HEMPAGUARD® X5 and HEMPAGUARD® X7: Novel ActiGuard®-based Fouling Defence technology

Kim Flugt Sørensen, Dorthe Hillerup, Anders Blom, Stefan Møller Olsen, Diego Meseguer Yebra

Summary

HEMPAGUARD X5 and X7 are the first products on the market to utilise patented ActiGuard® technology. By fusing hydrogel-based Fouling Release technology with a controlled release of biocide, ActiGuard® provides a biocide-activated hydrogel at the surface of the coatings, while simultaneously controlling the release of biocide. ActiGuard® modified coatings deliver extraordinary fouling defence performance under idle conditions in aggressive waters and do not release unnecessary amounts of biocide while the ship is sailing. HEMPAGUARD® employs a silicone binder providing the same initial fuel efficiency as conventional silicone-based fouling release coatings. Fuel efficiency remains significantly higher throughout a docking interval compared to a standard antifouling, regardless of sailing speed and water temperature, due to the fouling protection provided by ActiGuard.

ActiGuard®-technology

ActiGuard® works by forming a biocide-activated hydrogel on the surface of the fouling defence coating. The hydrogel effectively traps the biocide during diffusion out of the film, thereby increasing the surface concentration of the biocide and prolonging the retention time of biocide in the coating matrix and on the surface. The working mechanism of ActiGuard® is schematically illustrated in Figure 1 below.

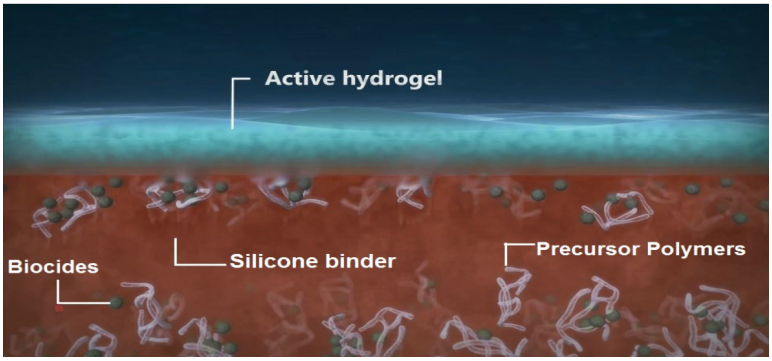


Figure 1: schematic illustration of the working mechanism of ActiGuard®.

The figure illustrates how the concentration of biocide increases in the hydrogel surface of a coating based on ActiGuard®. In addition to highly effective utilisation of a minimal amount of biocide, this means that the biocide concentration can be maintained at a level allowing the coating to retain its silicone properties.

Biocide content

ActiGuard® needs only a very limited amount of biocide to work efficiently during prolonged immersion. Figure 2 shows the average biocide content pr. square centimetre coating for HEMPAGUARD X5 and X7 compared to a conventional silyl acrylate antifouling coating. It is evident from the figure that the biocide content in a typical ActiGuard® formulation is negligible compared to that of a conventional antifouling. The low amount of biocide also means that HEMPAGUARD® retains the beneficial properties of the silicone binder (i.e. smoothness and low surface tension).

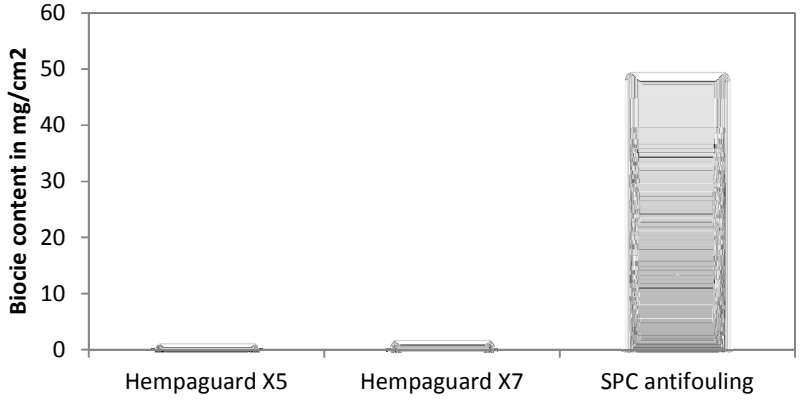


Figure 2: Average biocide content per cm^2 of coating for HEMPAGUARD® X5 and X7 compared to a conventional antifouling coating. The calculation is based on conventional specifications (150 µm DFT for HEMPAGUARD® and 280 µm for the antifouling system).

