Strategie di mitigazione da inquinamento da microplastiche

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DIPARTIMENTO INGEGNERIA CHIMICA MATERIALI AMBIENTE
SAPIENZA UNIVERSITÀ DI ROMA
FOIR
Ordine degli Ingegneri della Provincia di Roma
ATIA ISWA ITALIA
AIDIC Associazione Italiana di Ingegneria Chimica
con il patrocinio di
ASSOAmbiente

"INQUINAMENTO DA MICROPLASTICHE NELLE ACQUE: STATO ATTUALE E STRATEGIE FUTURE"

Prospettive professionali ed industriali

10 Maggio 2023
Facoltà di Ingegneria Civile e Industriale
La Sapienza,
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DIRECTOR: PROF. TEODORO VALENTE

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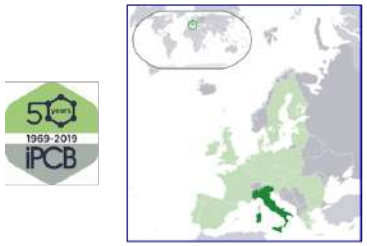
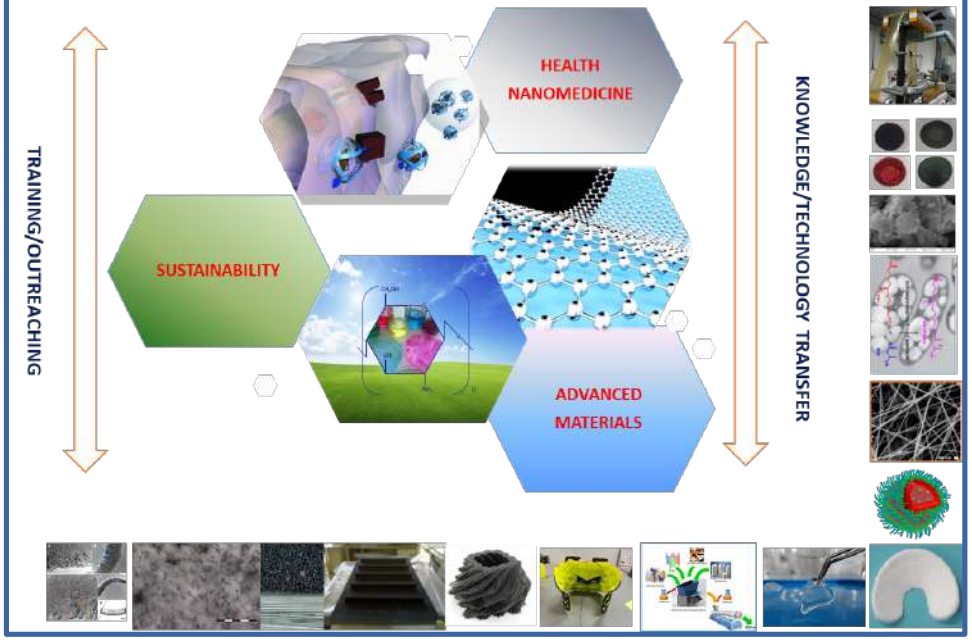
- 22 TECHNICIANS
- 6 ADMINISTRATIVES
- 20 RESEARCH FELLOWS
- 30 ASSOCIATE MEMEBRES

