
Photo: TAU

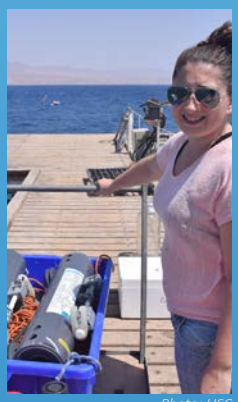
Photo: USC


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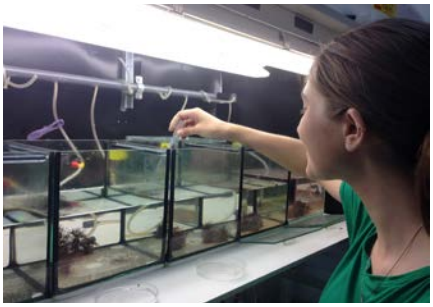
Summary description of project context and objectives

BBiofouling has profound effects on different branches of maritime activities. It is the major cause of maintenance expenses of any (partially) submerged man-made surface, including transport ships, buoys, aquaculture, but also membrane bioreactors and desalination units, power plant cooling water systems and oil pipelines. It also poses a significant problem for the entire aquaculture industry, the broadest and the most documented impact being in marine fish aquaculture. The settlement of marine invertebrates on the hulls of ships results in increased erosion, reduction of speed, increased fuel consumption and, consequently, increased air pollution and CO2 production.

The main goal of the BYEFOULING project, supported in the framework of the Ocean of Tomorrow by the European Commission, is to design, develop and upscale novel low-toxicity and cost-efficient environmentally-friendly antifouling coatings with enhanced performance compared to the currently available products. The approach in BYEFOULING is to tackle different stages of the biofouling process using innovative antifouling agents, covering surface-structured materials, protein adsorption inhibitors, quorum-sensing inhibitors, natural biocides and microorganisms with antifouling properties. Encapsulation of the innovative compounds in smart nanostructured materials will be implemented to optimize coating performance and cost throughout their life cycle. A proof-of-concept for the most promising candidates will be developed and samples will be produced and tested in the field.

The specific objectives of BYEFOULING are to:

- obtain coatings with extended service life;
- reduce VOC content in coating formulations;
- reduce fuel costs due to drag reduction in maritime transportation and fishing vessels;
- increase operation life of floating devices;
- reduce fish mortality resulting from conventional biofouling processes and respective control measures
- reduce maintenance costs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Description of work performed and main results

In the project management tasks, an internal website (eRoom) was created for BYEFOULING partners providing information on the project. A homepage is available for public access (www.byefouling-eu.com) and an internal website (eRoom) has been established for the BYEFOULING partners. The 6M meeting was held on 27-28. May 2014 in San Sebastian, the 12M meeting was held on 19.-20. November 2014 in Athens and the 18M meeting was held on 19.-20. May 2015 in Mons. Dissemination has been carried out according to a revised decision procedure for publications. A project ethics committee has been established to follow research activities on living animals.

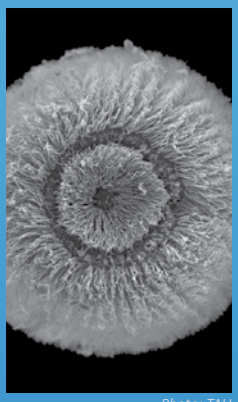
Innovative antifouling approaches have been focused on studies on surface structuration, protein adsorption inhibitors, quorum-sensing inhibitors (QSI), natural biocides and living active species. For surface structuration, the feasibility of obtaining double wavelength-wrinkled surface with labyrinth morphology has been shown. In the field of biomimetic surface composition, several compounds have been extracted from different marine

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612717

organisms, having potential antifouling properties. With respect to protein adsorption inhibitors, peptide-like and poly-zwitterionic materials have been tested.
Different QSI compounds/extracts have been tested and a large number of novel marine bacteria with wide-spectrum enzymatic QSI activity have been already identified. In the field of Living Active Species, freeze-dried cells and endospores of different bacteria strains have been produced.


