Layman's Report

LIFE PAINT-IT Project

An overview

FOR THE PERIOD 2016-2020

A new environment-friendly manufacturing approach for marine antifouling coating

LIFE 15 ENV/IT/000417 PAINT-IT

Project co-funded by the European Commission within the Life + Programme (2014-2020)
(**% EU Co-funding on eligible costs: 59.96**)

PROJECT INFO

LIFE 15 ENV/IT/000417 PAINT-IT

A NEW ENVIRONMENT-FRIENDLY MANUFACTURING APPROACH FOR MARINE ANTIFOULING COATING

Coordinating beneficiary

- **UNITOR**

University of Rome «Tor Vergata»
Department of Enterprise Engineering

Associated beneficiaries

- **UNICUSANO**

University of Rome «Niccolò Cusano»
Department of Engineering

- **AZIMUT**

Azimut-Benetti SpA
(Avigliana, TO, Italy)

- **CERICOL**

Colorobbia Consulting Srl
(Sovigliana-Vinci, FI, Italy)

Project duration

01/10/2016 – 31/10/2020

Project location **ROME**
Other locations **VINCI, AVIGLIANA, VIAREGGIO**

Project budget **5,712,506 €**
Project eligible costs **2,148,506 €**
EC Contribution **1,288,163 €**
(59.96% of total eligible costs)
Beneficiaries' Contribution **4,424,343 €**

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PROJECT AIM

The LIFE PAINT-IT Project is aimed to develop innovative non-toxic antifouling paints for naval applications, by the transfer of the production from the laboratory scale to the prototype plant.

The high environmental sustainability of the formulations is due to the complete absence of release into the marine environment of biocides harmful to the aquatic species, unlike what happens in traditional antifouling paints which continuously release biocides in the EU seas based on the toxic action of copper and its organo-metallic compounds.

In addition to the nautical sector (ships and yachts industry, marine platforms, offshore plants) the tested formulation can be extended to other potential applications such as civil construction, wastewater treatment plants and in general plants involving water systems and pipelines in different industrial production processes (food sector, bioplastics, etc.).
A potential application concerns the efficiency of heat exchangers which can be seriously reduced by the formation of biofouling, as well as the surface pollution due to the formation of biofilms inside the ducts of cooling systems which require periodic cleaning and maintenance. These significantly affect the productivity of the plants with the generation of waste and the consumption of resources.

POLICY FRAMEWORK ANALYSIS AND IMPACT

Considering the environmental benefit that the commercialization and the broad application of a product such as Paint-it might bring, it is worth considering the policy framework affecting the antifouling paints market. An initial critical step forward towards more environmentally safe ships antifouling solutions was represented by the adoption of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS Convention). The convention promoted by the International Maritime Organisation (IMO) banned the application of tributyltin-oxide (TBT) coatings on ships starting from 2003. Organotin compounds, including TBT, are aggressive biocides that have been widely employed since the 1960s, that are toxic for a variety of aquatic species as well as for humans, due to food-chain contamination (*Marine Antifoulants: Tributyltin Case Study # 8 Presented by: Jacob Etzkorn & Brian Allan for CHEM 301: Aqueous Environmental Chemistry*).

AFS Convention banned, starting from 2003, the application of TBT antifoulants for ships and indicated the end of the full phase-out period in 2008. The European Union, following the AFS Convention, adopted the EC Regulation (Regulation EC No 782/2003 of the European Parliament and of the Council of 14 April 2003 on the prohibition of organotin compounds on ships) stating that, starting from January 2008, "ships that enter a port or offshore terminal of a Member State (..)" (including those entitled to fly a flag or operating under the authority of a Member State) cannot bear organotin compounds antifoulants unless an additional coating layer is protecting the aquatic environment from the leaching of the banned biocide. It is necessary to highlight that other biocidal substances other than TBT are currently employed in antifouling solutions entailing the release of biocides into seawater, potentially harming humans and the environment. According to EU Regulation 528/2012, "Biocidal Products Regulation" (Regulation EU No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products), that entered into force in September 2013, biocidal products (employed in different sectors) require a preliminary assessment and approval before being marketed. "Annex V" of the regulation includes, as "Product-type 21", anti-fouling products "used to control the growth and settlement of fouling organisms (..) on vessels, (..) or other structures used in water" (it is worth noticing that also underwater pipelines coating is included in the scope of the regulation). In this sense, despite TBT and other solutions have been and might be banned, the use of several biocides substances is currently approved. It is worth highlighting that the Biocidal Products Regulation also indicates, as the recommended quantity of biocide, the minimum necessary to obtain the desired effect. With this regard, copper-based products are still available in the market despite they proved to have negative environmental effects and copper oxide is still the most widespread biocide in anti-fouling paints (Reducing copper oxide biocides used in antifouling paints for ships in Baltic sea, LIFE Fit for REACH).