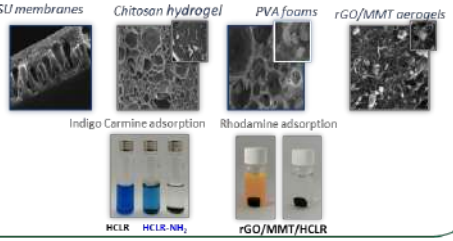


RESEARCH PLATFORMS

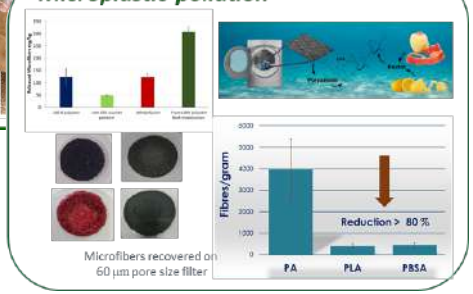


biodegradable and biobased polymeric materials

Hierarchical porous structures for Environmental applications

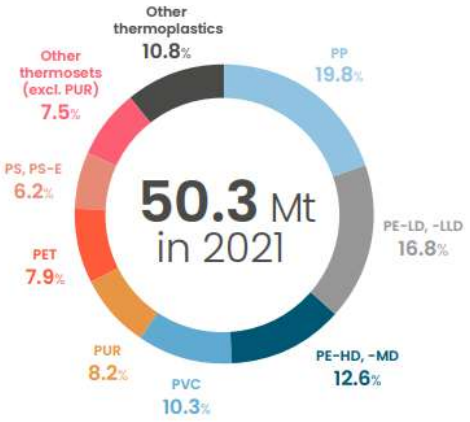


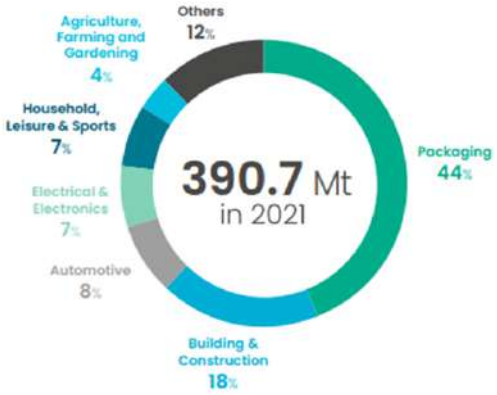
Microplastic pollution



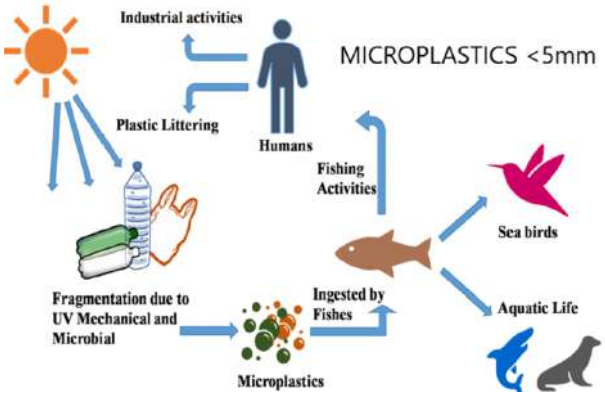
recycling of polymers and composites

PLASTIC & ENVIRONMENT

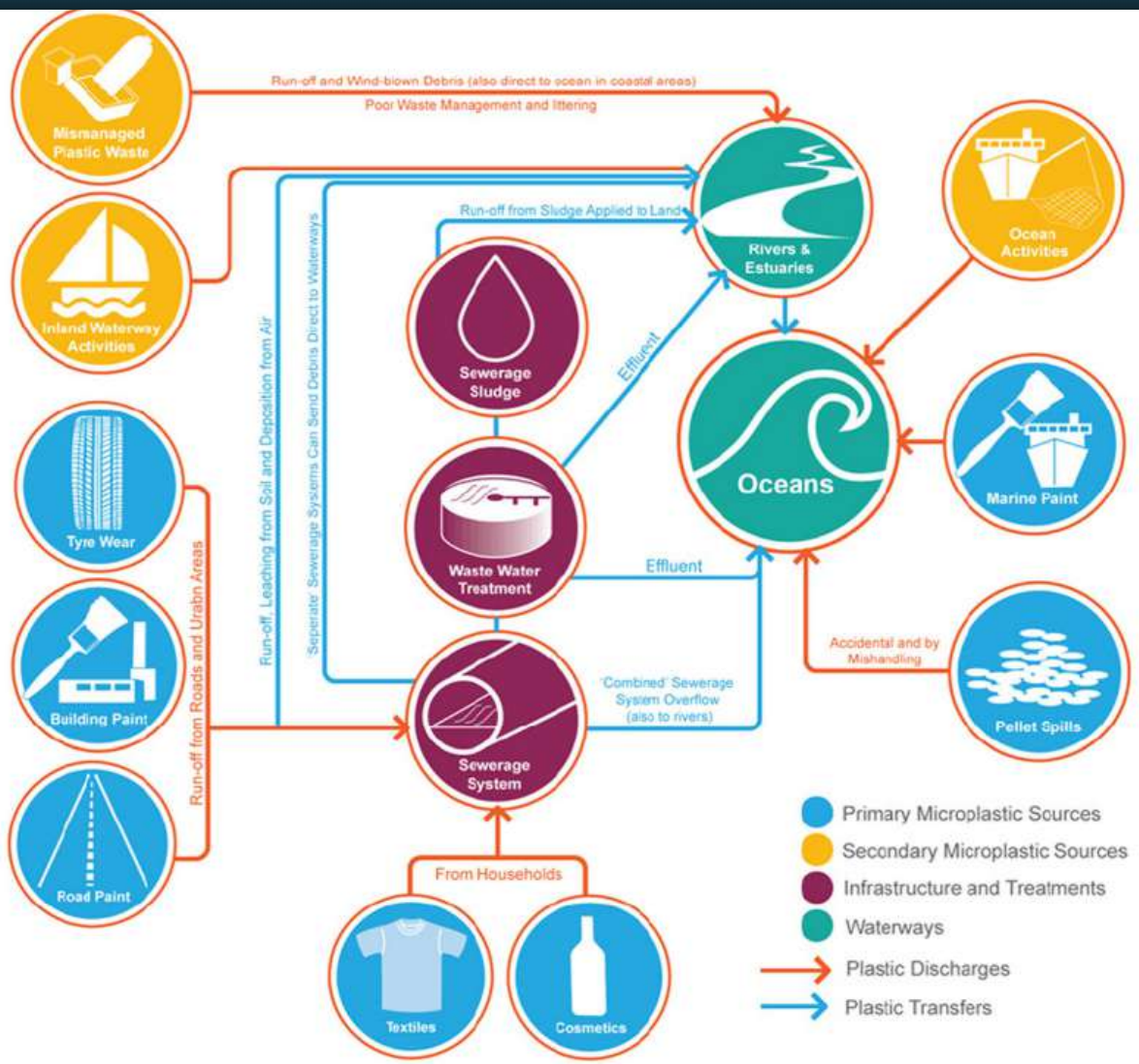




European plastics converters demand by segment in 2021
[*PlasticsEurope, Plastics – the Facts 2022*]



MICROPLASTICS SOURCES

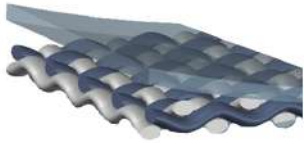


[Eunomia 2015]

MITIGATION STRATEGIES

Preventive measures to avoid MPs generation/ entrance in the environment

Preventive measures to avoid secondary MPs generation/ distribution in the environment



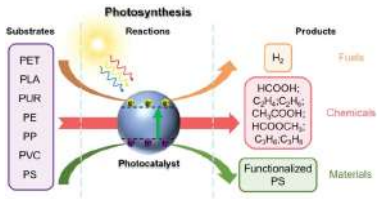
Coating

Ocean Plastic collection and upcycling

Filtration system for washing machine

Biodegradable and compostable polymers

Liquid laundry detergent formulations



Degradation techniques

MITIGATION STRATEGIES: microplastics released from textiles

It is generally recognized that the presence of microplastics released from textile in the environment is mainly due to the washing and wearing process of synthetic fabrics.

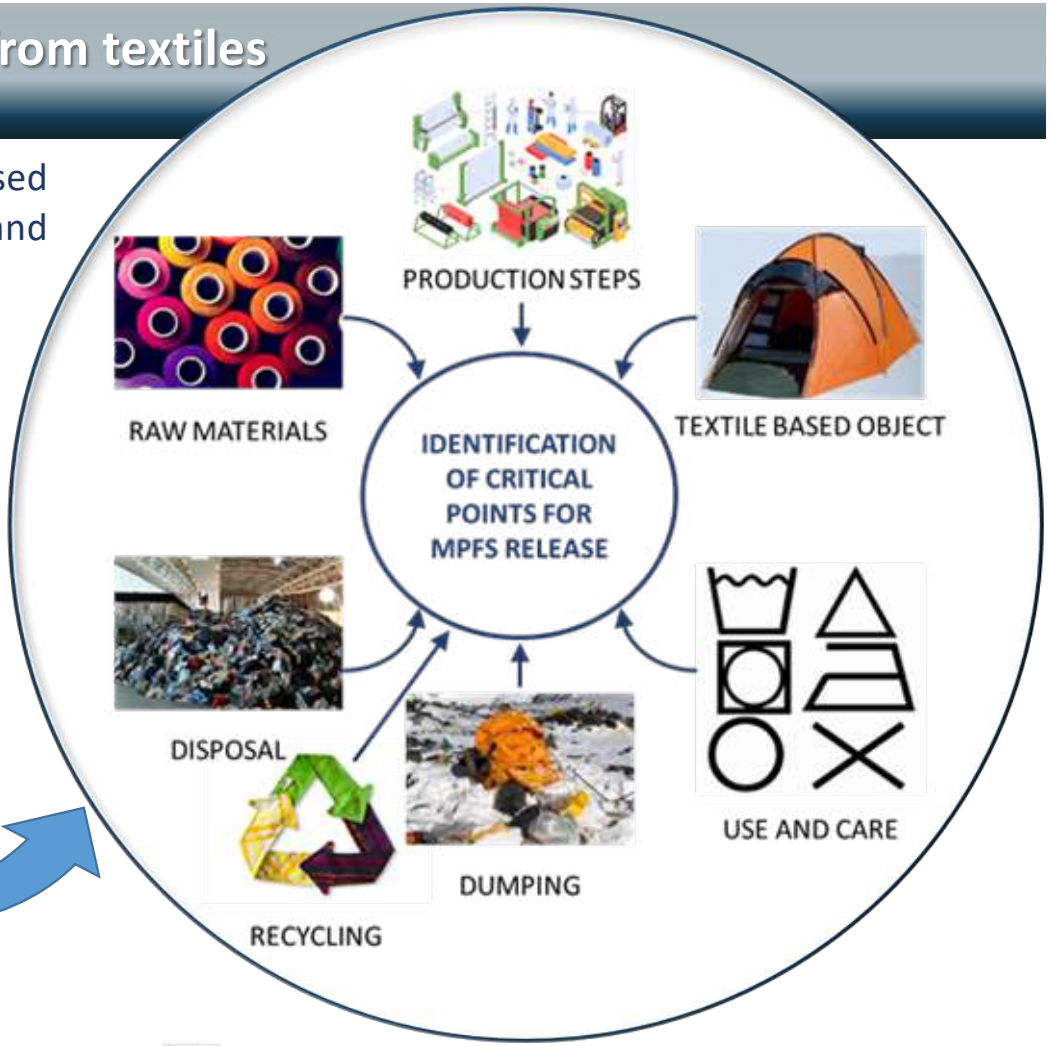
Environmental Pollution

Evaluation of microplastic release caused by textile washing processes of synthetic fabrics

SCIENTIFIC REPORTS

OPEN The contribution of washing processes of synthetic clothes to microplastic pollution

Francesca De Falco, Emilia Di Pace, Mariacristina Cocca & Maurizio Avella



mermaids. OCEAN CLEAN WASH

Environmental Science & Technology

Microfiber Release to Water, Via Laundering, and to Air, via Everyday Use: A Comparison between Polyester Clothing with Differing Textile Parameters

Francesca De Falco, Mariacristina Cocca, Maurizio Avella, and Richard C. Thompson

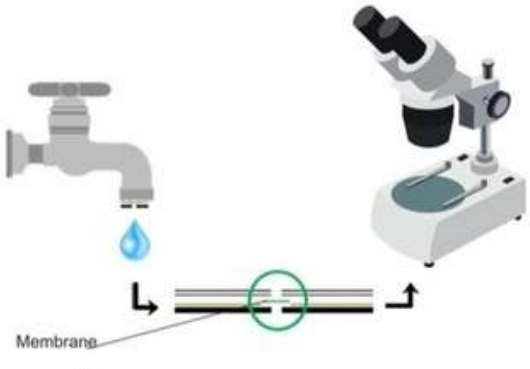
scientific reports

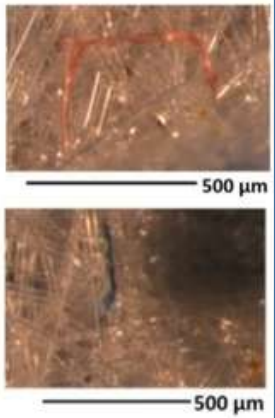
OPEN Washing load influences the microplastic release from polyester fabrics by affecting wettability and mechanical stress