Silicone properties of HEMPAGUARD® coatings

The efficient utilisation of biocide offered by ActiGuard® allows for a very low pigment volume concentration, meaning that HEMPAGUARD® coatings share many of the same physical properties as hydrogel-based fouling release coatings. HEMPAGUARD® coatings are based on a silicone elastomer; they have a low content of pigments and fillers, and they have a low content of Volatile Organic Compounds.

Surface smoothness

The low amount of biocide in HEMPAGUARD® ensures that the coating is very smooth after application. This is a highly distinctive feature of silicone-based fouling release coatings. Figure 3 shows the surface morphology on a fresh and an aged HEMPAGUARD® coating compared to that of a conventional antifouling coating. It is seen that there is a significant difference in surface roughness between the two coating types.

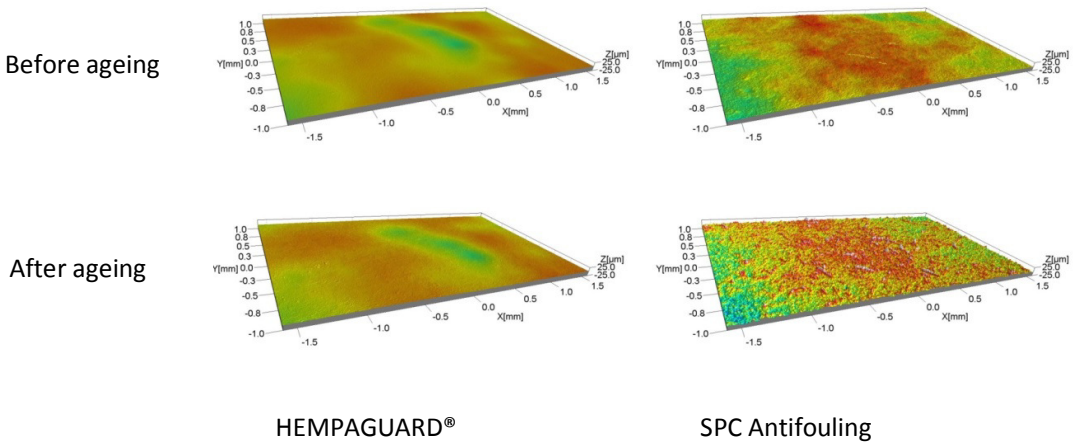


Figure 3: Smoothness of HEMPAGUARD® (left) and SPC antifouling (right) before (top) and after (bottom) aging.

Biocide release

The biocide diffusion from ActiGuard® can be described by Fick's laws of diffusion. The theoretical biocide release shown in Figure 4 has been modelled from laboratory testing and the model predictions verified by ship-scale trials. It is seen that the model fits real-life tests very well.

