Interreg CENTRAL EUROPE
European Union European Regional Development Fund
BIOCOMPACK-CE

Sustainable Packaging and Environmental Issues

Marek Kowalczuk

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CMPW PAN

OUTLINE

- Introduction
- Social responsibility
- Strategy for Plastics in a Circular Economy
- Composting
- Biodegradable polymer packages
- Forensic engineering of advanced biodegradable polymeric materials
- Conclusion

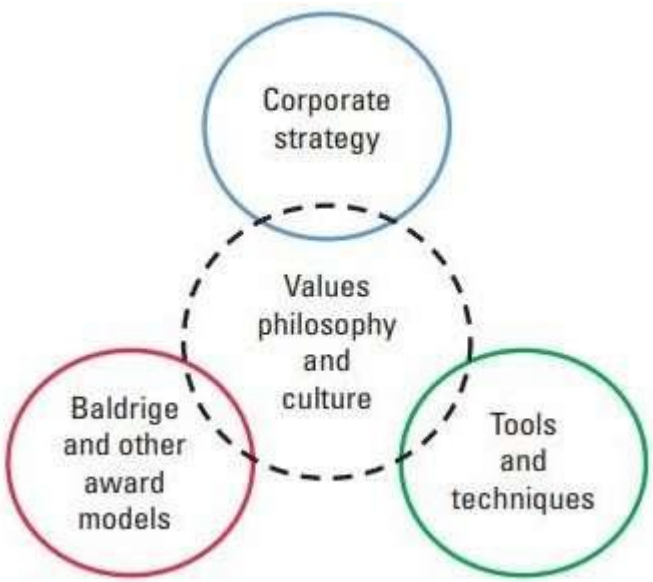
ISO 26000:2010

Guidance on social responsibility

ISO 26000:2010 provides guidance to all types of organizations, regardless of their size or location, on:

- **concepts, terms and definitions related to social responsibility;**
- **the background, trends and characteristics of social responsibility;**
- **principles and practices relating to social responsibility;**
- **the core subjects and issues of social responsibility;**
- **integrating, implementing and promoting socially responsible behaviour throughout the organization and, through its policies and practices, within its sphere of influence;**
- **identifying and engaging with stakeholders; and**
- **communicating commitments, performance and other information related to social responsibility.**

Core subject: Environment



The organization has a responsibility to reduce and eliminate unsustainable volumes and patterns of production and consumption and to ensure that resource consumption per person becomes sustainable.

6.5.3 Prevention of pollution
6.5.4 Sustainable resource use
6.5.5 Climate change mitigation and adaptation
6.5.6 Protection of the environment, biodiversity, and restoration of natural habitats

PROBLEMS WITH PLASTICS

- Plastics litter oceans and the coastlines
- Plastics use valuable/limited oil resources
- Some plastics leach small amounts of pollutants, that are toxic to life
- PE the most manufactured pertochemical polymer (29% of global production)

Source CNN (2018)

R.A.J. Verlinden, D.J. Hill, M.A. Kenward, C.D. Williams, I. Radecka, *Journal of Applied Microbiology* 102 (2007) 1437-1449, doi:10.1111/j.1365-2672.2007.03335.x
G. Jiang, D. Hill, M. Kowalczku, B. Johnston, G. Adamus, V. Irorere, I. Radecka, *International Journal of Molecular Sciences* 17 (2016) 1157, doi:10.3390/ijms17071157

A EUROPEAN STRATEGY FOR PLASTICS IN A CIRCULAR ECONOMY

55%

Revision of Waste

Fixing a new target of 55% recycling of plastic packaging waste by 2030

Plastics Bag Directive

Member states to reduce consumption to 90 bags per person by 2019 and to 40 bags by 2026

Eco-Design Working Plan

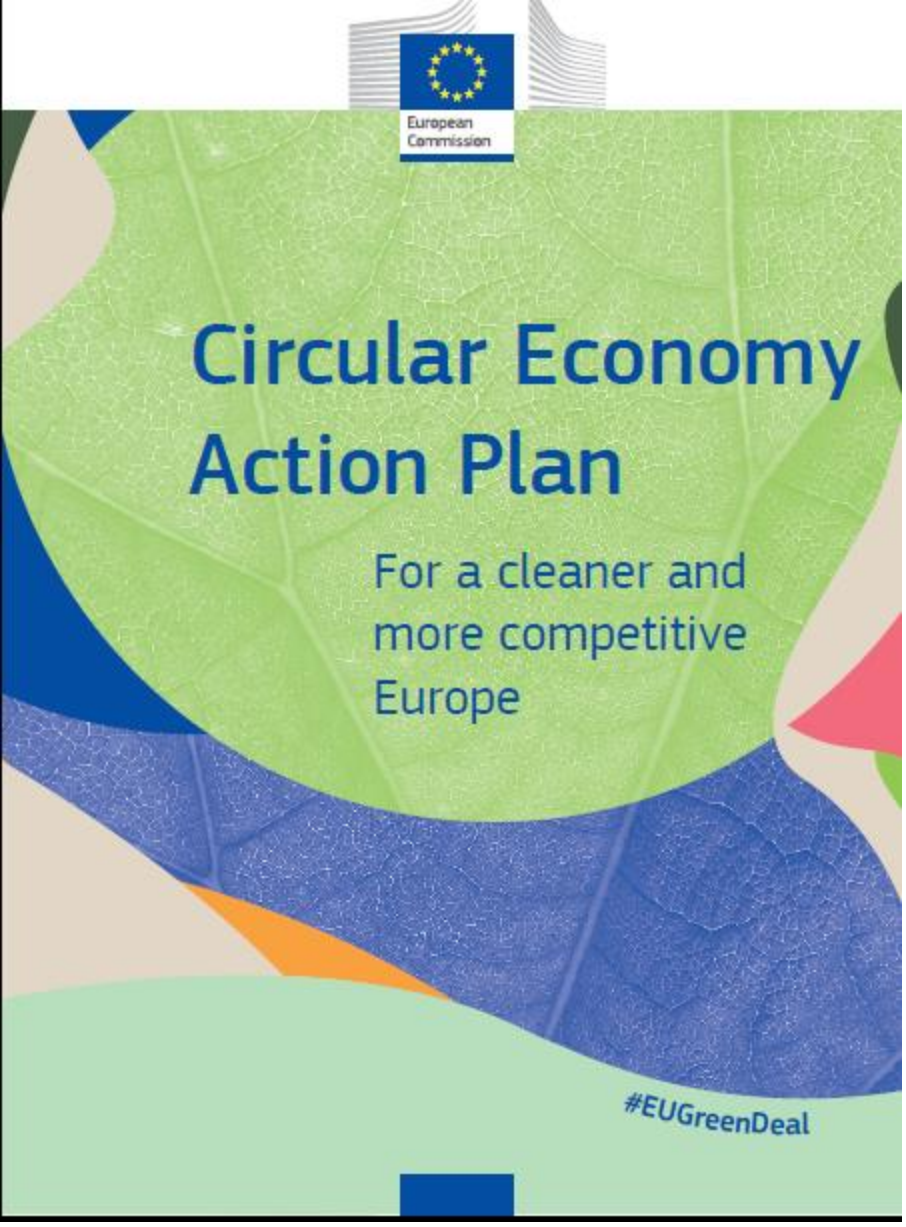
Improving product design to address durability, repairability and recyclability

Marine Strategy Framework Directive

Member States obliged to monitor and reduce their marine litter

Actions on compostable and biodegradable plastics:

- start work to develop harmonised rules on defining and labelling compostable and biodegradable plastics
- conduct a lifecycle assessment to identify conditions where their use is beneficial, and criteria for such application
- start the process to restrict the use of oxo-plastics.