POLICY FRAMEWORK AND PAINT-IT KEY POINTS

- Non biocidal antifouling paints such as Paint-it might represent a significant alternative that, in principle, would not be subject to the mentioned EU Regulation as it implies a 100% toxic biocides reduction and a 100% copper reduction, but the regulation remains relevant by affecting competing widespread products. In this sense, cuprous oxide is currently the most widespread biocide in antifouling paints (*M. Lagerströma E. Ytreberga, A. K. E. Wiklundb, L. Granhag, 2020, Antifouling paints leach copper in excess - study of metal release rates and efficacy along a salinity gradient*) involving copper leaching in water. Anyway Paint-it product is subject to the EC Regulation No 1907/2006 (REGULATION EC No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the registration, evaluation, authorisation and restriction of chemicals - REACH) aiming at ensuring human and environmental health protection requiring the identification and the evaluation of hazards and risks associated to chemicals. In this sense, manufacturers, importers, and downstream users are required to assess the risk associated to the substances they produce, import or use. Substances on their own, or in mixtures and articles are affected by the regulation as well as those whose production or import exceeds one tonne per year (ECHA, European Chemical Agency, 2017, Registration, Guidance in a Nutshell - Version 3.0).
- The manufacturing and commercialization of Paint-it product would be in line with the purpose of the Water Framework Directive (EC Directive No 2000/60 of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) entailing the protection and the prevention of 'further deterioration' of aquatic ecosystems by providing a 'green' viable alternative antifouling paint that does not imply the emission or discharge of priority and priority hazardous substances (including Tributyltin compounds) listed in EU Directive 2013/39 (EU Directive 2013/39 of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 008/105/EC as regards priority substances in the field of water policy).
- At the same time, with regard to the Marine Strategy Framework Directive (EC Directive 2008/56 of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy - Marine Strategy Framework Directive) the Paint-it product would be consistent with the aim of achieving good environmental status (by the year 2020) and especially referring to attaining the reduction of inputs in the marine environment "(..) so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health (..)". Paint-it would relate to "Contamination by hazardous substances" as part of the "Pressures and impacts" list, specifically referring to antifoulants but also in relation to heavy metals (such as copper).
- Finally, the Paint-it solution potential to further reduce the average fuel consumption is consistent with the EU objective of reducing greenhouse gas emission especially in relation to the Paris Agreement aim. In this sense, with the purpose of extending the European Union emission reduction commitment to the maritime transport context, a strategy has been defined in 2013 (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Integrating maritime transport emissions in the EU's greenhouse gas reduction policies 2013).
- Three steps are envisaged: an initial period, that started in 2018, to monitor, report and evaluate CO_2 emissions from ships above 5000 gross tonnage loading or unloading either passengers or shipment in a European Economic Area port. This data collection process will allow to set suitable emission reduction targets for the sector and the application of market-based measures. Paint-it introduction in the sector would have a beneficial effect supporting the overall emission reduction commitment within the European market, reducing fuel consumption and in turn the CO_2 emitted.