The overall importance of textiles as a source of microplastics for the environment is underestimate

MITIGATION STRATEGIES: microplastics released from textiles

Microplastics of fibrous shape have been detected everywhere …. in sample for human consumption





microplastics

MDPI

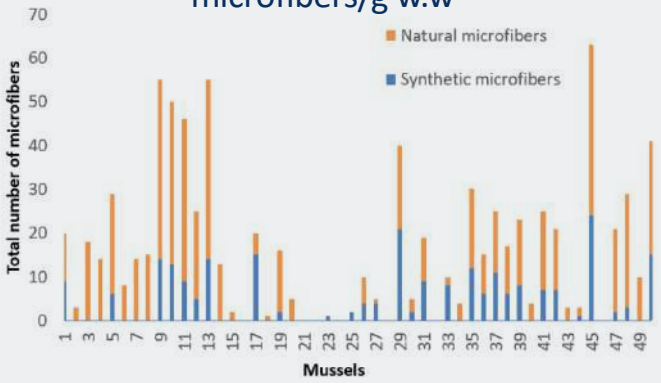
Article

Microfiber Contamination in Potable Water: Detection and Mitigation Using a Filtering Device

Michela Volgare [1], Roberto Avolio [1], Rachele Castaldo [1], Maria Emanuela Errico [1], Hakim El Khiar [2], Gennaro Gentile [1], Andreja Sinjur [3], Danilo Susnik [3], Andrej Znidarsic [3] and Mariacristina Cocca [1,*]

Mytilus galloprovincialis

Synthetic and natural microfibers were present in 74% of mussel samples, with a mean number of 14.57 microfibers/individual, corresponding to 3.13 microfibers/g w.w



scientific reports

OPEN **A versatile approach to evaluate the occurrence of microfibers in mussels *Mytilus galloprovincialis***

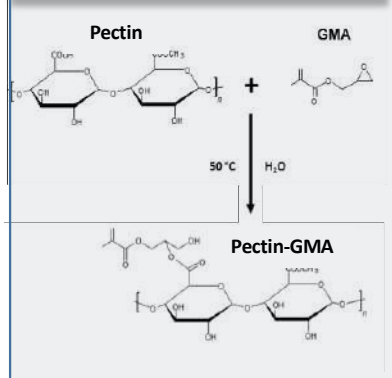
Bee & Honey

Data not published, results from SI IZS ME 08/21 RC - Caratterizzazione e mappatura di microplastiche su api e prodotti dell'apicoltura nell'areale campano – finanziato dal Ministero della Salute.

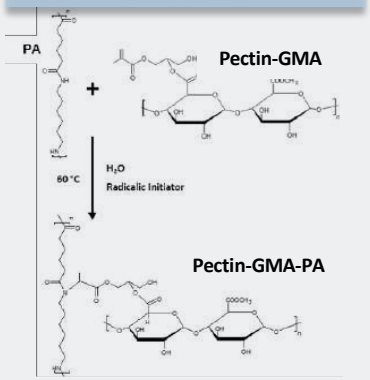
MITIGATION STRATEGIES: Coatings

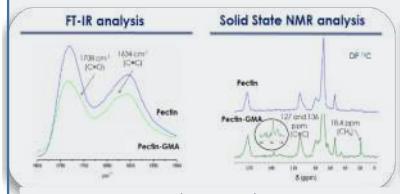
Pectin grafted on polyamide fabric

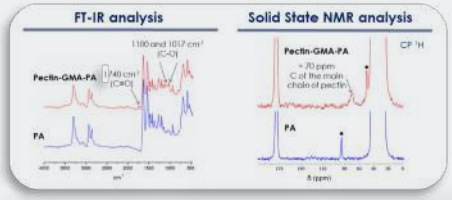
1° STEP: Synthesis of Pectin-GMA



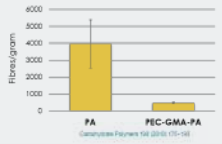
2° STEP: Grafting of Pectin-GMA on PA

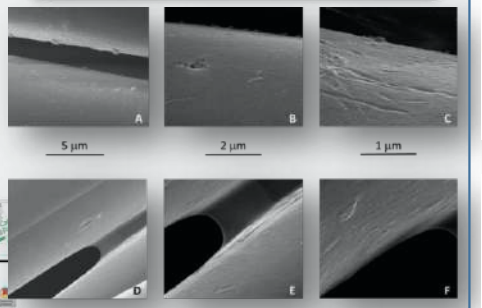






$$\% G = \frac{(W_g - W_0)}{W_0} = 1.25$$

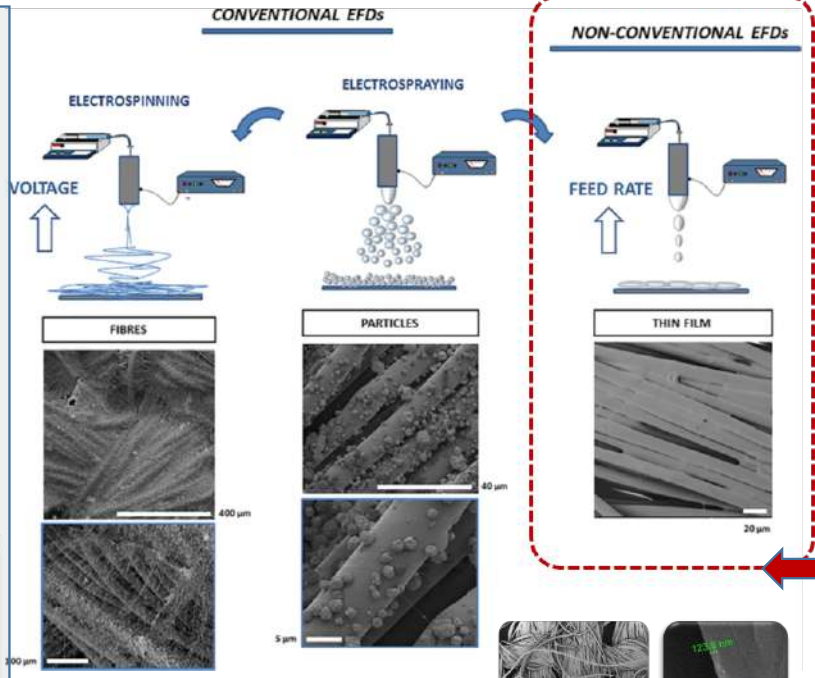




Carbohydrate Polymers

Pectin based finishing to mitigate the impact of microplastics released by polyamide fabrics

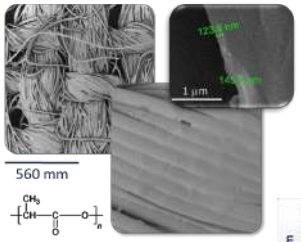
De Falco Francesca[1,2], Gentile Gennaro[2], Avolio Roberto[2], Errico Maria Emanuela[2], Di Pace Emilia[3], Ambrogi Veronica[1,2], Avella Maurizio[2], Cocca Mariacristina[1,2]



Journal of Colloid and Interface Science

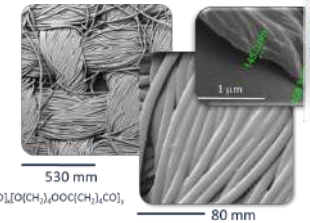
Design of functional textile coatings via non-conventional electrofluidodynamic processes

Francesca De Falco[1,2], Vincenzo Guarino[1,2], Gennaro Gentile[2], Mariacristina Cocca[1,2], Veronica Ambrogi[1,2], Luigi Ambrosio[1], Maurizio Avella[2]

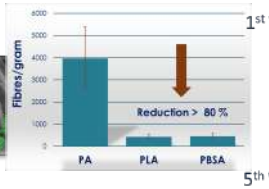


Polymer Degradation and Stability

Novel finishing treatments of polyamide fabrics by electrofluidodynamic process to reduce microplastic release during washings

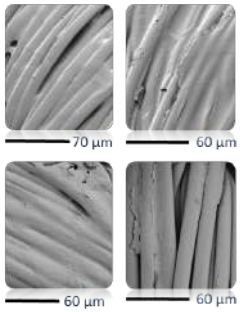


$[O(CH_2)_4OOC(CH_2)_2CO]_x[O(CH_2)_4OOC(CH_2)_4CO]_y$



1st WASH

5th WASH

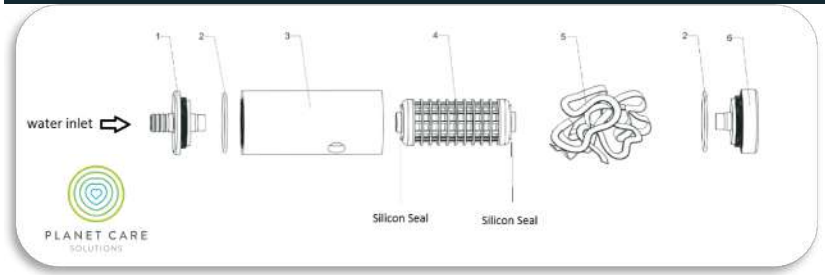


Dilute solutions of polymers can easily promote the formation of particles by the conventional regime of **electrospraying**.
In presence of polymers with high MW, such as PLA used in this study (Mn = 1.3 10^5 g/mol), an increase of the applied voltage (**conventional electrospinning mode**) can lead to the formation of fibers.