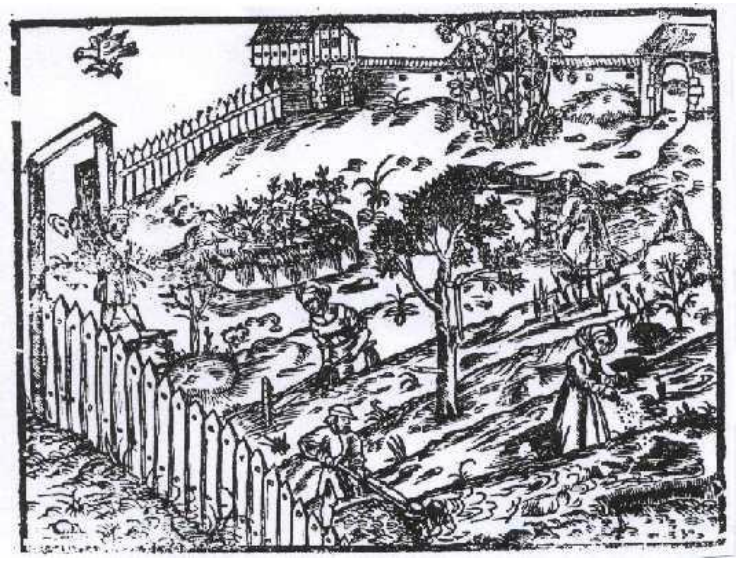
- **use of biodegradable or compostable plastics, based on an assessment of the applications where such use can be beneficial to the environment, and of the criteria for such applications.**

It will aim to ensure that labelling a product as 'biodegradable' or 'compostable' does not mislead consumers to dispose of it in a way that causes plastic littering or pollution due to unsuitable environmental conditions or insufficient time for degradation.

25 March 2020

CERTIFICATION OF COMPOSTABLE POLYMERIC MATERIALS FOR PACKING

COMPOSTING

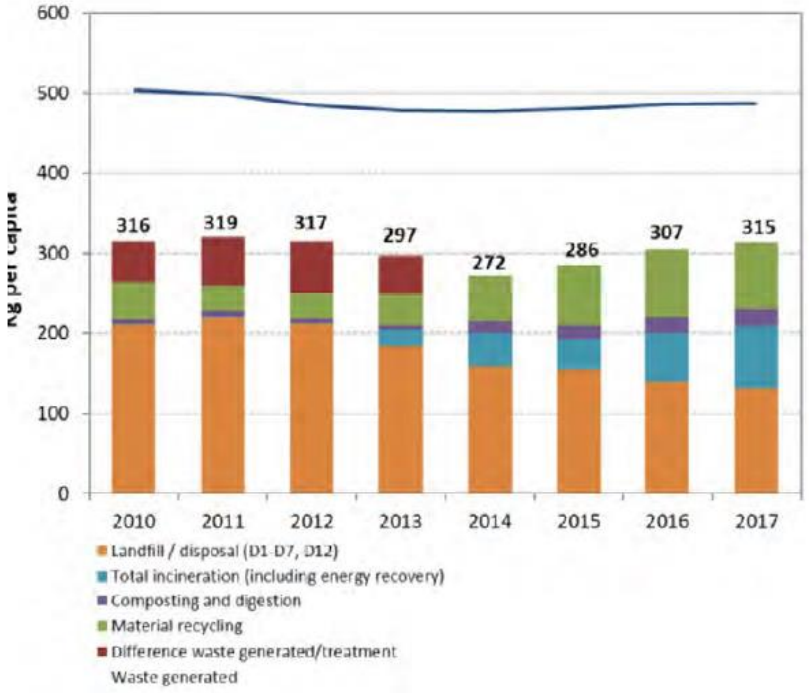


1644

The first advice on rational composting in Poland:
“The Farmstead”
by Anzelm Gostowski, 1563

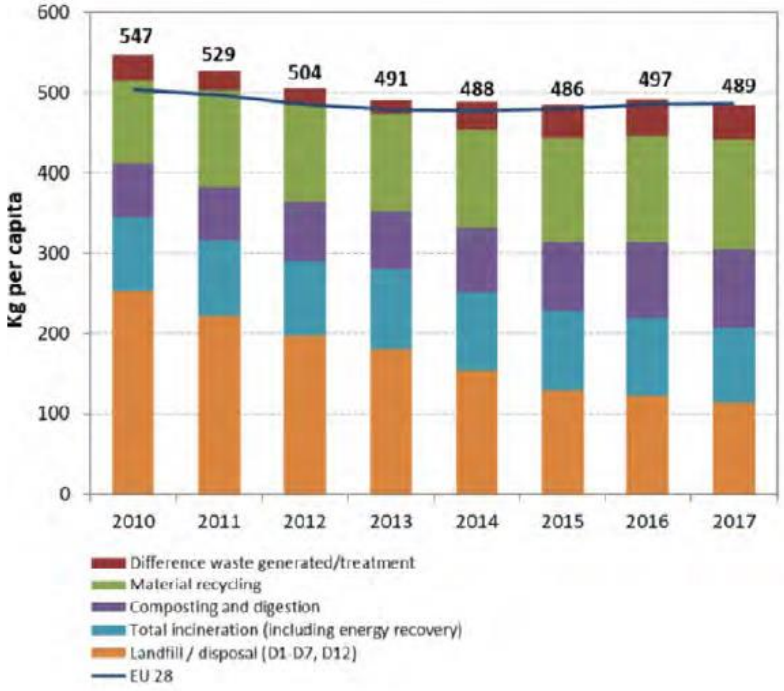
http://naturemill.com/products.html

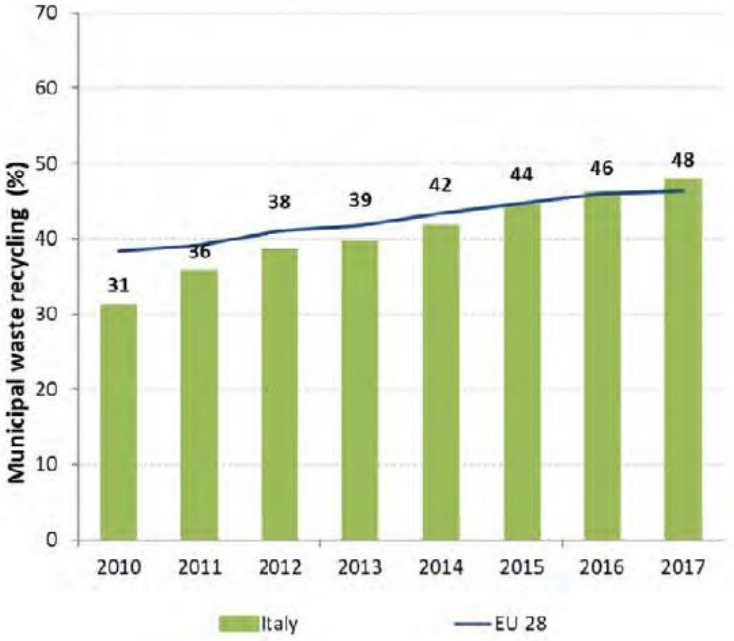
POLAND



Source: EC Environmental legislation implementation assessment, national reports 2019

