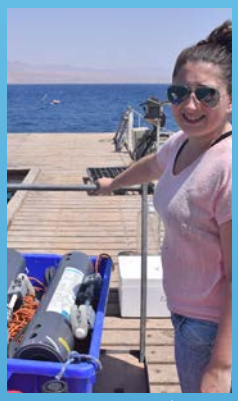
Photo: USC


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Photo: TAU

Summary description of project context and objectives

Biofouling has profound effects in different branches of maritime activities. It is the major cause for maintenance expenses of any (partially) submerged man-made surface, including ship transport, buoys, aquaculture, but also membrane bioreactors and desalination units, power plants' cooling water systems and oil pipelines. It poses also a significant problem for all the aquaculture industry, the broadest and the most documented impact being in marine finfish aquaculture. The settlement of marine invertebrates on the hulls of ships results in increased erosion, reduction of speed, increased fuel consumption and therefore 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 toxic and cost-efficient environmentally friendly antifouling coatings with enhanced performance compared to 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 is under implementation to optimize coating performance and cost all along their life cycle. A proof-of-concept for the most promising candidates is being developed and demonstrators will be produced and tested on fields.

The specific objectives of BYEFOULING are:

- 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 as a result of conventional biofouling processes and respective control measures
- reduce maintenance costs

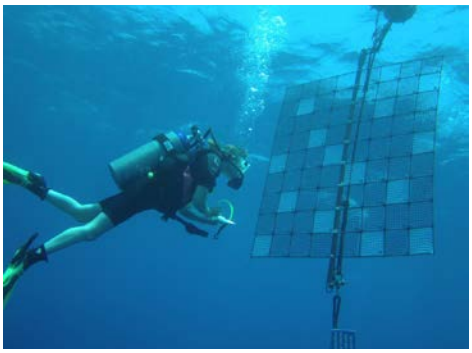
Photo: TAU

The project is organized in eight work packages (WP) and is running from December 2013 to November 2017. BYEFOULING combines a multidisciplinary consortium involving 19 partners from SMEs, large companies, research organisations and universities in Europe, able to develop a full production line for new antifouling coatings.

Description of work performed and main results

In the project management task, the internal website (eRoom) for BYEFOULING partners with detailed information on the project was updated to promote an efficient project internal communication. The homepage for public access was regularly revised with open information. EB/MST meetings were conducted monthly. The 24M meeting was held on 25.-26. November 2015 in Aveiro and the 30M meeting was held on 24-25 May 2016 in Berlin. The 24M interim report (financial and technical) was assessed and reviewed by the MST. The first periodic report was prepared and submitted to the Commission through the participant portal on 18 July 2016. An amendment of DoW/GPFs with minor changes was realised after internal revision of the project at SINTEF.

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


Photo: Jotun


Photo: SMT


Photo: USC

Innovative antifouling approaches have engaged with studies on surface structuration, protein adsorption inhibitors, quorum sensing inhibitors (QSI), natural biocides and living active species were carried out. Part of the activities performed were a continuation of the developments reported in the previous reporting period (screening of new compounds, improvement of synthesis conditions and optimization of conditions to extract biomass). In addition, the partners focused most of their final activities in these activities on the extraction, purification and identification of active components present in different extracts, for the most promising systems reported so far. This information, together with efficacy and toxicity testing obtained by WP4 will be used to build different exploitation scenarios and aid in the definition of the most promising technologies for demonstration activities.

In the tasks related to the development of antifouling coatings, the partners maintained their activities concerning synthesis and characterization of nanostructured inorganic, organic and hybrid materials that can be used as reservoirs for the encapsulation of active species, including dormant microorganisms with antifouling properties. Optimization of experimental conditions for synthesis, studies on release of active species and fitting of kinetic models were carried out during the present reporting period. The task concerning encapsulation of active microorganisms was completed according to the plan and the results concerning the encapsulation of bacteria spores are quite encouraging. Several partners were also involved in the preparation of nanostructured materials for testing in WP4 and in the preparation of coatings for the second phase of field tests, to be launched early next reporting period. Additional focus was given to waterborne coating formulations and to the combination of different BYEFOULING technologies aiming at achieving synergistic antifouling actions.

In the task on antimacrofouling activities and benchmarking, activities were carried out on antifouling efficacy testing at lab-scale both against micro- and macrofoulers, mesocosm tests and ecotoxicity testing on a variety of model system in the food web. In addition, the results obtained from the first field tests were compiled, processed and enabled coordination of the subsequent work related to the launching of the second field tests. Finally, compilation of results obtained so far allowed an appropriate comparison of BYEFOULING substances with commercially available ones.