By increasing the feed rate, the formation of particles or fibers is compromised, favouring the deposition of thin polymer layers. Indeed, in this **non-conventional EFD** deposition process, faster flowing of fluid combined to solvent evaporation become predominant deposition mechanisms, thus promoting the coalescence of droplets and the coating formation.

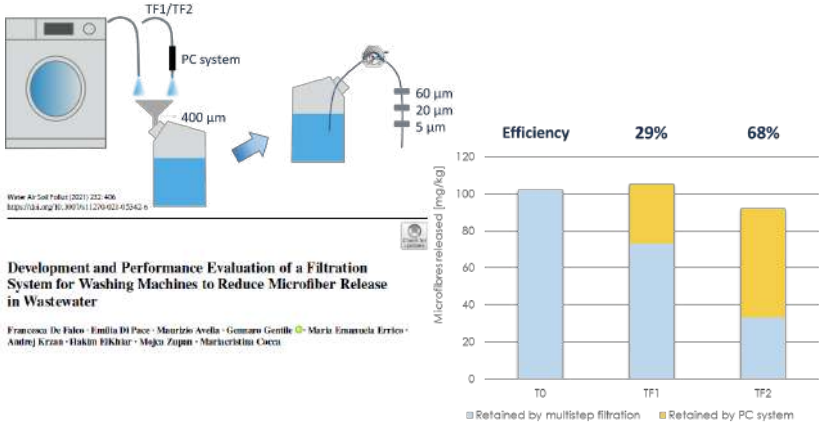
Non-conventional EFD to realise a coating on polyamide fabrics, using polylactic acid (PLA) and polybutylene succinate adipate (PBSA).

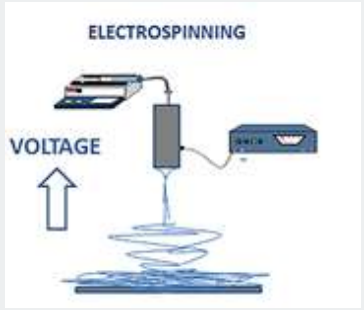
MITIGATION STRATEGIES: Filtration Systems



PROTOTYPE 1: water enters the filter housing (2) and is filtered by passing through membrane (3) supported by the cartridge frame (5) and enters into the filter cartridge where it passes through the filtering medium (4).

PROTOTYPE 2: the flow of water is changed in order to reverse the two filtering stages: water enters into the filter housing 2 and enters inside of a 5-in. cartridge where it passes through the filtration filtering medium (4) after which it continues through the membrane (3).

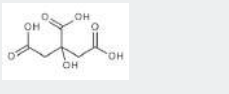


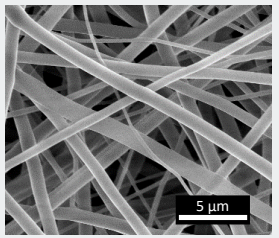


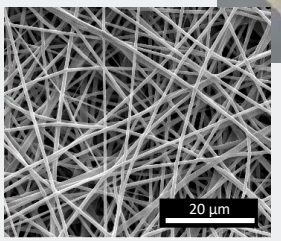
- Feed Rate: 1 mL/h
- ΔV = 30 kV

Water solutions of **Poly(vinyl alcohol)** Mw 89000-98000, 99+% hydrolyzed 15%, 18% e 20%.

Citric acid 30%



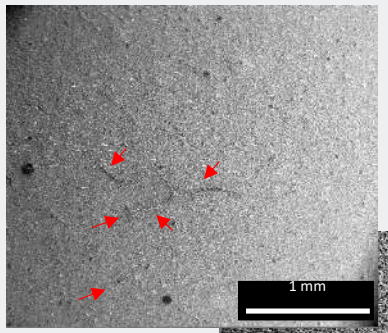




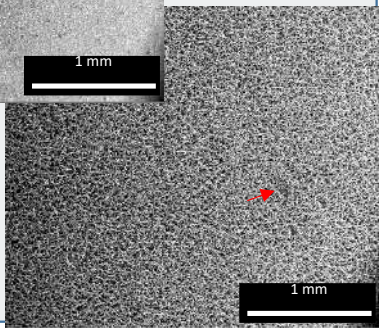
PVA membrane

Wastewater derived for Washing tests were performed in a Linitest apparatus, containing around 0,030 mg/mL of microfibers, was filtered through the PVA membrane and a 5 mm pore size PVDF filter for comparison.

Number of microfibers on PVA 58.5
microfiber length 0,162 mm
Number of microfibers on PVDF 10
microfiber length 0,251 mm



PVDF filter



MITIGATION STRATEGIES: Liquid laundry detergent formulations

INDITEX

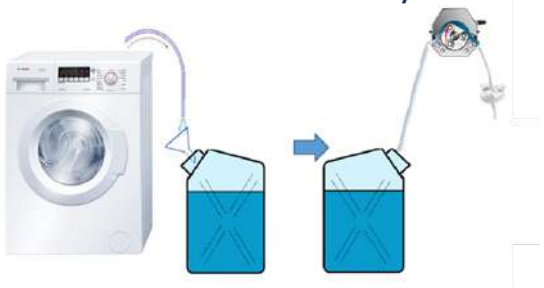
The effect of a liquid detergent, specifically formulated by BASF for Inditex to reduce the release of microfibers from synthetic fabrics during washing tests was evaluated

For the washing test two types of fabric were supplied by Inditex

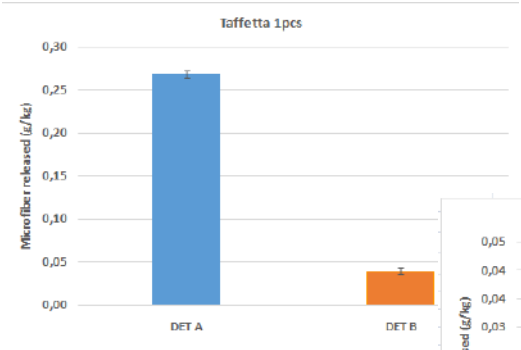
(1) Taffetta with a continuous and texturized warp yarn type;

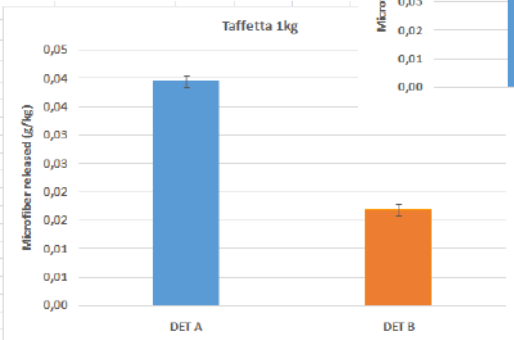
(2) Jersey black with a staple carded yarn.

A commercial (DET A) and the other one specifically formulated to limit the microplastics release (DET B), were provided by Inditex for the washing tests.

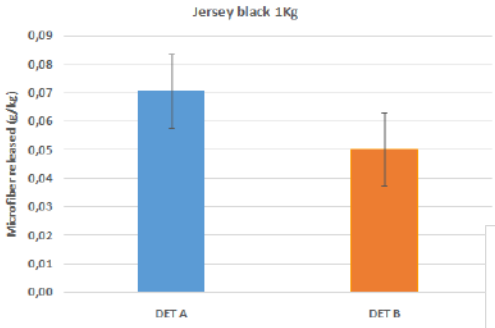


Detergent B strongly reduces the release of microplastics for both fabric type and used washing load.