PAINT-IT Project solution & targets

HOW

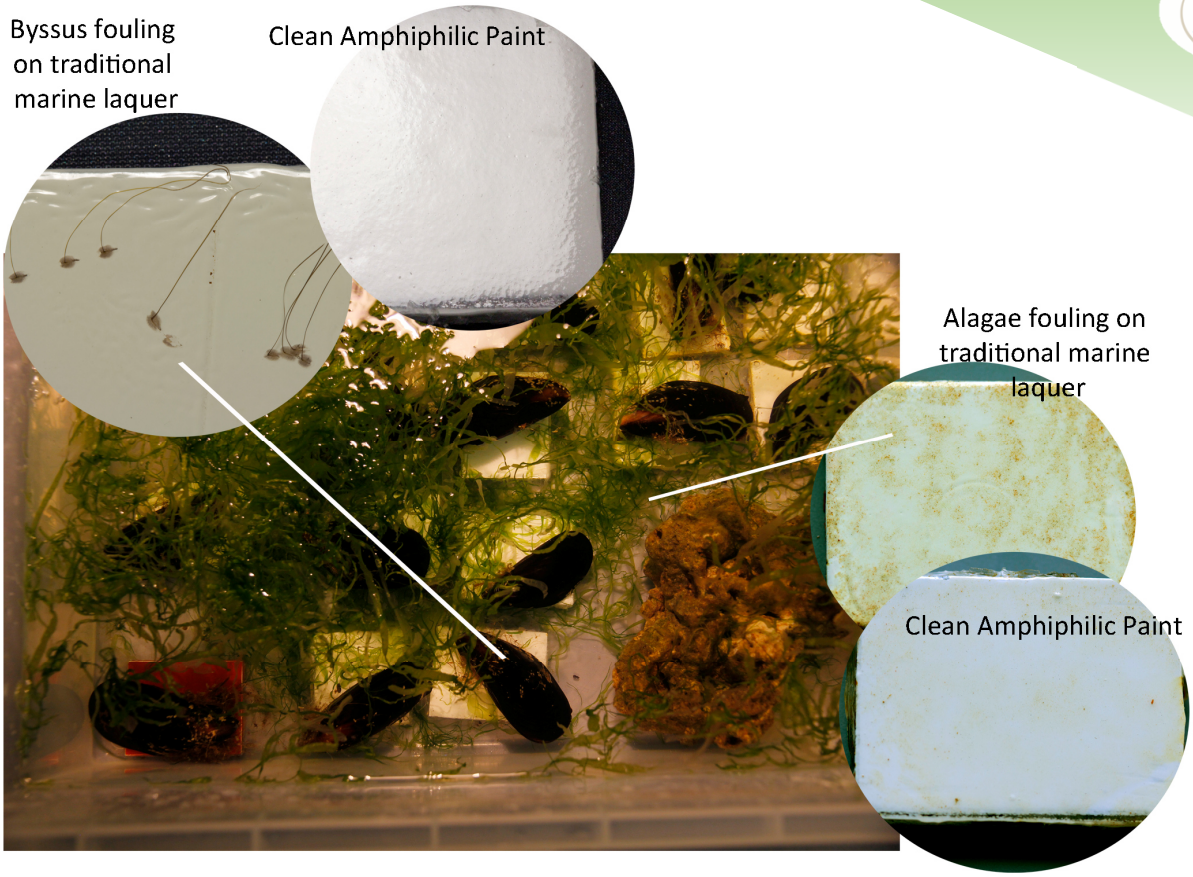
By targeting the functionalization of organic-inorganic hybrid resins, exploiting available raw materials, it has been shown that it is possible to produce coatings capable of physically disorienting marine species thanks to a mixed amphiphilic structure of the surface formed…

WHAT **Demonstration of a novel anti-fouling paint for naval application:**

- ***Formulation of environmentally high-quality safe antifouling paints***
- ***Pre-industrial scale production***
- ***Validation on real-to-close conditions***

WHY **Significant expected environmental and technical benefits:**

- ***100% reduction of biocides in marine ecosystems***
- ***Decrease of waste due to reduction of hull maintenance activities***
- ***Consistent reduction in CO_2 emissions due to reduced friction on clean vessels (up to 19.2 million tons CO_2 eq)***



The Consortium

UNITOR *University of Rome «Tor Vergata» -Department of Enterprise Engineering:*
«Tor Vergata» stands out in the World University Ranking among the top universities for the teaching quality student learning. It is ranked for the Times Higher Education (THE) in the range 401-500 for the 2021. At national level is in the 11th place on 49 Italian universities in the ranking.

