Sailing on air

by the AIRCOAT Team

To achieve the greenhouse gas emission (GHG-E) reduction goals outlined in the European Green Deal, the aim of which is for Europe to be the first climate-neutral continent, the maritime shipping industry must reduce its footprint: by 50% by 2030 and 90% by mid-century. This can hardly be ticked off by a single measure alone. Ship resistance reduction means (via advanced coatings, air lubrication, hull management of biofouling, hull form design) are the necessary drivers to reduce emissions. Shipowners cannot solely focus on alternative fuels, which won't be on hand in the medium-term in large quantities, nor other solutions such as slow steaming, which is well understood but will increase delivery times and the number of ships needed for transport. As such, hull optimisation technologies look increasingly tempting – for newbuilds and retrofits alike.

Since 2018, the AIRCOAT project has been targeting the development of a bio-inspired green solution to create a passive air layer on ship hulls underwater – so-called air lubrication. The goal is to reduce drag and prevent biofouling, thus lowering fuel consumption and emissions.

The AIRCOAT technology consists of a structured foil that retains air when submerged. Due to the lower viscosity of air (low resistance to deformation) in comparison to water and the air barrier, drag reduction and limited attachment of fouling organisms are expected. The foil will also help avoid releasing biocide anti-fouling substances into the water.

Johannes Oeffner, Project Coordinator of AIRCOAT and Team Leader at Fraunhofer Center for Maritime Logistics, highlights, "We have developed production lines and testing facilities, produced a foil prototype, coated a research vessel and applied a test patch to a container ship, performed a vast number of calculations and simulations and spent many hours with hydrodynamic and biofouling experiments. We have tackled a lot of challenges, had to make some compromises and learned a lot which will help to advance AIRCOAT further for being a future ship efficiency technology."

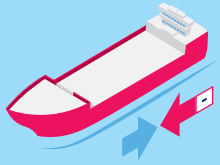
From plant to a lab to a ship

AIRCOAT is responding to one of the main challenges of the European Green Deal: nothing less than halving shipping emissions by 2050. Today, maritime transport still emits around 940mt of CO_2 every year, about 2.5% of global GHG-E. Because it can reduce up to 10% of the ship's velocity per year, biofouling is an important factor in increasing fuel consumption and, consequently, the industry's carbon footprint. Many solutions exist to reduce biofouling or drag, but none addresses both.

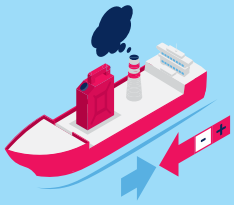
Professor Thomas Schimmel, Scientific Coordinator of AIRCOAT and Director at the Karlsruher Institute of Technology's Institute of Applied Physics, explains the bio-inspiration methodology that AIRCOAT foil uses, "It was amazing to understand the mechanism, how the plant keeps a layer of air under water and to produce first artificial air-keeping samples in our lab – which by the way still are keeping

What is friction and why is it important?

The movement of water along the ship hull causes skin friction resistance.



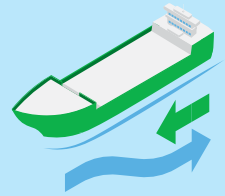
This frictional resistance works against the movement of the ship, reducing their speed.



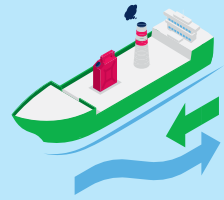
To conserve speed, ships have to exert more force in order to move through the water, which increases fuel consumption and CO_2 emissions.

What solution does AIRCOAT provide?

By covering the ship hull with the passive AIRCOAT layer, the air acts like a lubricant between the hull and the water.



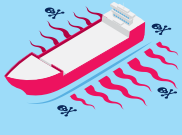
The air layer lowers the frictional resistance of the ship, minimizing the speed reduction.



The AIRCOAT technology has the potential to save 73 million tonnes of fuel at any speed and 225 million tonnes of CO_2 emitted in relevant ships.

What is biofouling?

Ship hulls are often covered in marine life and organisms – this is called biofouling.



Common anti-fouling paints wear off, containing chemical substances that can harm the sea.

Biofouling increase surface roughness, which increases friction...

... increasing their fuel use by 40%...

... and increasing their emissions.

What solutions does AIRCOAT provide?

