning is the option selected, then less force is required to remove the fouling resulting in less damage to the coating.

The better static resistance and improved foul release properties of fluoropolymers means they are suitable for use on newbuildings during fitting out periods and special procedures have been developed to allow application of these systems during new construction.

To fully understand how fouling adheres to submerged surfaces and what force is required to remove them, a coating company “grows” its own barnacles and has developed a sophisticated computer controlled system to apply force to the barnacle - the Barnacle Push Off Apparatus. The equipment measures the peak force required to remove the barnacle but, as all barnacles are different sizes, the area in contact with the coated system must be measured. This is done using a computer controlled camera and results are derived from dividing the peak force (in Newtons) by the barnacle area (in mm²) to give the force per area in N/mm². Barnacle shear adhesion strength is measured in kPa and fluoropolymers typically required 40% less shear force to remove barnacles in comparison to silicone systems.

**Resistance to Slime Fouling**

Certain owners enjoying the benefits of using silicone systems have noticed that slime build-up can occur which may lead to fuel or speed penalties. Fluoropolymer technology integrates advanced surface energy characteristics with an ultra smooth surface to reduce slime build-up by 50%.

**Savings**

In terms of fuel efficiency and reduced emissions, fluoropolymer technology offers predicted savings of 2% in comparison to silicone based systems and 6% in comparison to typical SPC antifoulings. The potential exists for even greater savings in comparison to controlled depletion antifoulings.

For a single VLCC currently coated with an SPC antifouling, this could mean savings of over 9,300 tons of fuel (US$2.8 million with bunkers at US$300 per ton) and a reduction in carbon dioxide emissions of around 12,000 tons over a five year period.

**Summary**

In comparison to typical SPC antifoulings and current silicone based foul release products, the latest fluoropolymer technology offers significant environmental and financial benefits for vessel operators.