Photo: TAU

The tasks related to the development of antifouling coatings were dedicated to the synthesis and characterization of nanostructured inorganic, organic and hybrid materials that can be used for the encapsulation of active species, including dormant microorganisms with antifouling properties. The surface functionalization of the synthesized nanomaterials has been investigated in order to improve dispersion in polymeric matrices. Synthesis of carbon nanotubes (CNTs) with specific characteristics and different fillers with antifouling and hydrophobic functionalities have also been performed. Finally, screening paints and reference antifoulants have been produced and sent to several partners to apply the first coatings for field and mesocosm tests.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For the task of antifouling performance and benchmarking, protocols have been written for laboratory tests on anti-microfouling efficacy, anti-macrofouling efficacy, mesocosm efficacy tests, field efficacy tests of the antifouling paint prototypes and ecotoxicity tests. The developed free innovative compounds and intermediate materials have all been tested. Results on antifouling activity in lab tests have been communicated to the partners and the first field tests have been launched with the most promising BYEFOULING systems developed so far.

Activities related to the development of the mathematical models for drag reduction prediction and activities related to LCA have been performed. Models for studying self-polishing paints have been used, flow of fluids has been simulated and experimental designs have been studied to obtain relevant experimental data. Furthermore, the first results on LCA have been obtained.


Photo: SMT

Planning activities on sample design and exposure locations for ships, aquaculture and satellite buoys have begun.

Several dissemination activities have been carried out, including organization of training courses, short visits, website and newsletters. The first BYEFOULING workshop was organised by the University of Santiago de Compostella, in collaboration with Tel Aviv University. A first draft of an exploitation plan of the results has been prepared.


Photo: TAU

Expected final results and potential impacts

The BYEFOULING project addresses high-volume production of low-toxicity and environmentally- friendly antifouling coatings for mobile and stationary maritime applications. The technology will fulfil the coating requirements as a result of the incorporation of novel antifouling agents and a new set of binders into coating formulations for maritime transportation and fishing vessels, floating devices and aquaculture. Readily available low-toxicity and cost-effective antifouling coatings will increase the efficiency of maritime industry and constitute the enabling technology to realize new products.

The potential impacts of the project can be divided into internal and external ones. Internally, academic partners participating in BYEFOULING will train young researchers in an interfacial field in which knowledge in biology, marine sciences, chemistry, physics, materials science and engineering, as well as coating technology, come into play to generate both environmentally-friendly and high-performance products. This is a positive point when considering higher education and the competitiveness for jobs in the global market. In addition, the generated knowledge will be reflected in publications in peer-reviewed journals, which is always one of the main factors for assessment of institutions applying for funding support. From an industrial perspective, the involved SMEs and large industries have a unique opportunity to establish transnational networking while developing high-level products that can be effective in the global market.

Externally, the impact of BYEFOULING can be detailed for different sectors. In the ship transport sector, BYEFOULING will offer more efficient and less toxic antifouling coatings, the operation and lifecycle costs will be significantly reduced, thereby increasing the efficiency and competitiveness of the ship transport industry. Furthermore, the project will contribute to reducing the negative impacts on the marine environment and CO2, NOx and SOx emissions. In the aquaculture sector, BYEFOULING products will improve the performance of marine operations, with better growth rates and improved water quality, and provide a better control of disease vectors, reduced costs associated with copper waste disposal, enable lighter structures and improved resistance towards extreme weather and enhance the viability towards more stringent regulations on the use of biocides.

BYEFOULING provides new societal insights by taking into account national and transnational objectives within the EU for the future. Specifically, it pertains to several aspects of what is termed “blue growth”. BYEFOULING thus targets a new generation of materials derived directly from marine renewable resources; while the impact of antifouling coatings generated in the project will profoundly affect industrial activities directly related to the marine realm.