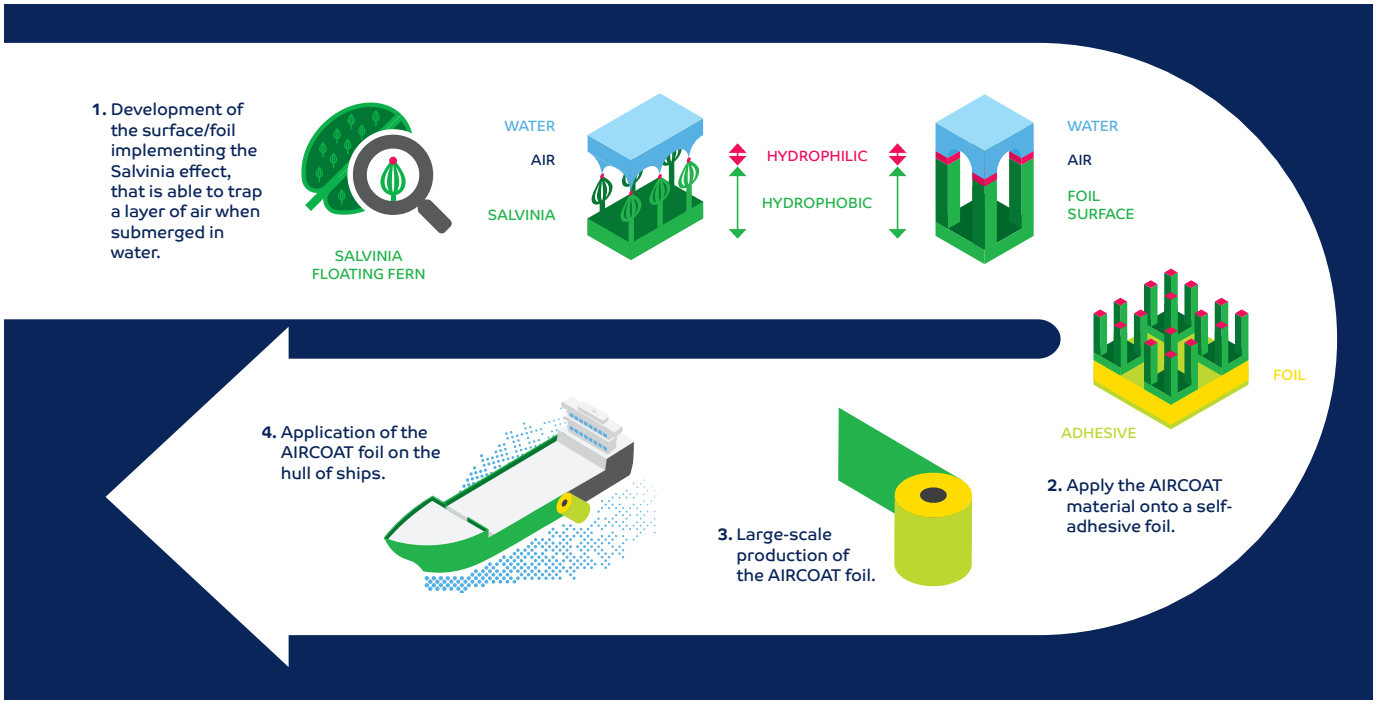
The passive air layer created by AIRCOAT separates the ship hull from the water, reducing or preventing biofouling.

The AIRCOAT coating does not harm the sea.

AIRCOAT protects ships from the added friction due to biofouling...

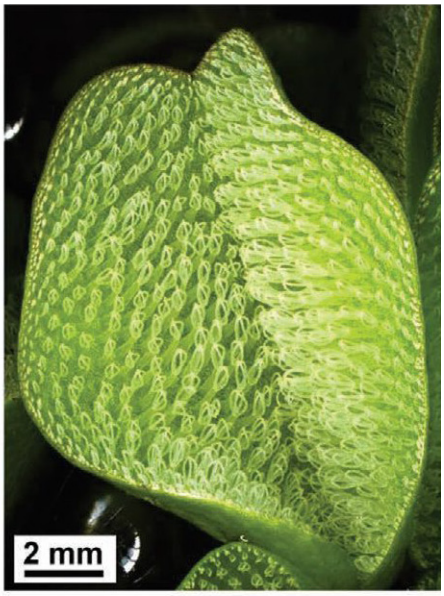
... thus reducing their fuel use...

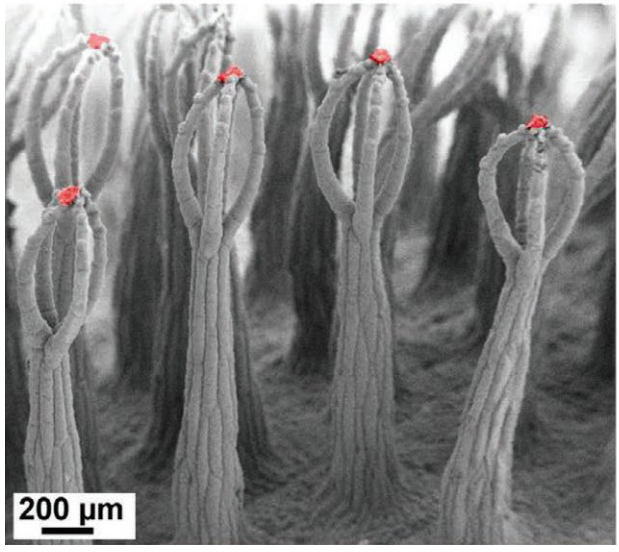
... and decreasing their emissions.