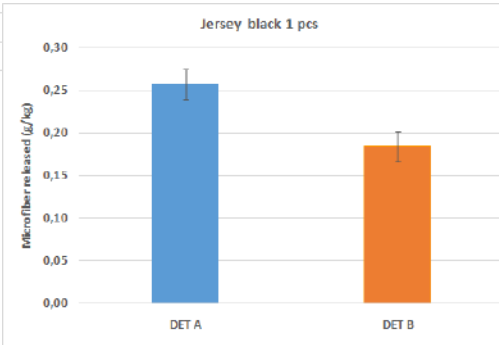




The reduction in the amount of released microfibers obtained in washing tests of Taffetta with DET B was 85% in the case of low washing load (1pcs) and 57% in the case of high washing load (1kg) .

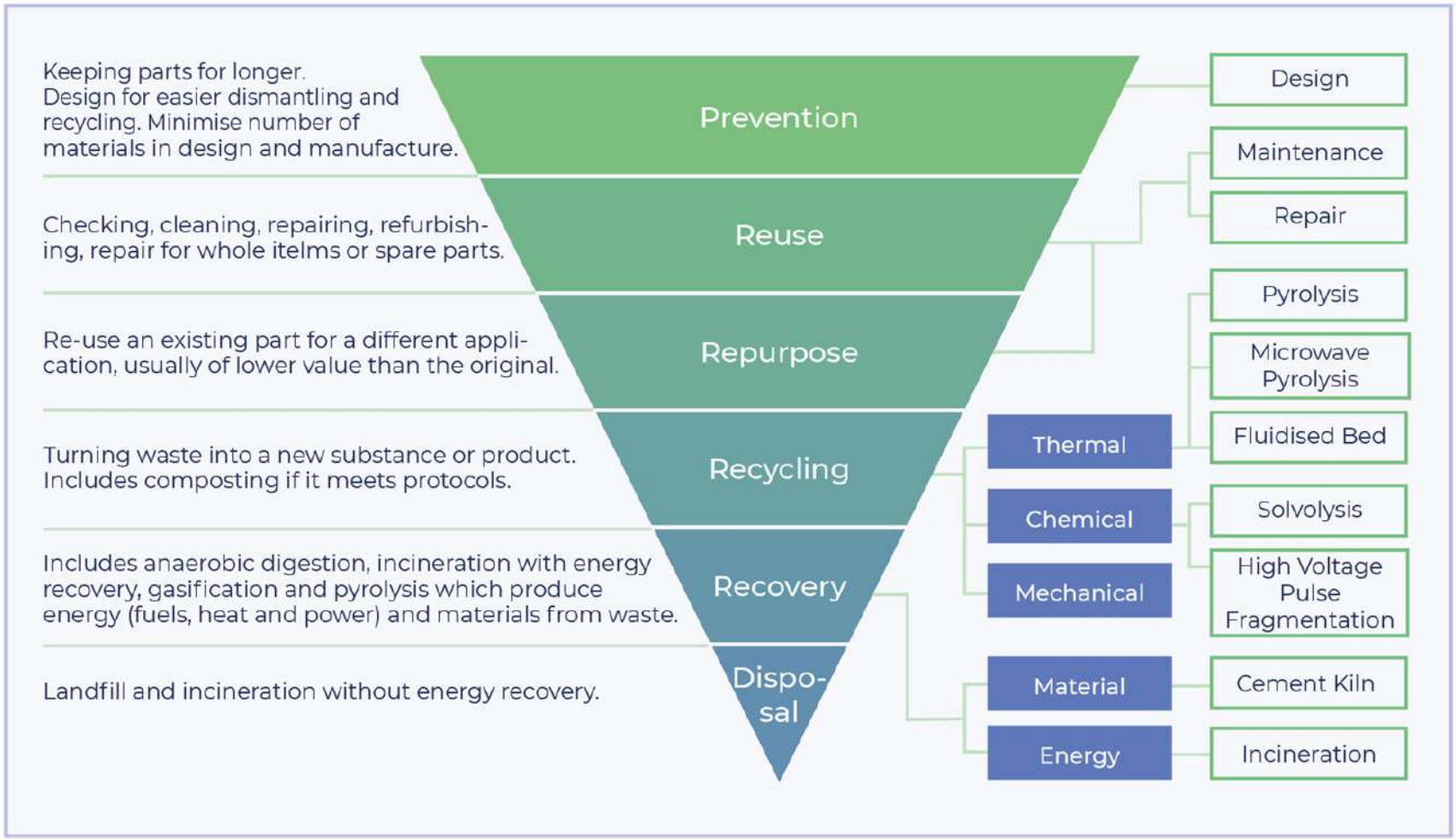


The reduction in the amount of released microfibers obtained in washing tests of Jersey black with DET B was 28% in the case of low washing load (1pcs) and 29% in the case of high washing load (1kg).



MITIGATION STRATEGIES: Ocean Plastic collection and upcycling

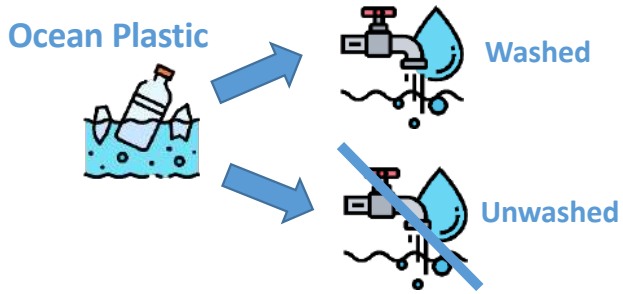
Waste Mangement Hierarchy

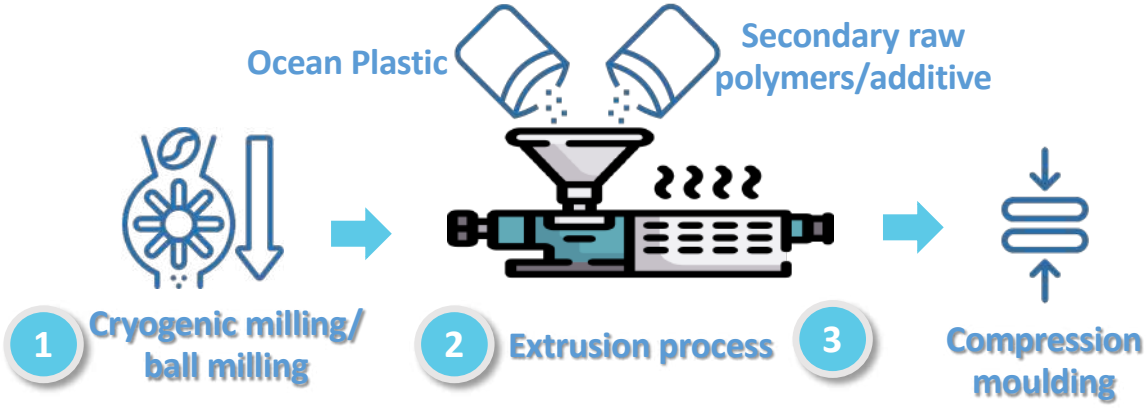


MITIGATION STRATEGIES: Ocean Plastic collection and upcycling

SIRIMAP PON Ricerca e Innovazione 2014- 2020

Polymer recycling: mechanical





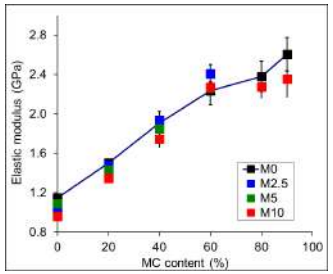
Multicomponent materials with high content of cellulose fractions → Milling + compounding

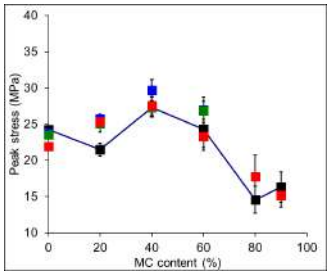
Multilayer cartons (paper, aluminium, PE):

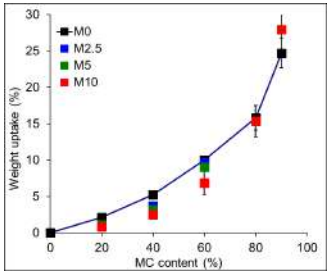
High amount of carton scraps, MC, in marine litter;

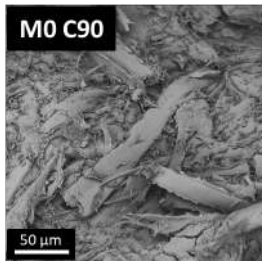
High commercial distribution in place of traditional PET bottles.