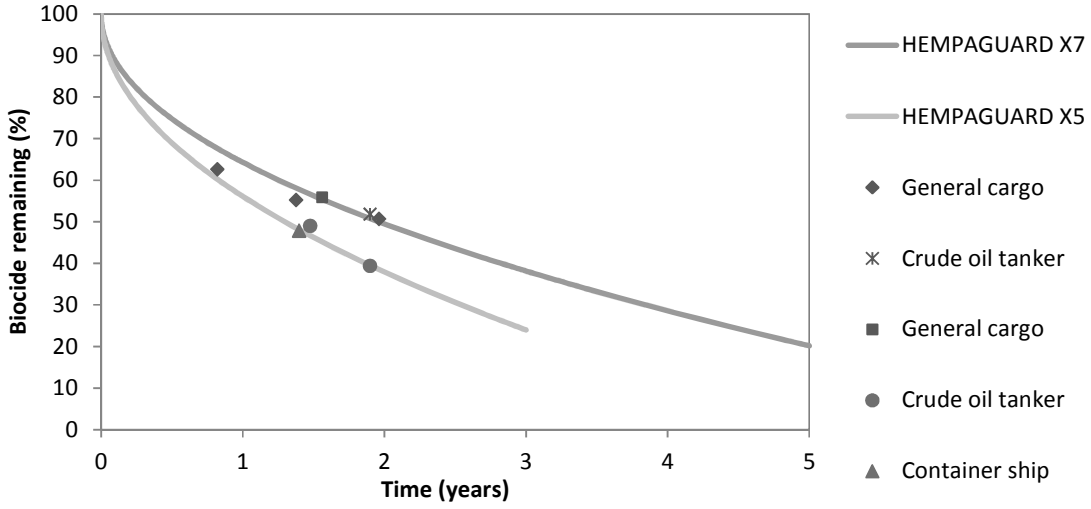


Figure 4: Real-life testing compared to modelled biocide release. All examples are trading ships.

Biocide release rate as a function of travelling speed

One major advantage of ActiGuard ® technology is the stable biocide release-rate as travelling speed increases. Figure 5 below shows the results of measurements of biocide diffusion performed on samples immersed dynamically at speeds ranging from 0.08 knots to 20 knots. The figure shows that the release-rate of biocide from HEMPAGUARD® products based on ActiGuard® is stable between 0.2 and 20 knots. This means that, even under static conditions with a current of more than 0.2 knots, the hull of an idle vessel enjoys the same protection as a vessel travelling at 20 knots. The stable biocide release-rate is thus a key factor allowing for very low speed and activity of vessels

protected against fouling by ActiGuard®. From an environmental perspective, the stable release of biocide irrespective of travelling speed means that less biocide is released into the environment when travelling at higher speeds with lower fouling pressure. Furthermore, whereas conventional antifouling coating systems are specified according to speed of operation and water-type, trading waters are the only operating parameter that needs to be considered when specifying ActiGuard® based systems. This enables changes in sailing pattern during operation without affecting the service life of the coating.