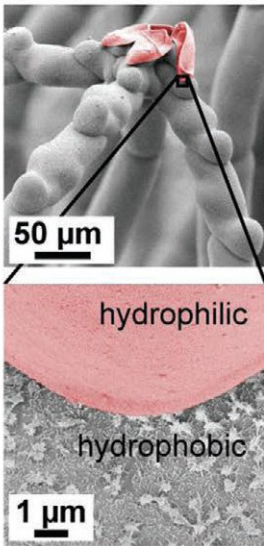


the air layer even after years under water. But this was just the beginning. It was the step from the plant to the lab. The step from the lab to the ship had still to be performed, and progress has been achieved during the past four years. Starting with small, fragile samples on the centimetre scale, we meanwhile produce elastic foils on the kilometre scale. And the structures which in the beginning were on the scale of one millimetre are now on the micrometre scale."

The innovative eco-friendly air lubrication technology developed within the project coats the ship hull with a thin and permanent layer of air without the need for continuous pumping or air bubbling. The solution is inspired by *Salvinia Molesta*, a floating water fern that forms a permanent air layer when submerged in water. The air retaining ability of the so-called Salvinia effect relies on a complex micro- and nano-structured surface with hydrophobic and hydrophilic characteristics. AIRCOAT has technologically implemented this natural phenomenon to produce a bio-inspired hull coating technology that combines three key advantages: reducing the hull's underwater







friction; minimising fouling (as fouling organisms find it rather impracticable to settle on a layer of air); and getting rid of toxic anti-fouling substances.

The AIRCOAT foil is introducing advanced technology in hull coatings and, as such, will come with strong investments from the vessel owners' side. What makes AIRCOAT a lucrative choice is the expected operational savings. The solution brings direct business profit to the ship operator by materialising savings in fuel consumption and hull maintenance costs between dry dock intervals whilst promising significant investment returns.

Testing, testing

Several remarkable project advancements have been made in developing a foil with a surface structure to retain air and realise drag reduction.

First, there is the geometry and the size of the surface structure. Theoretical calculations and simulations on a high-performance computer cluster have shown that drag reduction increases with surface structure and that 10% is possible for frictional drag reduction. Hence, depending on ship speed and length, the size of the surface structure has to be adapted to reach equal drag reductions.

Second, the production of the air-retaining foil in a novel, kilometres-long roll-to-roll process has been developed. To reach the deep-water and high-speed stability of the air layers, it has been necessary to manufacture the individual structures down to the micrometre scale.

Third, appliquéing the foil on ships: industry procedures have been developed to manually apply the self-adhesive prototype foils to commercial vessels within standard dry-docking processes. Demonstration tests with a container ship showed the coating's function applicability and operational durability.

Fourth, testing the solution. A ten-metre-long **research vessel** in the Mediterranean was coated on one side with the air-retaining foil. Meanwhile, the first 'real' maritime conditions demonstration was performed on a **container ship** in Romania, where the foil was attached to a part of the hull.

Lastly, **a laboratory check of the anti-fouling quality** has been carried out. Experiments have indicated that diatoms, a special kind of micro-organisms widespread in natural aquatic environments, avoid growing on air layers. They, however, like to inhabit the same surface when the air is removed for a comparative experiment.

Tool up!

In the pursuit of energy efficiency gains, it is crucial that all efforts also preserve the integrity of marine ecosystems. After all, what good can come from climate action that leads to adverse environmental impacts? The maritime sector has been working to phase out harmful compounds from anti-fouling coatings since 2001; however, negative effects of anti-fouling biocides on marine life are still being detected. Established anti-fouling coatings have an average duration of five years between applications, which generates costs, i.e., funds that could be directed towards other green investments aboard ships or in port/terminal infrastructure.

Further incentives to the shipping industry to invest in environmentally friendly solutions to tackle biofouling are essential to ensure that solutions put in place today are contributing to both climate and marine protection goals. In addition to offering significant fuel efficiency gains, AIRCOAT is a retrofit technology: it can be put into place on existing ships, which avoids early tonnage retirement and the need to build new vessels to reap the technology's benefits. In practice, it allows for a much faster transition to a greener fleet. With 50% of the European tonnage being under 15 years, retrofit solutions give the industry the tools to quickly adapt. ■

AIRCOAT stands for AIR-induced friction-reducing ship COATing. It is a Horizon 2020 EU funded project promoting a passive air lubrication technology with the potential to revolutionise the ship-coating sector. Head to **aircoat.eu** to discover more. You can also watch the project's Final Event by going **here**.