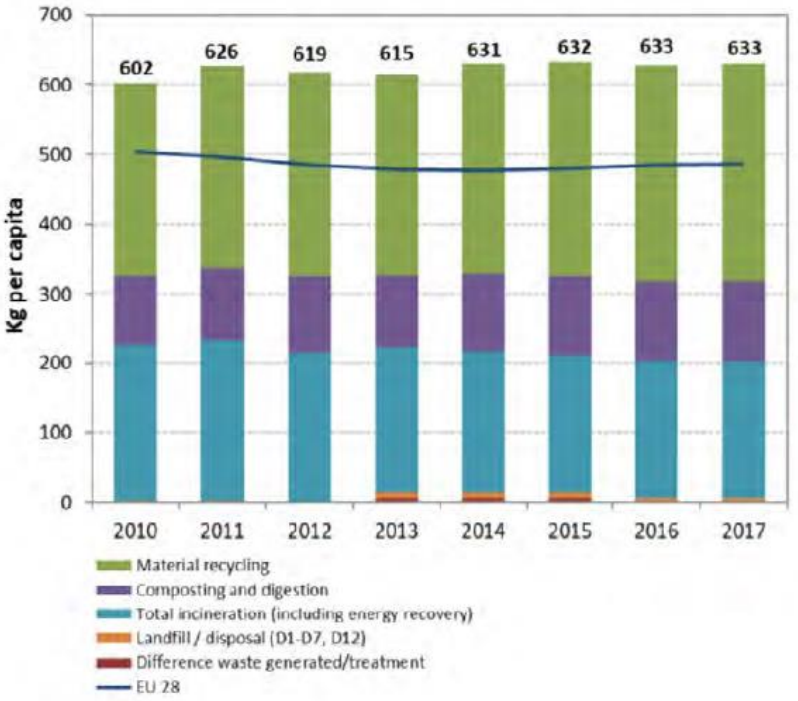
ITALY

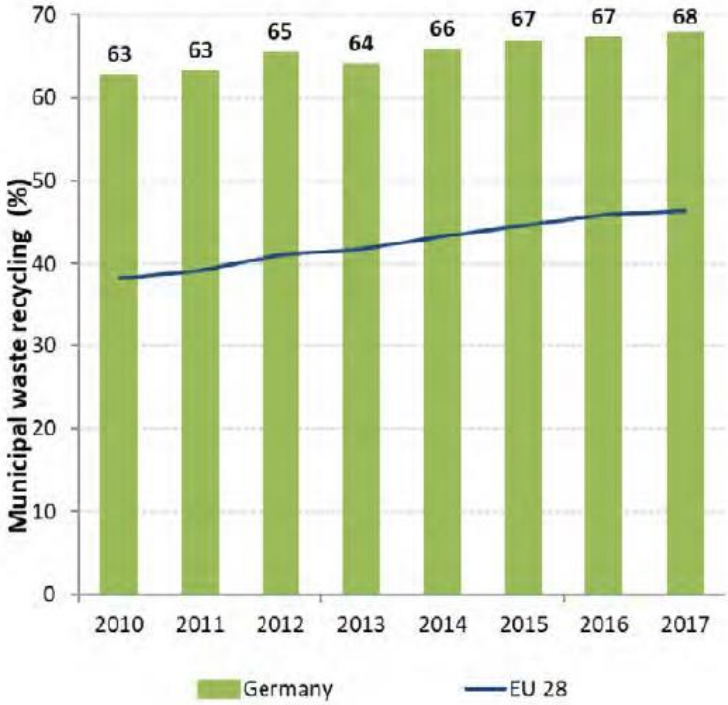




Source: EC Environmental legislation implementation assessment, national reports 2019

GERMANY





Source: EC Environmental legislation implementation assessment, national reports 2019

Biodegradation process under laboratory condition

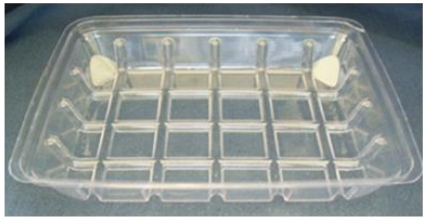
Automatic composters

– *NatureMill*

Bioreactors

Organic waste

Respirometer Micro-Oxymax
S/N 110315, COLUMBUS



42 days

plastice

Innovative value chain development
for sustainable plastics in Central Europe
www.plastice.org