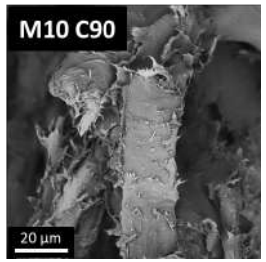
As a model system for litter with high content of non polymeric materials, a common multilayer packaging (MC) was selected. A recycled HDPE was used to produce composites. Maleated PE (MAPE) was also considered as a process additive.



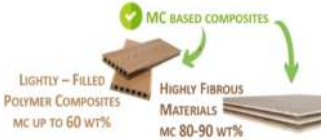








- **Water absorption increases with increasing MC content**
- **The additive slightly reduces the water uptake**

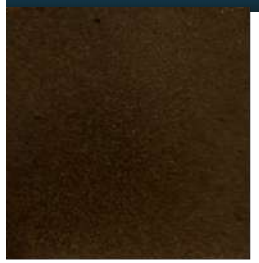


MC + recycled HDPE
Up to 90 wt% MC

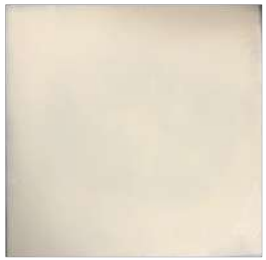
polymers

Sustainable Cellulose-Aluminum-Plastic Composites from Beverage Cartons Scraps and Recycled Polyethylene

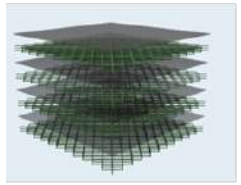
MITIGATION STRATEGIES: Ocean Plastic collection upcycling and reuse

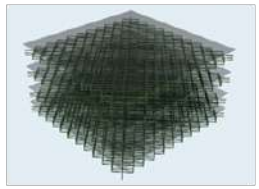


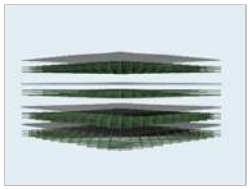
MC + HDPE 50/50



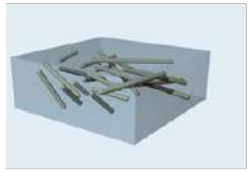
MC + HDPE 50/50 Laminated with HDPE

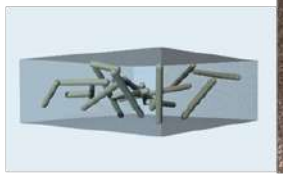






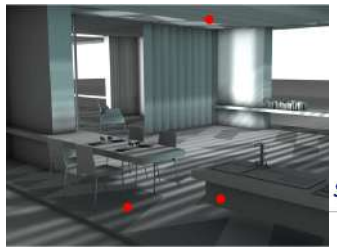
PA fishing net + PS 10/90



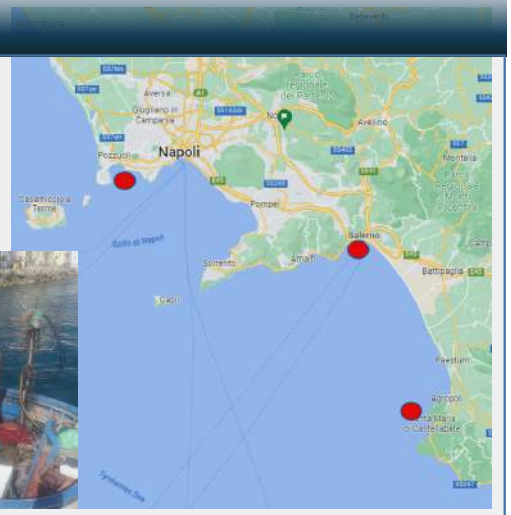


PA (fishing net) milled at 1mm + PS 50/50

PE-PP (Litter) + recycled PE 40/60

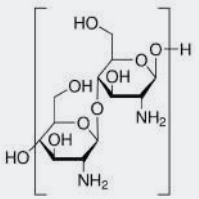


SIRIMAP PON Ricerca e Innovazione 2014- 2020

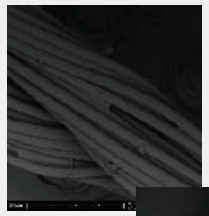


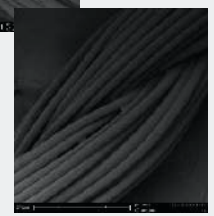
PA 66 treated with Chitosan, CS, at different concentration for different time

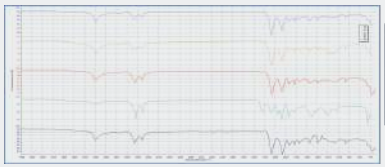
+



2% CS -5 min





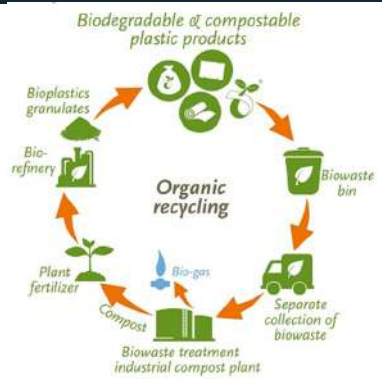


4% CS - 10 min

FIRM FILIERA RIFIUTI MARINI

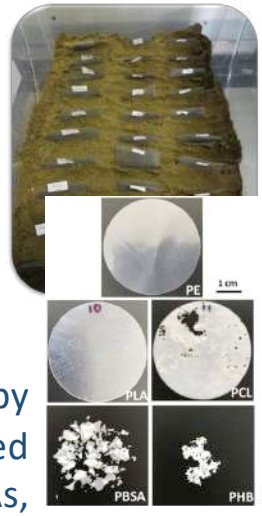
MITIGATION STRATEGIES: Biodegradable and compostable polymers

Biodegradable and compostable plastics were designed to facilitate bio-waste collection and organic recycling, in line with the requirements of the European Packaging and Packaging Waste Directive 94/62/EC)



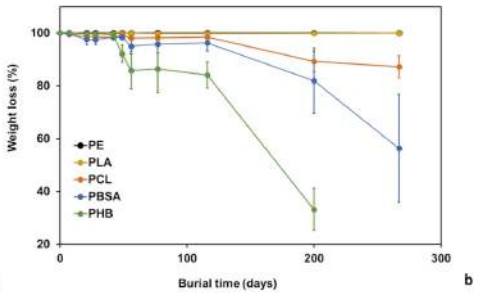
Some degradation trends of BPs: PLA is slightly affected by marine environment and its degradation could be improved by the presence of natural fibers. The degradation of PHAs, considered to be highly biodegradable in various marine environments, was well documented.

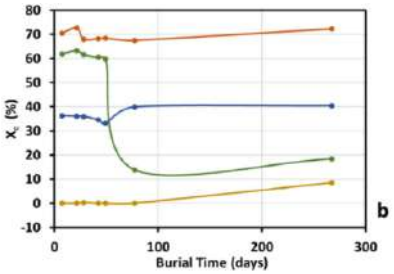
Ecotoxicity of BPs in the marine environment: (i) no adverse effects of BPs; (ii) similar responses between conventional and BPs ; (iii) benefit to the organism at low BPs concentrations.

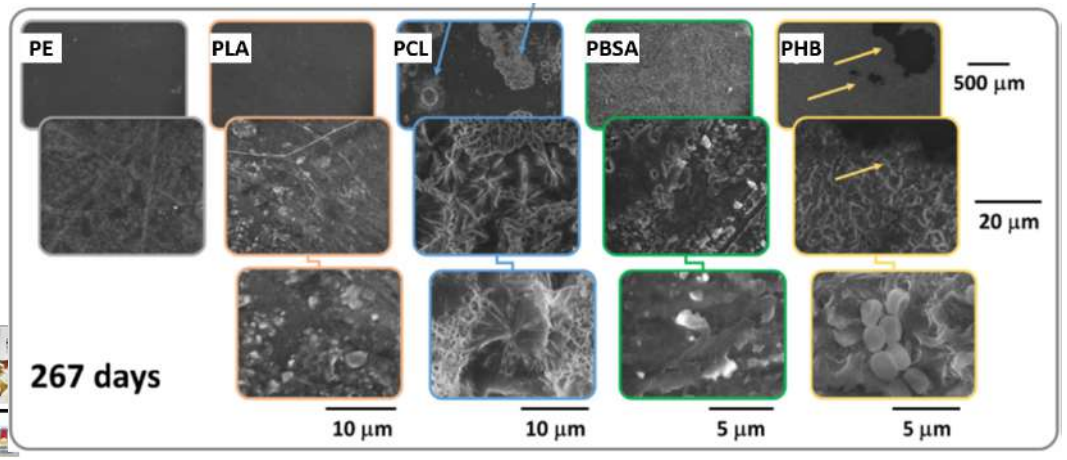


PLA, PCL, PHB and PBSA were buried in sand

The degradation trend in sand decreased in the order PHB > PBSA > PCL > PLA. PLA, PCL and PBSA did not undergo complete degradation in sand.








