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 ship hulls results in increased erosion, reduction of speed, increased fuel consumption and therefore increased air pollution and CO2 production.

Photo: TAU

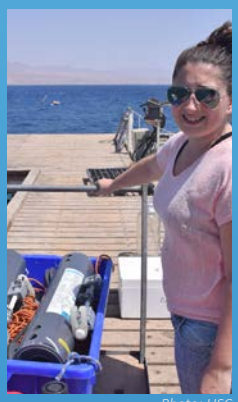

Photo: USC

Photo: Jotun

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 will be implemented to optimize coating performance and cost all along their life cycle. A proof-of-concept for the most promising candidates will be developed and demonstrators will be produced and tested on fields.

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

The project is organized in 8 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. In WP1, the project is coordinated and directed according to a work plan. In WP2, novel compounds, development of interfacial microstructures, and preparation and growth of antifouling microorganisms are under investigation. In WP3 different tools are used to incorporate the new antifouling approaches into coating formulations, including encapsulation to protect compounds from the coating matrices and to enable controlled release of active species, preparation of functional fillers with hydrophobic and biocide-active functional groups, and development of waterborne coating formulations. In WP4, assessment of antifouling performance and benchmarking of the obtained systems with commercial and state-of-art technologies are carried out. Ecotoxicity measurements are performed to investigate the effect of the developed materials in the ecosystems. In WP5, relevant parameters for application of coating formulations in subsequent stages are under testing and characterisation. In addition, fundamental studies on adhesion of fouling organisms and effects of fouling on biocorrosion are under investigation. In WP6, reliable methods for evaluation of drag resistance of vessel hull coatings and for the application of holistic and comprehensive assessment tools such as Life Cycle Assessment (LCA) are under development. In WP7, demonstration activities will be performed aiming at preparing three types of demonstrators, specifically for ships, aquaculture and buoys. To obtain enough paint and related components, up-scaling of the most promising technologies will be implemented. In WP8, the results are disseminated and exploited. SMEs and industrial partners will in particular use the developed technology to address new market areas.

Photo: USC

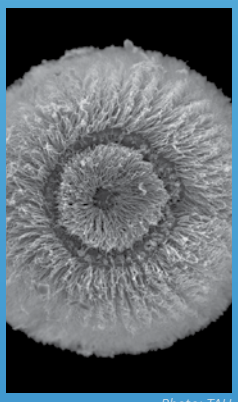
Photo: TAU


Photo: SMT

Description of work performed and main results

In WP1, coordination of the project was realised at different levels: day-to-day coordination, establishment of a web-site for efficient internal communication, organization of regular meetings within the Management Supporting Team and executive board, establishment of a progress reporting routine, review of the technical work performed and the submission of deliverables. Additionally, implementation of decision procedures related to dissemination of the main project results is perfomed. Financial and legal issues handled during the first 6 months were based on implementation and fulfilment of a Consortium Agreement. The EC financial support received was distributed among partners and an overall project plan and follow-up of cost and work performance established. A draft of the risk management plan was presented in 6M meeting.

In WP2, studies on surface structuration, protein adsorption inhibitors, quorum sensing inhibitors and natural biocides and living active species were initiated. For surface structuration, the feasibility of obtaining double wavelength wrinkled surface with labyrinth morphology has been shown and the production of textured samples has started. With respect to protein adsorption inhibitors, two types of systems are being studied: peptide-like and poly-zwitterionic materials. Different peptoids were successfully synthesized and the synthesis capacity increased; the set up and optimization of a testing protocol for zwitterionic materials under development is established and a robust protocol for the synthesis of different “zwitterionic polymers” launched. In terms of quorum sensing inhibitors and natural biocides, the main efforts have been focused on establishing the most suitable microorganisms and techniques for the screening of the quorum sensing inhibitors and algal biocides. Lastly, in the field of Living Active Species, freeze-dried cells of different bacteria strains have been produced and sent to several partners in WP3, so initial work in encapsulation could start soon.

In WP3, synthesis and characterization of nanostructured inorganic, hybrid and polymeric materials that can be used as reservoirs for the encapsulation of active species was initiated. Additionally, synthesis of fillers with functional groups attached to the surface to impart hydrophobic or biocide functionalities have been initiated. Attempts for encapsulation of living microorganisms prepared in the frame of WP2 have started.
In WP4, normalization of procedures to characterize antifouling systems is completed and verified using commercial samples. Protocols are written for: laboratory tests on anti-microfouling efficacy, laboratory tests on anti-macrofouling efficacy, mesocosm efficacy tests of the antifouling paints, field efficacy tests of the antifouling paint prototypes.
In the frame of WP5, data about surface characterization are collected. With respect to fundamental studies, partners have performed literature review, set up of experimental characterization techniques and cultures of bacteria have started to produce biofilms.

In WP6, activities related to the development of the mathematical models for drag reduction prediction and activities related to LCA were performed.

In WP7 there were no activities planned in this period.

In WP8 several dissemination activities have been realised, including designing a logo, launching a user friendly website (www.byefouling-eu.com), preparing a leaflet published by the European Commission, promoting the project in local press and international journals and conferences and designing a poster and a Powerpoint presentation of the project.
An outline of dissemination plan and activities was presented during the project kick-off meeting and since then, dissemination activities have been routinely updated.

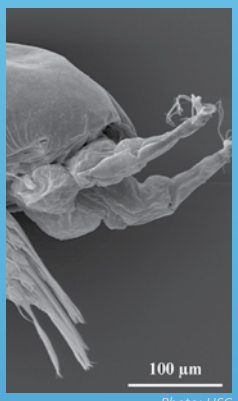

Photo: USC


Photo: USC


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 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 toxic and cost-effective antifouling coatings will increase the efficiency of maritime industry and be the enabling technology to realize new products.

The potential impacts of the project can be divided into internal and external ones. Internally, academic partners (universities, research institutes) participating in BYEFOULING will introduce young researchers in an interdisciplinary field where knowledge on biology, marine sciences, chemistry, physics, materials science and engineering, and coating technology are combined to generate 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 high impact factor journals, which is always one of the main factors for assessment of public institutions when looking for funding supports. From an industrial perspective, the involved SMEs and large industries have a unique opportunity to establish transnational networking developing 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 life cycle costs will be significantly reduced, thereby increasing the efficiency and competitiveness of the ship transport industry. Furthermore, the project will 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, improved water quality and better control of disease vectors, reduce 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.

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


Photo: TAU

SEVENTH FRAMEWORK PROGRAMME