Data on surface characterization have been acquired in the coating testing activity. Partners performed a literature review, established experimental characterization techniques and bacteria cultures now produce biofilms. Initial experimental results have been obtained on biocorrosion.

Activities related to the development of mathematical models for drag reduction prediction and to LCA have been realized. With respect to fundamental studies, partners have done several measurements to investigate the adhesion of cyprid-larvae on different coated surfaces and corrosion of mild steel was investigated in the presence and absence of sulphate-reducing bacteria. Furthermore, testing of coating formulations properties, such as viscosity, adhesion and stability was carried out for model formulations containing different nanostructured materials produced within the frame of project.

Partners compiled procedures to estimate the release of antifouling compounds from paints and compared with the parameters required for simulation of environmental concentrations in specific software packages.

Photo: USC

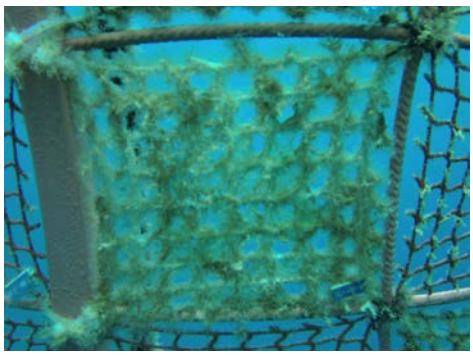
Photo: TAU

Experiments were performed to obtain data for validation of models for drag reduction prediction. LCA analysis was accomplished and models refined using data provided by industrial partners.

Moreover, selected BYEFOULING technologies were analysed using paint and maritime transportation models.

Upscaling of active compounds and nanostructured materials was initiated, the design of a 3-D demonstrator was completed and the testing of demonstrators for the next reporting period similarly was defined.

Photo: USC

Several dissemination activities have been realised, including organization of training courses, short visits and specific tools (public website and newsletters) for dissemination. The second BYEFOULING workshop was organised by TAU, in collaboration with ABT and MNOVA.

It was carried out in collaboration with the EU-funded project SEAFRONT under the auspices of the 18th International Congress on Marine Corrosion and Fouling in Toulon (19-24 June 2016). The Joint Workshop addressed the theme: “Bridging the gap between academia and industry – A collaborative enterprise”. The activity reflected the need for joint collaboration between academic and industrial partners in the field of fouling.

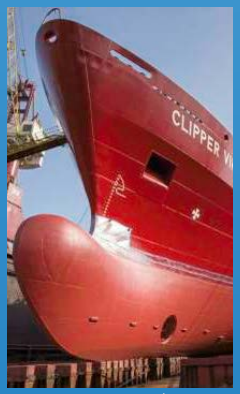

Photo: Jotun

Expected final results and potential impacts

The BYEFOULING project addresses high volume production of low toxic and environmentally friendly antifouling coatings for mobile and stationary maritime applications. The technology will fulfil the coating requirements because 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 toxic and cost-effective antifouling coatings will increase the efficiency of maritime industry and be the enabling technology to realize new products.

There are both potential impacts inside and beyond the consortium. Internally, academic partners (universities, research institutes) participating in BYEFOULING will form young researchers in an interfacial field where knowledge on biology, marine sciences, chemistry, physics, materials science and engineering, and coating technology come into play to generate more environmentally-friendly and at same time high performance products. This is a strong positive point when considering high-level education and competitiveness of jobs in the global market. In addition, the generated knowledge will be reflected upon publications in journals of high impact factor, which is always one of the main factors for assessment of public institutions applying for funding supports. From an industrial perspective, the involved SMEs and large industries have a unique opportunity to establish transnational networking and to develop high-level products that can be disruptive 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 reduce 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, improve water quality and provide a better control of disease vectors, reduce costs associated with copper waste disposal, enable lighter structures and improve resistance towards extreme weather and enhance the viability towards more stringent regulations on the use of biocides.

Finally, BYEFOULING is a project that opens new societal insights taking into account national and transnational objectives within EU for the forthcoming years. Specifically, it pertains to several aspects of so-called blue growth. In this sense, BYEFOULING is targeting the generation of new materials coming directly from marine, renewable resources. On the other hand, the impact of antifouling coatings generated in BYEFOULING will have a profound impact on industrial activities directly related to the marine sector.