UNICUSANO *University of Rome «Niccolò Cusano» -Department of Engineering:*
«Niccolò Cusano» is a consolidated university study center aimed at education, medical and scientific research and technologies for the environment, which provided its support to the toxicological characterization and development of the environmental impact analysis.

CERICOL *Colorobbia Consulting Srl – Centro Ricerche Colorobbia (Sovigliana, FI, Italy):*
This Italian Company with experience in the synthesis, scaling-up and industrialization of chemical products, in particular formulations of nano-materials, has provided the knowhow for plant design and production of the new formulations.

AZIMUT *Azimut-Benetti SpA (Avigliana, TO, Italy):*
Azimut-Benetti is an international private group builder of yachts, producer in its six shipyards and with its two brands of over 40 models for the widest range of production in the sector worldwide, which has provided expertise as an end-user for the application of the formulations on real hulls.

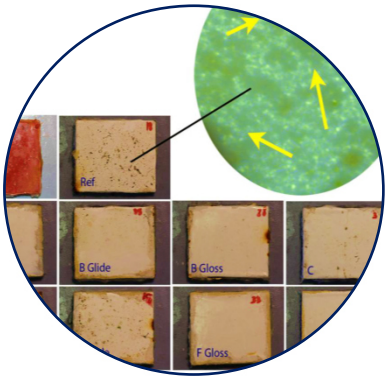
Project's structure

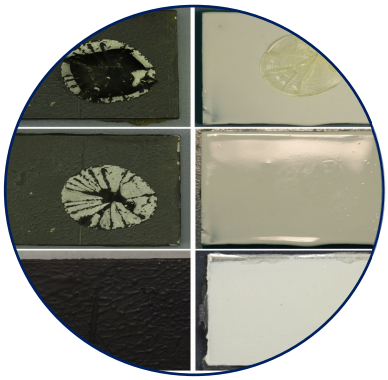
ACTION A: Preparatory actions	ACTION B: Implementation actions	ACTION C: Monitoring of the impacts of the project actions	ACTION D: Communication and dissemination	ACTION E: Management and monitoring of the project progress
Set of activities to finalize the antifouling formulation to be scaled-up	***Demonstration of the capability of the pilot plant***	***Life Cycle Assessment (LCA) analysis (ISO 14040:2006, 14044:2006)***	***Impact of project results at national/ EU scales***	***Administrative and network activities***
➢Adjustments of the coating formulation on the physical, mechanical and functional properties ➢Choise of the most promising formulations, curing and application processes	➢Design and construction of the pilot plant ➢Manufacture over a long-time range (continuous mode), production assessment and testing of the coating performance ➢Preparation and use to refit the hull of the targeted vessels ➢Evaluation of the performance of the repainted vessels in a harbour calm water and during operation at sea/lake	➢Assessment of the environmental impact with a cradle-to-grave approach ➢Evaluation of the entire production chain from raw materials to products disposal ➢Toxicological analysis: chemical analysis and biological tests	➢Written information, electronic media, and person-to-person contact ➢Establishment of connections with relevant stakeholders (industrial paints producers, applicators, etc.)	➢Administrative tasks, contingency planning, technical and quality monitoring and reporting ➢Giving indications for network activities with consortia of similar projects and for the After-Life plan

Project implementation

Technology Readiness Levels TRL

An evaluation of the readiness of the project's solution can be considered based on a TRL scale…





TRL 5

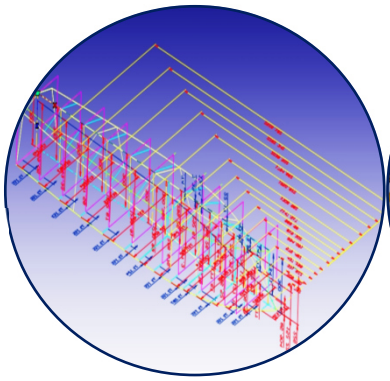
Laboratory-scale validation of the coatings

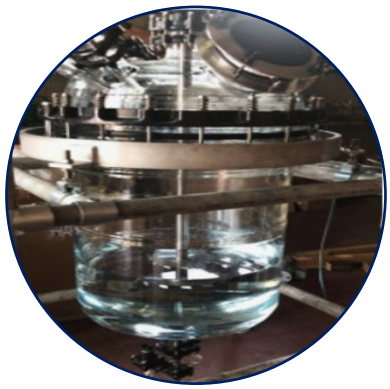
Lab research, formulation for the scaling-up, functional properties assessment, and mechanical evaluation