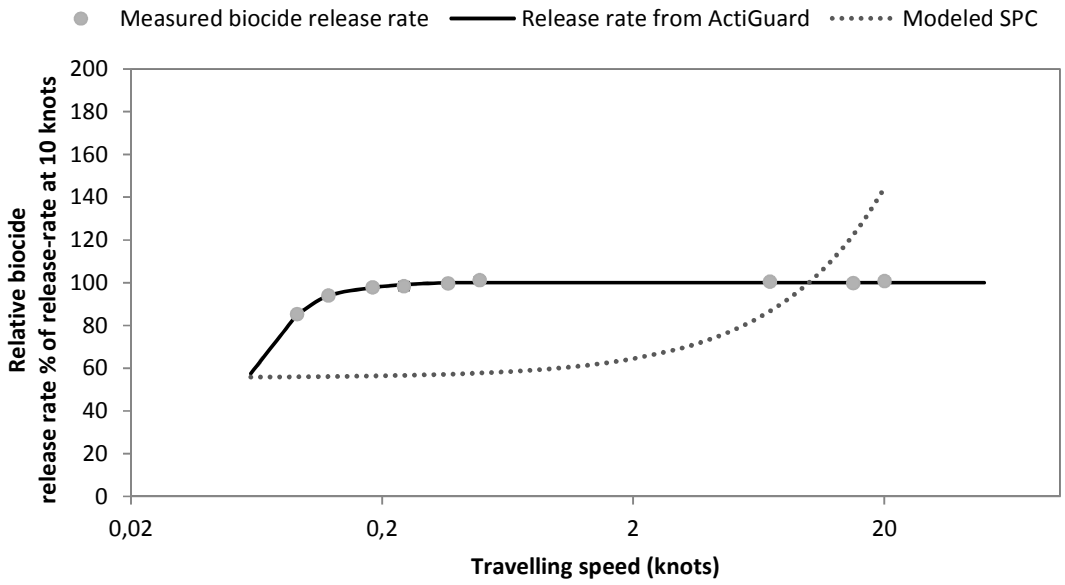


Figure 5: Relative biocide release rate from ActiGuard® as a function of travelling speed (10 knots as reference speed). Also indicated is the relative biocide release rate from conventional SPCs. Note the logarithmic scale on the X-axis.

Fouling protection of scratches

Damage is prone to occur on all antifouling systems including fouling release coatings. While these become vulnerable once damaged, ActiGuard® provides a window of defence even after damage.

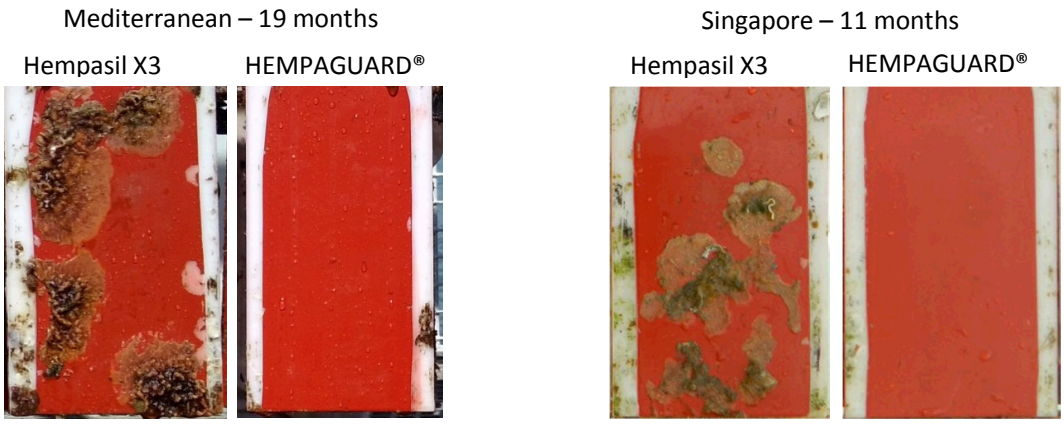


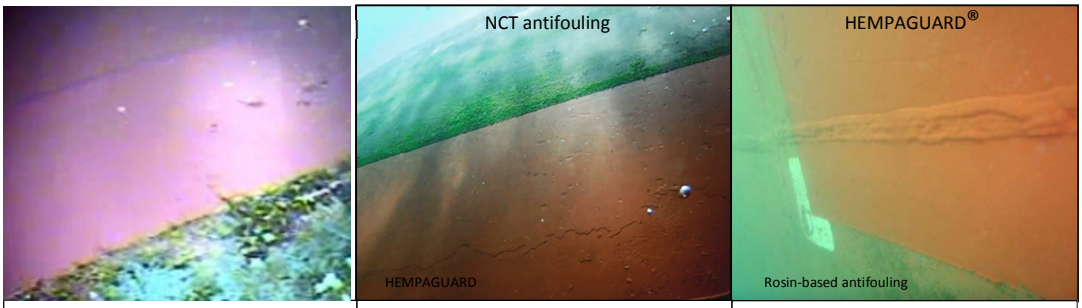
Figure 6: Pictures of panels damaged by sandpapering. Left: Hempasil X3 compared to HEMPAGUARD® after 19 months immersion in Spain. Right: Hempasil X3 compared to HEMPAGUARD® after 11 months immersion in Singapore.