Kassel Project

INDUSTRIAL COMPOSTING

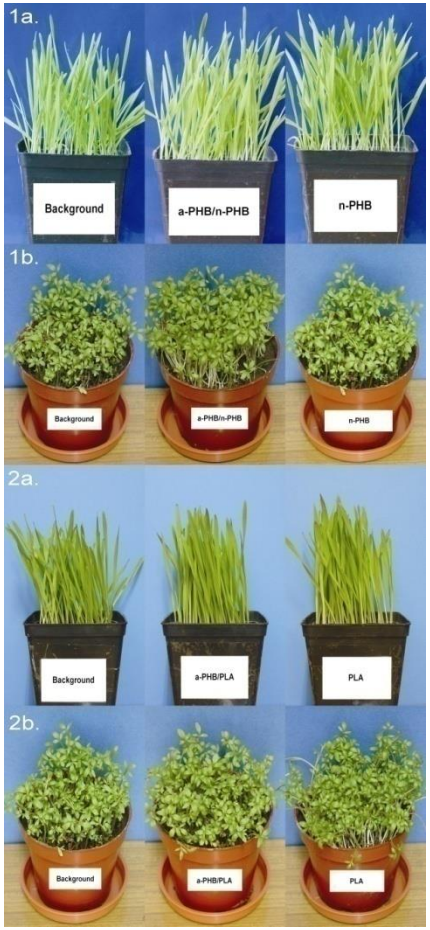
ZABRZE

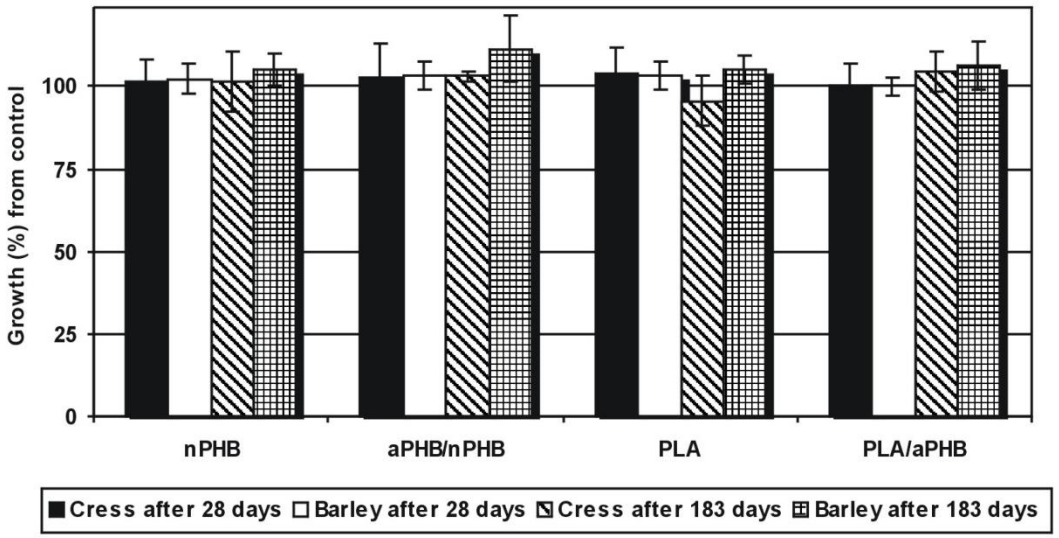
producer

shops

Sorting Station and Composting Plants

Growth of (a) barley and (b) cress in soil after 183 days of degradation of: (1) a-PHB/n-PHB/ - and n-PHB and (2) a-PHB/PLLA - and PLLA films





Growth of cress and barley measured as percent of dry weight against the control

Biomacromolecules **2006**, *7*, 3125−3131

Environmental Degradation of Polyester Blends Containing Atactic Poly(3-hydroxybutyrate). Biodegradation in Soil and Ecotoxicological Impact

Piotr Rychter,[†,‡] Robert Biczak,[†] Barbara Herman,[†] Aleksandra Smyłła,[†] Piotr Kurcok,[‡] Grażyna Adamus,[‡] and Marek Kowalczuk*[,‡]

INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

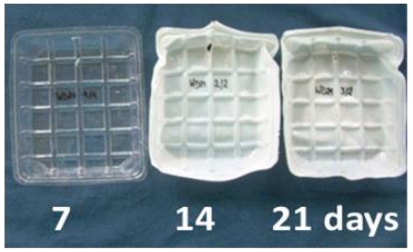
M A R G E N

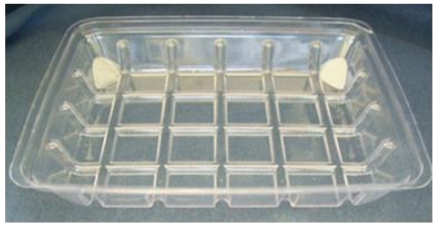
EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND

A new generation of packages from compostable polymer materials

POIG.01.03.01-00-018/08

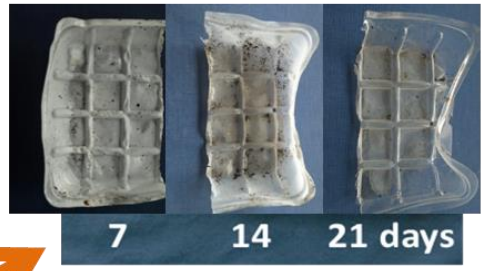
DEGRADATION STUDY



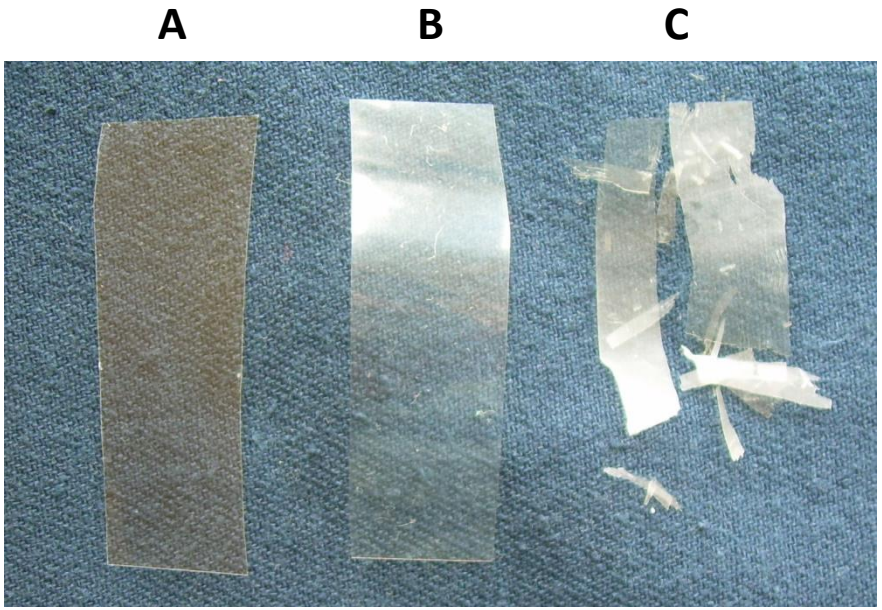


Polylactide (PLA) based container, the pilot production

MARGEN project no. POIG.01.03.01-00-018/08, “New generation packaging materials made from plastics subject to the organic recycling” in the framework of the Innovative Economy Operational Programme (IE OP).



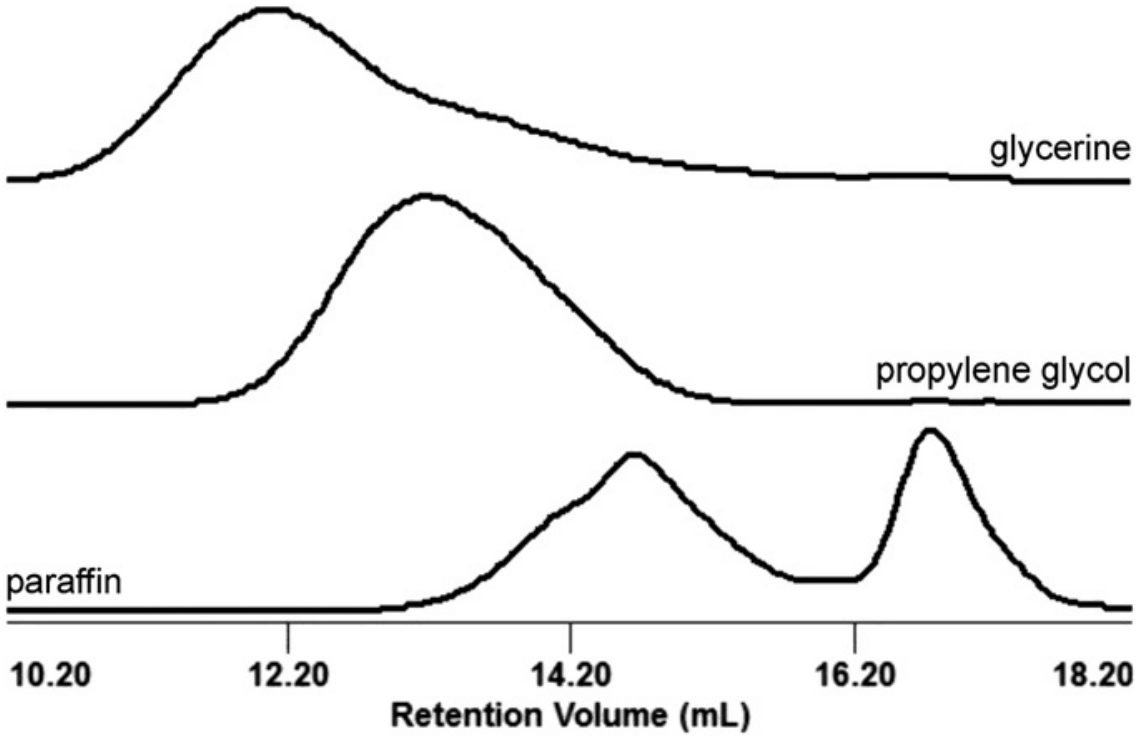
The use of environmentally friendly polymers as packaging materials for long shelf-life applications as cosmetic packages is the new trend for production