TRL 6

Comparative validation of the coatings on small-scale hulls in close-to real conditions

Modelling on small-scale hulls (2.5 m) and comparative tests in controlled conditions (Iseo Lake, BS, Italy)





TRL 7

Production in prototype plant and validation on medium/large-scale hull (80 feet) in close-to-real conditions

- **Prototype plant constructed and operating**
- **Application on AB 77S and AB V40 YACHTS hulls and tests in open sea**

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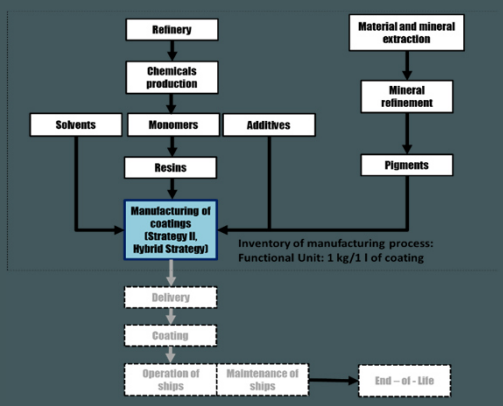
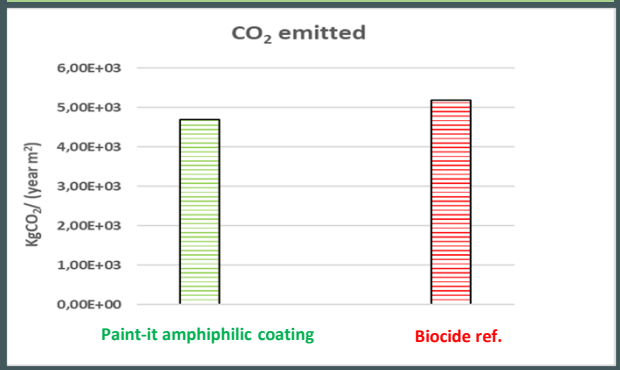
Environmental assessment results

Life Cycle Assessment (LCA)

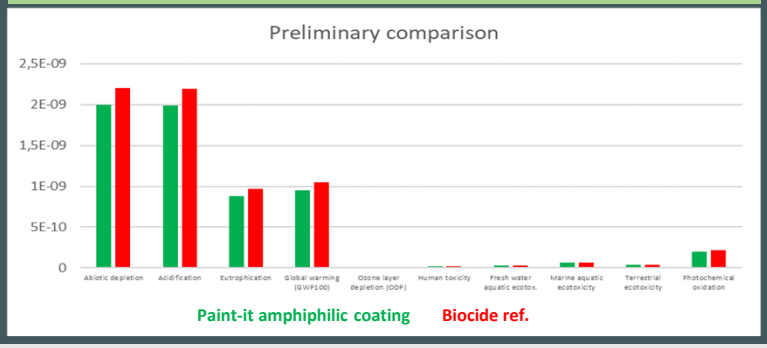
The whole environmental impact from the production phase to disposal was evaluated according to a «cradle-to-grave» approach



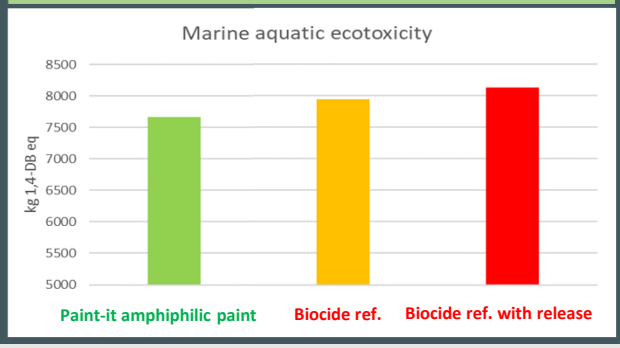
Direct CO_2 emission saving during navigation (from comparative towing tests at TRL 6)