Antifouling performance during static immersion has been tested after inflicting scratches by roughening of the full coating surface with sandpaper. Figure 6 shows the results of these tests. It is seen that, whereas the performance of a conventional fouling release coating is lower after roughening, HEMPAGUARD® retains its performance level, even under static conditions. This effect is also apparent in Figure 7, in which photographs of hull areas damaged by scattered scratches taken during an underwater inspection of a HEMPAGUARD® test patch after 22 months in service show that HEMPAGUARD® retains its high level of performance.

Figure 7: Pictures of a test patch mechanically damaged by scratches. The pictures were taken after 22 months in service.

Real-life testing

Several ship trials have demonstrated the efficacy of ActiGuard® technology. Figure 8 shows the performance of HEMPAGUARD® coatings compared to three different conventional antifouling coatings on test patches on ocean going vessels. The three test patches represent 2 vessel types, and 2 different levels of activity. In all of the tests, HEMPAGUARD® outperforms the antifouling systems. One of the vessels had idle periods of up to 20 days without compromising the condition of the test patch.



Vessel type: general cargo Operation time: 19 months Activity: 69% Idle periods: 8 & 10 days	Vessel type: oil tanker Operation time: 22 months Activity: 85% Idle periods: 13 & 11 days	Vessel type: general cargo Operation time: 16 months Activity: 66% Idle periods: 20 & 17 days

Figure 8: Pictures of test patches of HEMPAGUARD® on commercial vessels.

In addition to test patches, a significant number of full ship test applications were performed prior to the worldwide launch of HEMPAGUARD® X5 and X7. As of September 2013 a total of 30 full ship applications representing 2,627,813 DWT and 18 different owners have been performed. Full ship

and test patch applications were performed on Ro/Paxs, Ro/Ros, container ships, bulk carriers, VLOCs, cruise ships, supply vessels, VLCCs, fishing vessels, general cargo ships, crude oil tankers and chemical tankers.

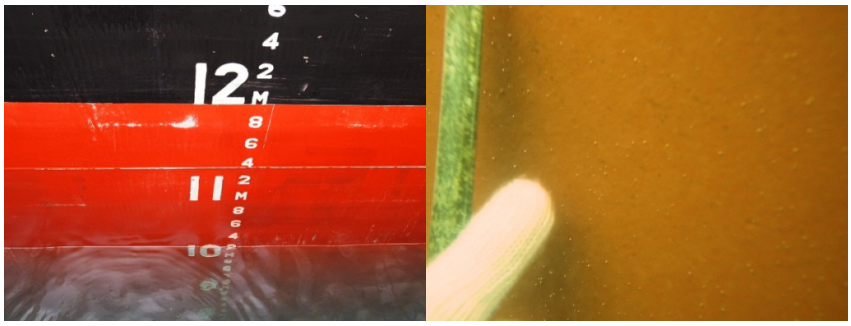


Figure 9: Condition of a HEMPAGUARD® coating on a container ship after 17 months of operation. Vessel activity: 84 %, and no longer idle periods were reported

Figure 9 shows the condition of the first full application of HEMPAGUARD®. The pictures were taken after 17 months of operation. As can be seen from the figure, the coating was in perfect condition and completely slime free.

Conclusions

ActiGuard® is a novel technology, that fuses antifouling and Fouling Release technologies by biocidal activation of a hydrogel-layer. This means that ActiGuard® offers unprecedented fouling protection while minimising biocide release to the environment. HEMPAGUARD® X5 and X7 are the first Fouling Defence coatings based on ActiGuard®. Because the binder system in HEMPAGUARD® is silicone, they offer unprecedented long-term fuel-efficiency by keeping a very smooth hull free from fouling for longer than any alternative technology available. Considering the limited amount of biocide utilised in ActiGuard® to efficiently prevent biofouling together with significantly improved fuel-efficiency, HEMPAGUARD® can be considered the most efficient and environmentally friendly fouling control coating ever developed. In summary HEMPAGUARD® offers:

- ActiGuard® technology for highly efficient fouling defence
- Fuel-efficiency due to very smooth binder systems
- Fouling defence over scratches and smaller damages
- Limited biocide release to the marine environment