Visual evaluation of the PLA film before degradation (A), after 16 weeks (B) and after 24 weeks (C) of degradation in paraffin at 70°C

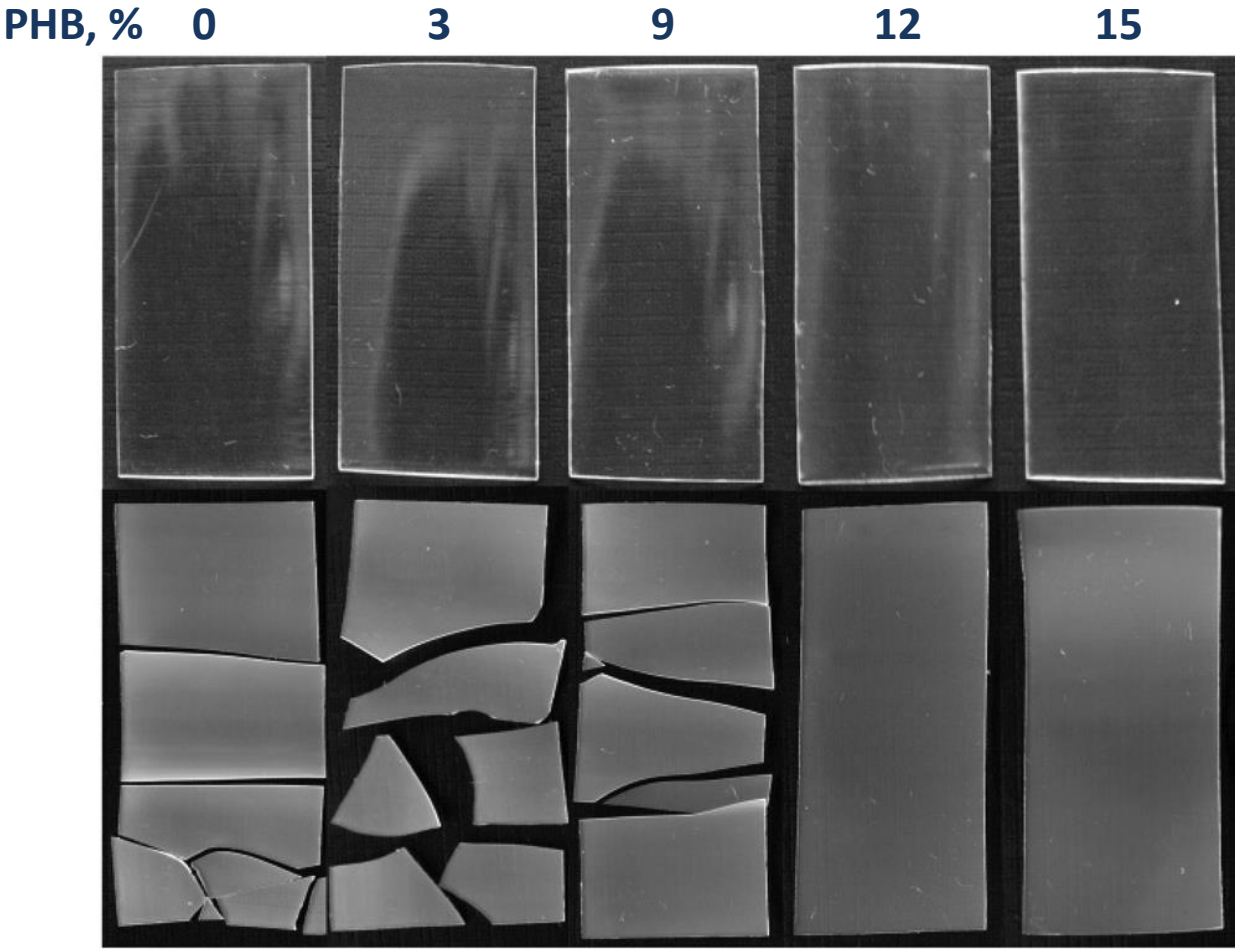
***Polymer Degradation and Stability*, 98 (2013) 316-324**

The *ex-ante* investigations as well as *ex-post* studies are needed in order to define and minimize the potential failure of novel biodegradable polymer products before, during and after specific applications



Changes in GPC chromatogram of PLA samples after 44 weeks of degradation in glycerine, propylene glycol and paraffin at 70°C

