Sol-Gel-Hybrid-Formulations as Non-Toxic Anti-Fouling Coatings – On the Example of Underwater Boat and Engine Screw

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On all parts of a boat that are in contact with water, such as engine screw (propeller), shaft and bearing or bearing block, there is increased growth of organisms - also known as fouling - especially after long periods of mooring. This undesired colonization of marine organisms on surfaces can be separated into hard and soft fouling[1,2]. Hard growth is characterized by infestation with different crustaceans, bryozoans, molluscs and tube-forming worms. Soft fouling represents the colonization of algae and soft corals among others. Without suitable protection, dense fouling of the submerged parts of the boat will inevitably occur over time, which can usually only be removed with great effort. Crustaceans pose a particular challenge, removal is only possible using strong mechanical action, which often results in damage to the boat, which can result in expensive repairs. Currently, anti-fouling coatings mixed with biocides offer protection against marine growth. However, due to their sometimes highly toxic substances, these show serious effects on the ecosystem. For example, antifouling paints containing the toxic substance tributyltin (TBT) have been banned internationally since 2003. Copper and zinc compounds, approved biocide-based, self-polishing coatings such as Diuron, Irgarol 1051 (s-triazine), chlorothalonil, isothiazoline (Sea-NINE 211) currently dominate the market. These biocides are also harmful to marine environments and have therefore been banned in some countries. [3]

Sol-gel derived coatings have many advantages [4], since they are mechanically and chemically inert and resilient. The anti-fouling properties can be generated intrinsically or with additives that have anti-fouling properties. There are several approaches known. These include very hydrophilic as well as very hydrophobic coatings to generate anti-fouling surfaces. In our case it is possible to coat different substrates, like stainless steel, glass fiber reinforced plastic, glass itself and different types of metal with all known application methods, so it is possible to use painting, spraying, doctor blading and also dip coating as coating techniques. With this variable sol-gel system it is possible to generate film thickness of 10 µm to 200 µm, but in all cases the coating is full transparent, though it is also possible to mix the formulation with fillers to introduce e. g. a color or a specific quality. To characterized the coatings different analysis methods were used. Besides, the film thickness and the cross-cut test (for subjective adhesion), other methods like hydraulic adhesive strength (up to 24 MPa), TGA (for thermal behavior), Solid State NMR and IR (for structural insights) were used for characterization. To test the coatings under real conditions field trials were used, so engine screw and also plates of the interesting materials were coated and brought into rivers and the sea and after a half year of running the coatings were evaluated.

References

[1] Tuoc, T. K. Fouling in Dairy Processes. *Miner. Scales Deposits*, **2015**, *20*, 533–556.

[2] Tijing, D. L.; Woo, Y. C; Choi J.-S.; Lee, S.; Kim S.-H.; Shon H.-K. Fouling and its control in membrane distillation - A review. *J. Membr. Sci*. **2015**, *475*, 215–244.

[3] Almeida, E.; Diamantino, T. C.; Sousa, O. de. Marine paints: The particular case of antifouling paints. *Prog. Org. Coat***. 2007**, *59*, 2–20.

[4] Kroke, E.; Kraushaar, K.; Gellrich, F. Zusammensetzungen zur Beschichtung von Substratoberflächen, Patent DE 10 2019 110 519 A1, **2020**.