Journal of Hazardous Materials 416 (2021) 125763

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Biodegradable polymers: A real opportunity to solve marine plastic pollution?

Loredana Manfra [a,b,1], Vincenzo Marengo [b,1], Giovanni Libralato [b,c], Maria Costantini [b,*], Francesca De Falco [d,*], Mariacristina Cocca [d]


Journal of Hazardous Materials 416 (2021) 126201

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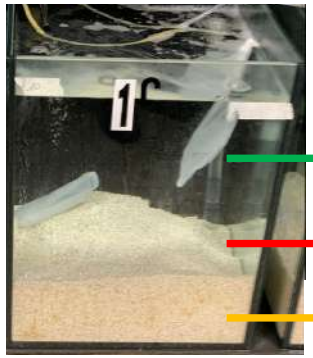
Research Paper

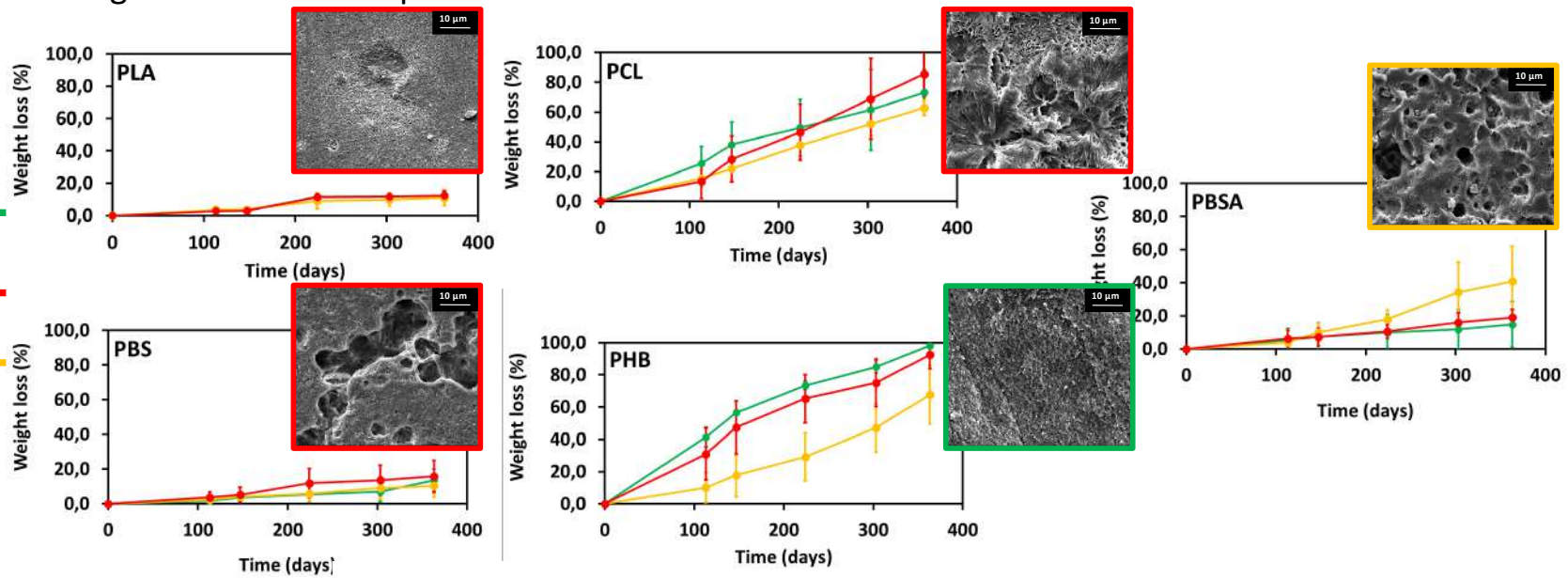
Comparison of biodegradable polyesters degradation behavior in sand

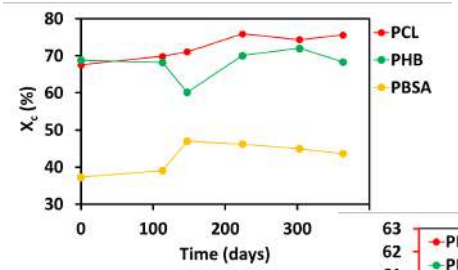
Francesca De Falco, Roberto Avolio, Maria Emanuela Errico, Emilia Di Pace, Maurizio Avella, Mariacristina Cocca *, Gennaro Gentile

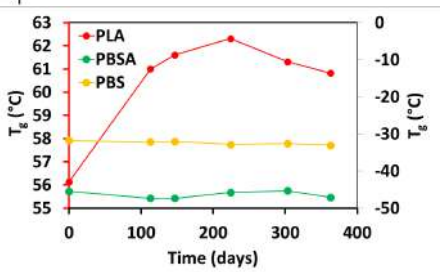
MITIGATION STRATEGIES: Biodegradable and compostable polymers

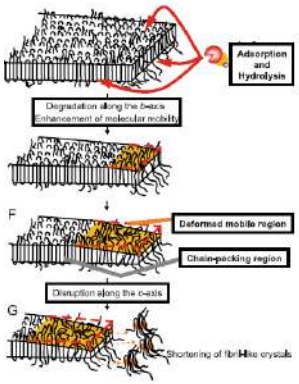
PLA, PCL, PHB, PBS and PBSA were aged at different depth level of sea water column in mesocosms

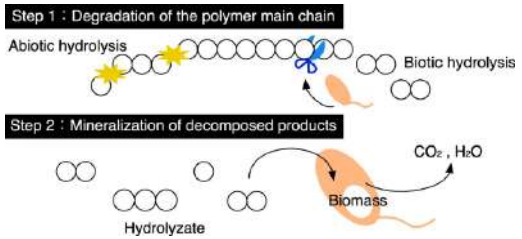










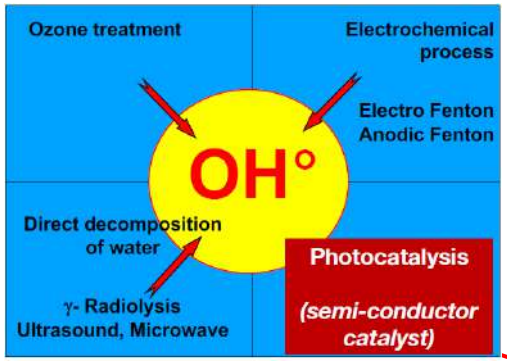


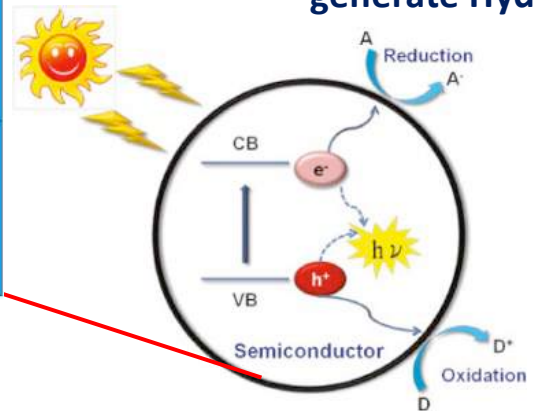
Microbial biofilm composition is under evaluation to identify and isolate bacteria and enzyme able to improve degradation of biodegradable polymers to find a biotechnological solution to mitigate microplastic and plastic pollution

BIO PLAST 4SAFE

MITIGATION STRATEGIES: Degradation techniques

There is an increasing attention towards the development of innovative strategies to treat plastic wastes and to design innovative degradation processes