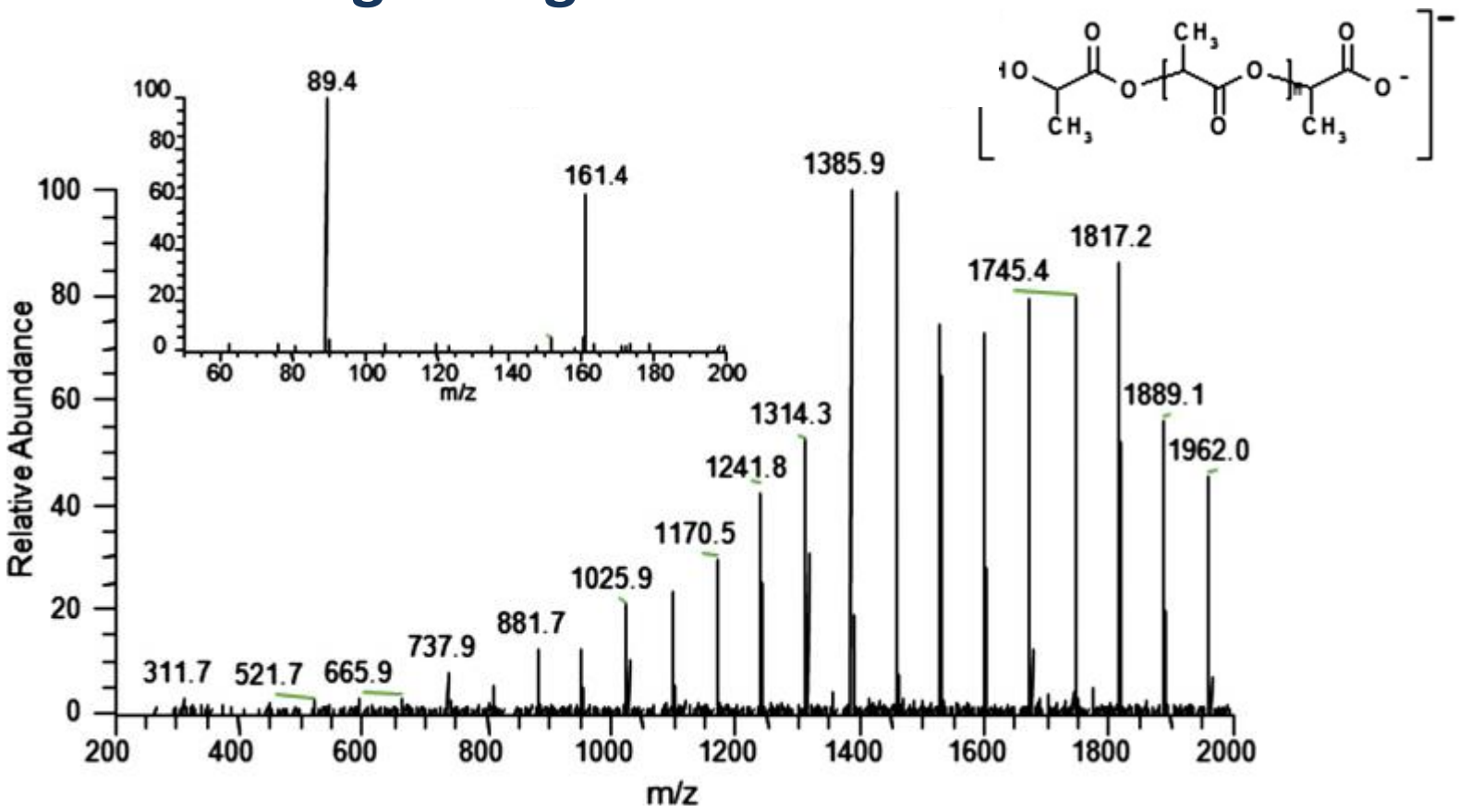
Visual evaluation of the PLA and PLA/(*R*,*S*)-PHB rigid films



(A) before degradation

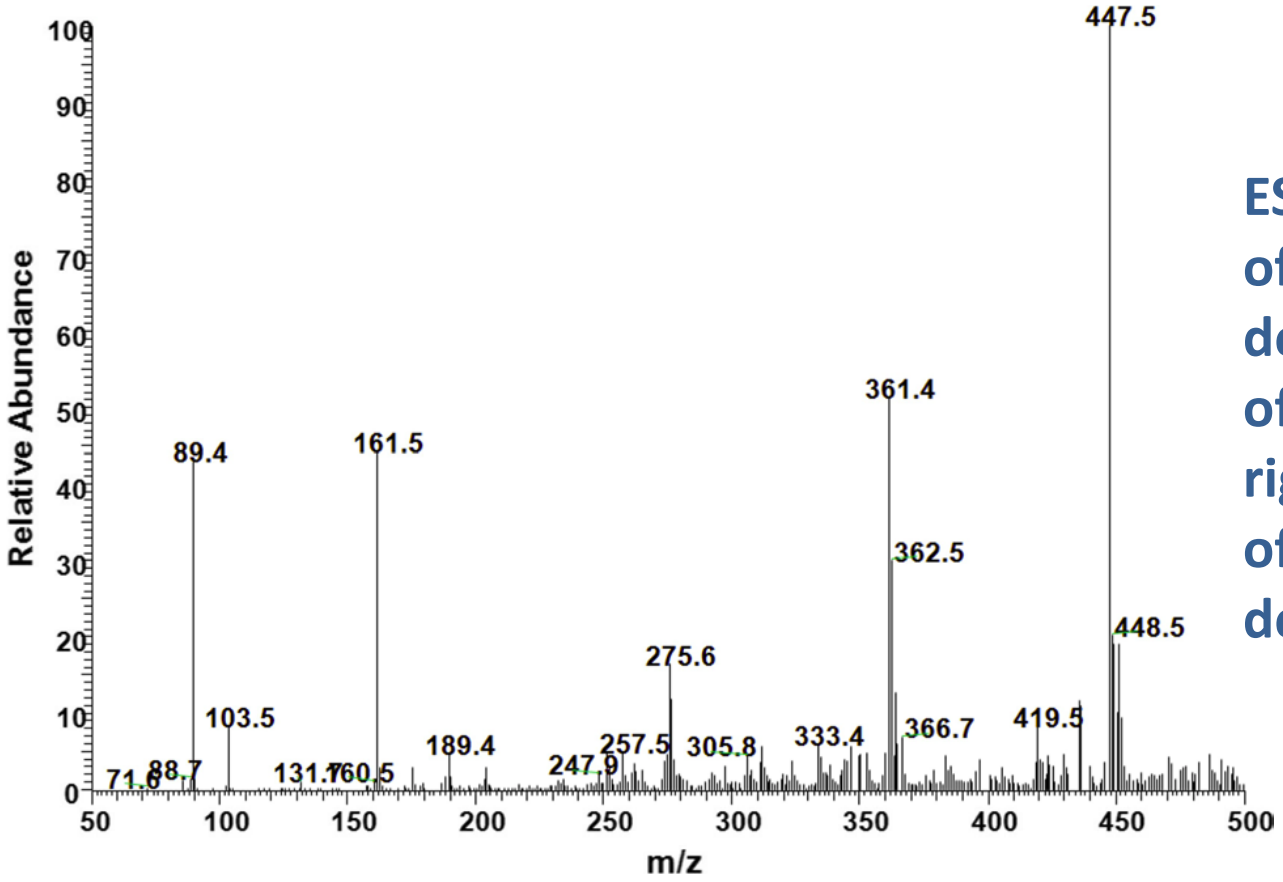
(B) after 15 weeks of degradation in paraffin

The most important requirement for plastic cosmetic packages is to avoid degradation and the migration of any low molecular weight components into a cosmetic formulation during storage



The ESI-mass spectrum (negative ion-mode) of the remaining PLA film after 1 year incubation in paraffin at 70°C

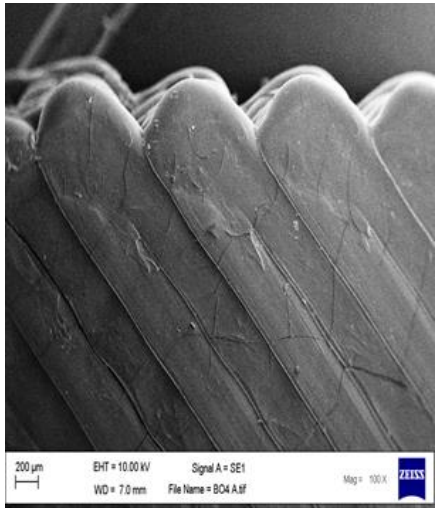
Water-soluble oligomers of PLA/a-PHB blend



ESI–MS(–) spectrum of water-soluble degradation products of 85PLA/15(*R,S*)-PHB rigid foil after 21 days of hydrolytic degradation at 70 °C