Environmental indicators calculated from LCA



Marine aquatic ecotoxicity indicator calculated from LCA



Toxicity Evaluation

All the implementation steps were evaluated, from the coatings obtained in laboratory-scale to those ones obatined in pre-industrial scale

ECOTOCITY TEST with Chlamydomonas reinhardtii wild ALGA

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Decalogue of results achieved

Environmental benefits

1. Total absence of biocides like copper compounds, thus total reduction of their release into the environment (of any type and class), particularly the reduction of copper release after 5 years from the end of the project was calculated considering initial average release in EU seas from traditional antifouling paints of 5000 tons/year. Assuming a market penetration of 20% after 5 years, the copper release is reduced by the same rate with our ecological paint.

2. No toxicity demonstrated by laboratory toxicological analyzes (due to the possible release of toxic components and/or by-products).

3. Total absence of fluorinated compounds, highly toxic components, and hazardous solvents in the formulation, therefore absence of release of these compounds into the environment.

4. Reduction of 10% (within the expected 5 ÷ 20% range) in fuel consumption and corresponding CO_2 emissions (calculated on the project baseline, i.e., of an 88-foot boat with traditional antifouling paint having an average fuel consumption of 648 l/h, and assuming a CO_2 production of 3.188 kg per liter of fuel consumed).

5. Reduction in GHG emissions (CO_2 eq and SO_2/SO_x) compared to the use of a traditional antifouling: reduction of 9.4% for global warming GWP100 indicator and 9.5% for Acidification indicator.

6. Reduction of waste production due to the possible reduction of hull maintenance activities and reduction of the frequency of maintenance cycles.

7. Reduction of highly toxic residuals from the waste originated from scrubbing of the solid coating from a hull.

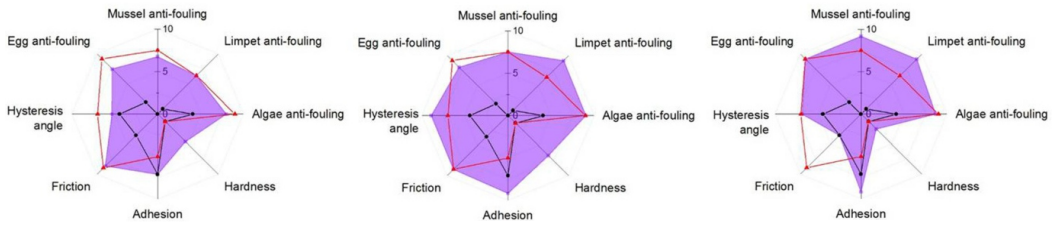
Technological results

8. Mechanical resistance of the coating due to the chemical composition of the base resin (polyurethane matrix combined with silicone component)

9. Kind of self-cleaning properties (silicone component)

10. Simple industrial processability for the formulation production, implying a low-risk process.

Properties radar plots of the Paint-it products from laboratory testing



Paint-it F *Paint-it G* *Paint-it I*

Results of applied formulations suggest a wide range of customizable solutions, towards wide replication potential!

Final actions implemented for the Exploitation

- ✓ ***Market analysis and definition***
- ✓ ***Business strategy and possible business plan for the production by the prototype plant (30 tons/y)***
- ✓ ***Preliminary socio-economic assessment for future 5-10 years***

SWOT ANALYSIS

Strengths: among the major strengths of the Paint.it product are a) it does not release Biocides and therefore avoid the discharge of toxic substances, b) CO2 savings c) Reduction of SO2 emissions Furthermore, the low toxicity of the organic components is a further strength compared to the closest competitor product.	**Weaknesses**: at the current stage of development, only one product is available and not a range and this limits the offer; furthermore, there are no comparative tests for each of the competing products on the market; finally, the product was only tested on a pilot scale.
Opportunities: the product follows the EU recommendations for limiting the use of biocides: unfortunately, however, the limitation on the use of biocides exists only for Tin-based compounds. However, it is thought that in the following years the issue will be increasingly felt and having a low toxicity product represents an advantage.	**Threats**: the threats are represented on the one hand by new emerging technologies and on the other by the possible lack of possibility of free commercialization in case the current producers had patented a similar product. In addition, the player who is going to sell is confronted with giants in the sector for many years.

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