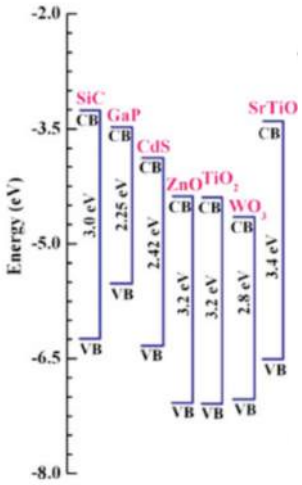
Advanced Oxidation Processes (AOPs)

AOPs are a set of chemical processes characterized by the generation of highly oxidative radicals at room temperature(most of time OH° radical). **A variety of AOPs exists according to the methods to generate Hydroxyl Radicals.**

1. Conversion of photons into charge carriers
- Absorption of light
- Generation of free photoelectrons and holes

2. Their transfer within the solid to the surface (bulk & surface recombination)

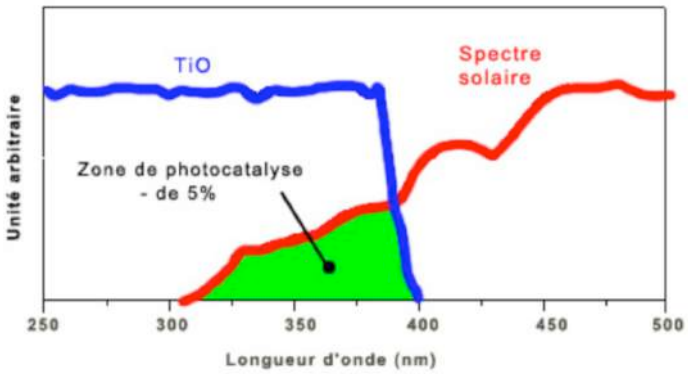
3. Their reaction with chemicals (redox species) at the solid–liquid or solid–gas interface



Criteria for selecting the semi-conductors:
Band gap vs. activation light (wavelength)
(Photo)chemical stability

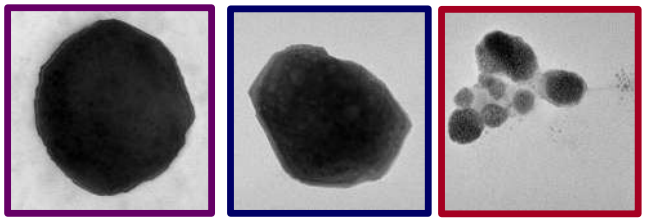
Anatase TiO_2

Band gap of 3.2 eV (UV < 388 nm)
Adequate position of BV and BC
Good (photo)chemical stability - Abundant (Ti)



MITIGATION STRATEGIES: photodegradation using bioinspired hybrid nano-photo-catalysts

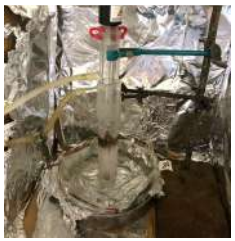
Novel nano-photo-catalysts synthesized @DICMAPI using an eco-friendly green wet-chemical route to produce hybrid nanocatalysts based on semiconductor oxide (ZnO) combined with organic molecules from biowaste (humic acids) with enhanced ability to generate Reactive Oxygen Species (ROS)



ZnO ZnO/HACOMM ZnO/HASS

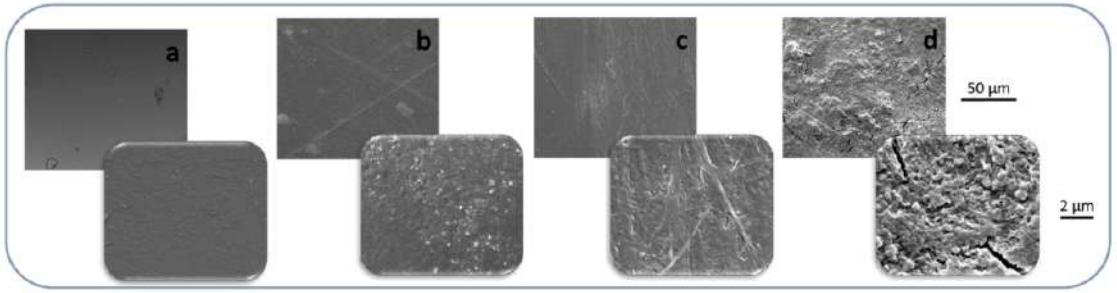
Photocatalytic process: UVA-vis irradiation for 225 hr in water-bath.

Nanostructured surfaces of nano-catalysts prepared by drop-casting method coated with polymers

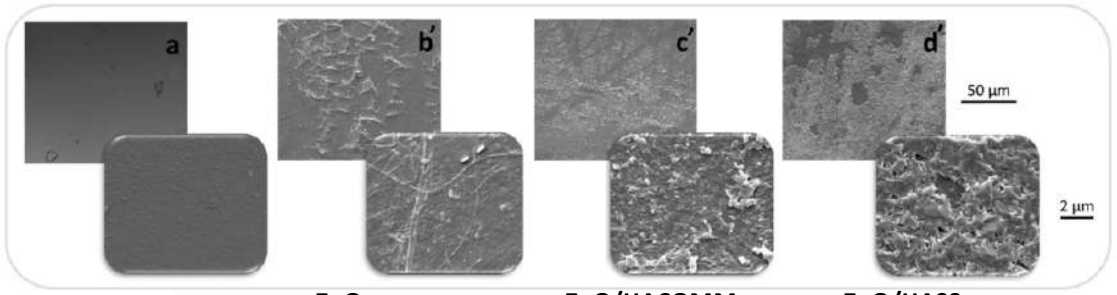


Photodegradation under UV-irradiation

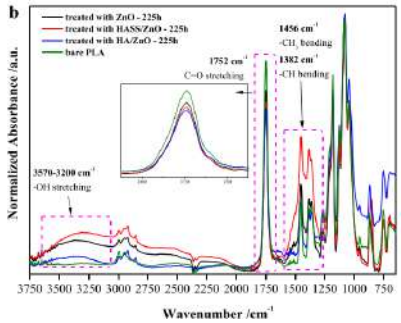
PLA dry-photolysis

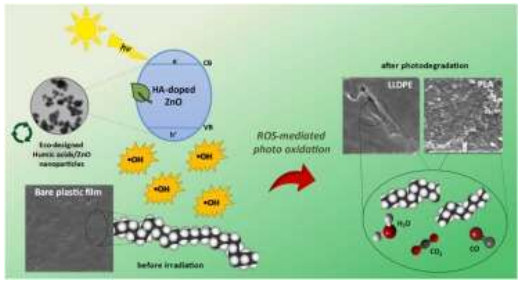


PLA wet-photolysis



ZnO **ZnO/HACOMM** **ZnO/HASS**





Eco-sustainable design of humic acids-doped ZnO nanoparticles for UVA/light photocatalytic degradation of LLDPE and PLA plastics

Paola Amato, Marica Muscetta, Virginia Venezia, Mariacristina Cocca, Gennaro Gentile, Rachele Castaldo, Raffaele Marotta, Giuseppe Vitiello

REMEDIES: Co-creating strong uptake of REMEDIES for the future of our oceans through deploying plastic litter valorisation and prevention pathways

REMEDIES, an innovation action project funded in the framework of Horizon Europe program (HORIZON-CL6- HORIZON-MISS-2021-OCEAN-03), aims to co-create solutions for the future of seas and oceans, through deploying innovative approaches to monitor and to mitigate plastic and microplastic pollutants

REMEDIES

Funded by the European Union

REMEDIES involves 23 Partners from 12 different countries bringing together a multidisciplinary team with expertise in chemistry, biology, ecology, materials science, water and waste management, innovative water technology, etc..

1

Innovative monitoring approach for MPs

Developing, testing and applying innovative membranes, filtration systems and drone technology, an innovative sampling and monitoring approach for microplastics in sea will be set up

2

New biodegradable formulations

Development of new formulations using biodegradable polymers and natural fillers for the realization of new biodegradable generation fishing gear

3

Plastic waste transformation

Plastic litter collection through clean up events and marine plastic waste valorization.

https://remedies-for-ocean.eu/

THANK YOU FOR YOUR ATTENTION

Thanks to …..

Serena Santonicola
Giampaolo Colavita

Maria Costantini
Valerio Zupo

Stefania Albrizio

Loredana Manfra

Jacopo D'Auria

Giovanni Libralato

Hector Alonso Fernandez

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Immacolata LIOTTA
Thomas VIEL
Marica Erminia SCHIANO