Eur Food Res Technol (2016)
DOI 10.1007/s00217-015-2611-y

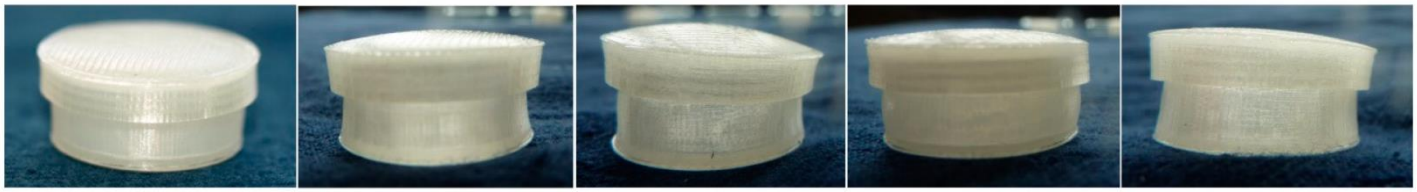
Degradation of PLA 3D printed samples in rapeseed oil at 70℃



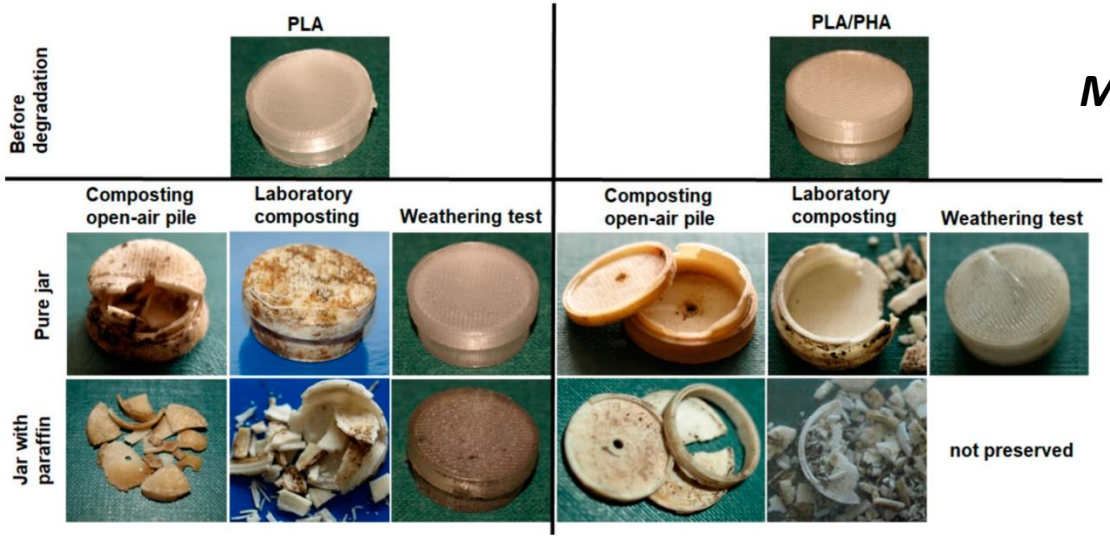
After 57 days of aging in rapeseed oil

Margaret Funmilayo Owojuyigbe
Bachelor of Science (Hons) Chemistry, 2018

3D-Printed Polyester-Based Prototypes for Cosmetic Applications



Photomacrographs of PLA cosmetic containers filled with paraffin, ethanol, deionized water, and blank test after 19 days of the accelerated aging test at 55 °C.



Materials 2019, 12, 994

Photomacrographs of PLA cosmetic containers before degradation and after 84 days of the composting under laboratory and industrial conditions as well as after 365 days under natural weathering conditions.

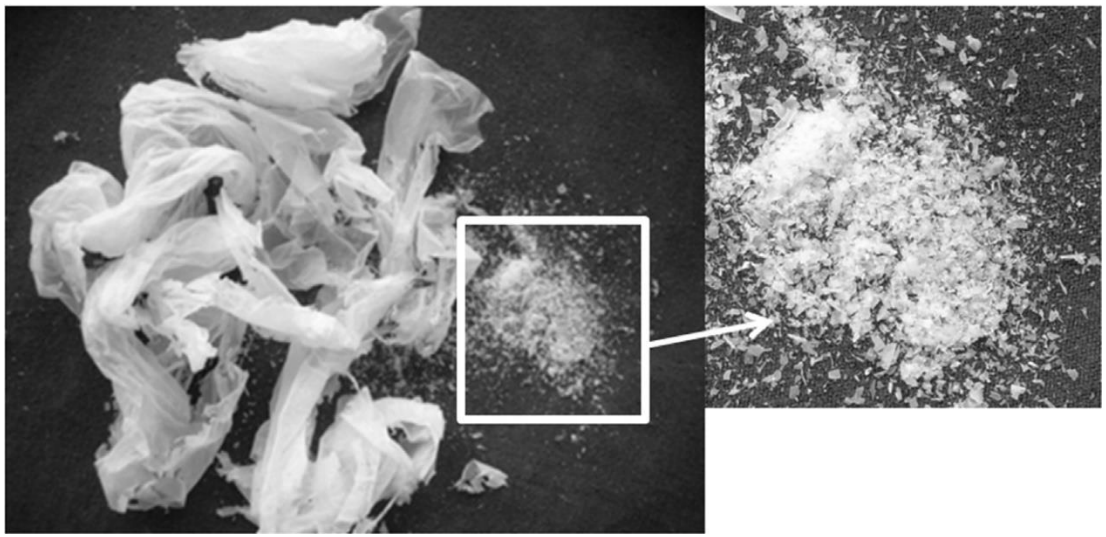
PE at the bottom of the MARIANA TRENCH

The Guardian:

“We’re just at the beginning of cleaning up what has been done by the development of classical plastics,”

https://www.theguardian.com/business-to-business/2017/oct/31/the-plastics-problem-are-natural-alternatives-doing-more-harm-than-good

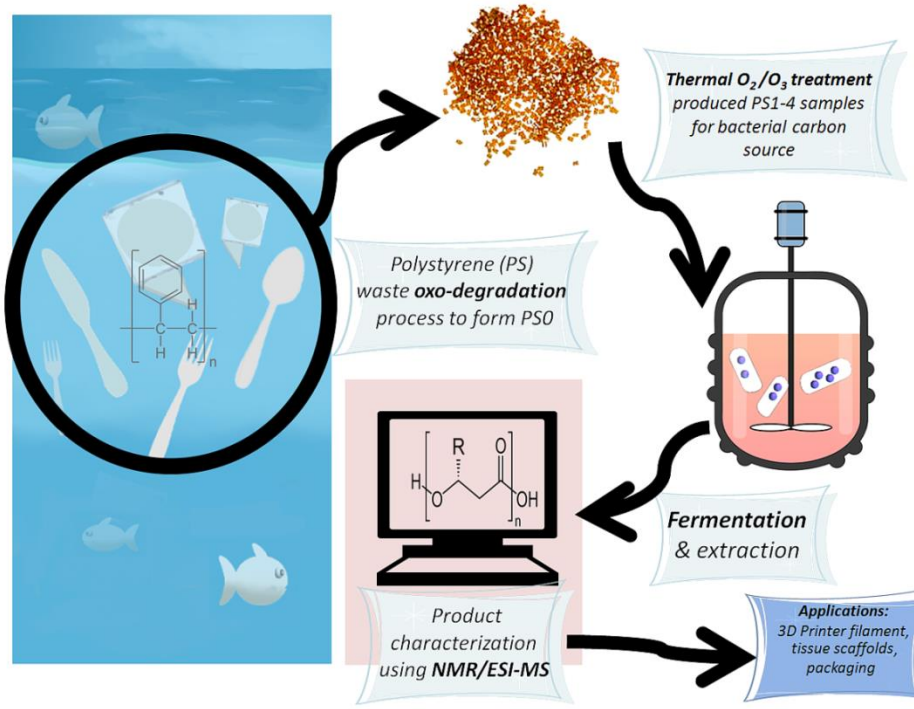
Forensic engineering of advanced polymeric materials Part IV: Case study of oxo-"biodegradable" polyethylene commercial bag – Aging in biotic and abiotic environment



