Antifouling Compounds: a systematic study on structure-property relationship

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Abstract

Biofouling is one of most important factors that affects the efficiency of waterborne systems. It has been the cause of serious detrimental effects on such surfaces leading to subsequent economic and environmental penalties. It can be for instance the cause of hydrodynamic drag increasing in ships and thereby fuel consumption and greenhouse gas (SO_2, NOx, CO_2) emissions [1]. The International Maritime Organization (IMO, 2009) estimates that under extreme scenarios, gas emissions due to increased fuel consumption by the world shipping fleet could lead to a maximum annual growth in CO_2 emissions from shipping of 5.1 %, which would correspond to more than the double by 2030. Protection surface strategies against such *biofouling* have been widely pursued [2]. Hitherto, antifouling biocide-releasing coatings seems to be the most effective, but the biocides ecotoxicity has led to strict regulations for their use, and those expected to come in 2013 will restrict even further the antifouling biocides currently in use. Therefore, greener antifouling alternatives are sought. In this work, a new approach for non-release antifouling coatings is being followed. It consists of the modification of already proved biocides (e.g. commercially available) or other potential antifouling compounds in order to immobilized them into conventional coatings' systems. The first task of this work involved the identification of potential antifouling compounds able to be immobilized in a polymer matrix. A list of potential antifouling compounds was selected based on their structure-properties and their feasibility to be included in a polyurethane based polymeric system.

The Issues vs. New greener antifouling approach

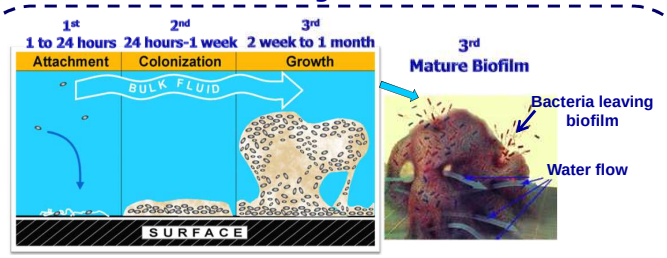
Biofouling on ships' hull or panel tests

Source: http://arzakcoper.com.ar/FOULXSPEL/about.php (FOUL-X-SPEL Project); ATLAR, M., 25th ITTC Group Discussions3 – Global Warming and Impact on ITTC Activities, Fukuoka, Japan, 2008.

Biofouling in cooling systems

Source: Jan Doelman, 2012 (ww.greenmanufacturer.net); David Daniels and Tony Selby, M&M Engineering, 2007 (http://www.eltronwater.com)

Biofouling formation



The initial step in biofouling involves the adsorption of organic molecules to a hard surface, providing the suitable conditions for colonization of foulings organisms (bacteria and microorganism), which adhere on the surface and creates the **biofilm**. Further fouling organisms, from algae to hard foulers (Barnacles, mussels, etc.), will attach over time: **Macrofouling**.

Approach: non-leaching antifouling coating

Approach: non-leaching antifouling polymeric coating

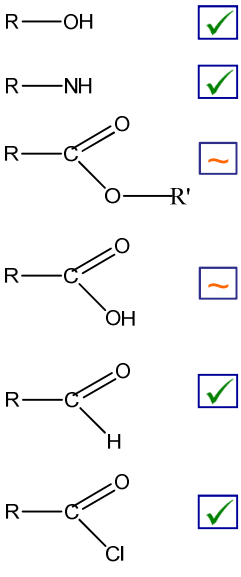
Model system for test: Two component Polyurethane (PU) based system

Tests in progress for non-leaching assessment of the developed coatings

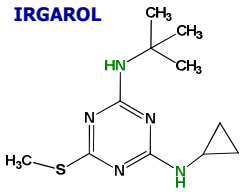
Potential antifouling agents able to be modified were selected; some of them are listed below

Antifouling Compounds

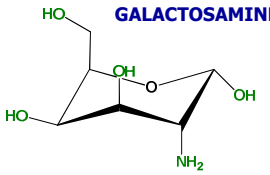
Functional potential Groups



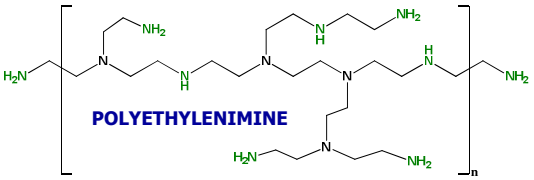
IRGAROL



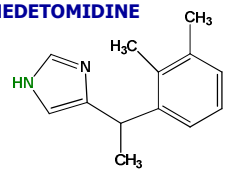
GALACTOSAMINE



POLYETHYLENIMINE



MEDETOMIDINE



Others:

- Quaternary Ammonium Salts (QAS)
- Farnesol
- Zineb, Mancozeb

MAIN BENEFITS

- A green and benign method of biofouling prevention is proposed, by avoiding leaching of toxic compounds to the environmental;
- Versatility – the followed strategy can be adapted to several antifouling agents, thus increasing the range of action;
- Reduction of cost maintenances by promoting a long-term effect of surface protection.

APPLICATIONS

Main areas of application are waterborne systems, such as for marine coatings or water cooling systems.

Conclusions

A list of compounds with antifouling properties have been selected based on the compatibility of their functional groups with a model polymer system (polyurethane);

Preliminary tests evidenced that molecules possessing mainly hydroxide and amine available functional groups are potential candidates for the proposed approach.

Next steps of the workplan will deal with finding the optimised conditions for tethering such antifouling compounds in a polymer system.

References:

1. International Maritime Organization, (2009) MEPC 59/INF.10; **2.** Banerjee et al. Adv. Mat. Vol. 23, 2011, 690-718; **3.** http://arzakcoper.com.ar/FOULXSPEL/about.php .

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