Digital photographs of PE-H after 365 days of incubation in distilled water at 70^0 C (two fractions: PE-HL – large pieces of investigated material, PE-HS – small pieces of investigated material)

http://dx.doi.org/10.1016/j.wasman.2017.03.043

The Microbial Production of PHA from Waste Polystyrene Fragments Attained Using Oxidative Degradation

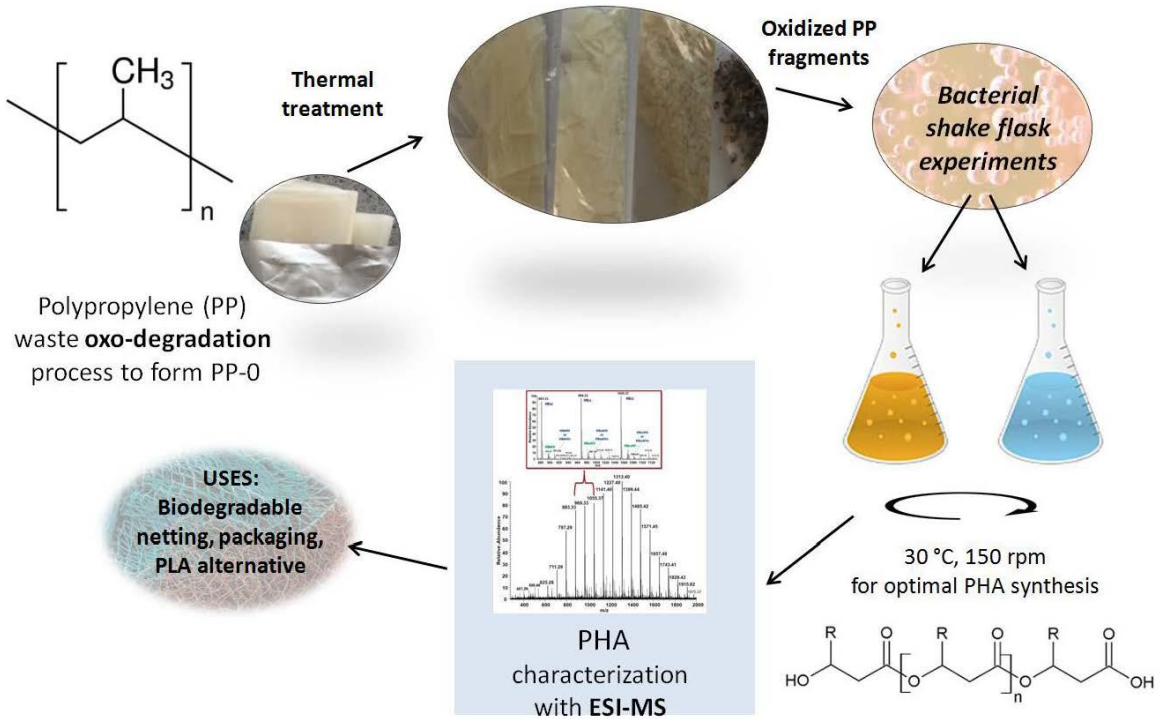


In Special Issue "Biodegradable Polymers—Where Are We and Where to Go":
https://www.mdpi.com/journal/polymers/special_issues/Biodegrad_Polym

B. Johnston, I. Radecka, D. Hill, E. Chiellini, V. Ilieva, W. Sikorska, M. Musioł, M. Zięba, A. Marek, D. Keddie, B. Mendrek, S.Darbar, G. Adamus, M. Kowalczuk,
Polymers 2018, 10, 957.

Mass Spectrometry Reveals Molecular Structure of Polyhydroxyalkanoates Attained by Bioconversion of Oxidized Polypropylene Waste Fragments

Beach area in Ambon, Indonesia contaminated with plastic waste.
Image provided by Chris Mason-Parker.



Polymers **2019**, 11, 1580

ANABEL ITOHOWO EKERE[1], BRIAN JOHNSTON[1], MAGDALENA ZIĘBA[2], PAWEŁ CHABER[2], GRAZYNA ADAMUS[2], FIDELINE TCHUENBOU-MAGAIA[1], DAVID BARSI[3], LUCÍA PÉREZ AMARO[3], EMO CHIELLINI[3]*, IZA RADECKA[1], MAREK KOWALCZUK[1,2]

*Corresponding author

1. Wolverhampton School of Sciences, Faculty of Science and Engineering, University of Wolverhampton, Wolverhampton, United Kindom
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3. Laboratorio Materiali Polimerici Ecocompatibili (LMPE), Capannori (LU), Italy

PEER REVIEWED

Environmental cleaning mission

Bioconversion of oxidatively fragmented polyethylene plastic waste to value-added copolyesters

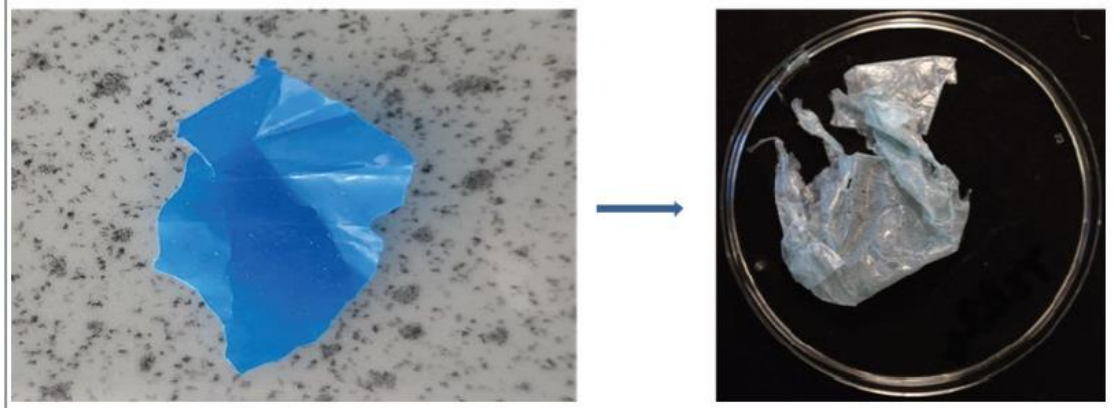
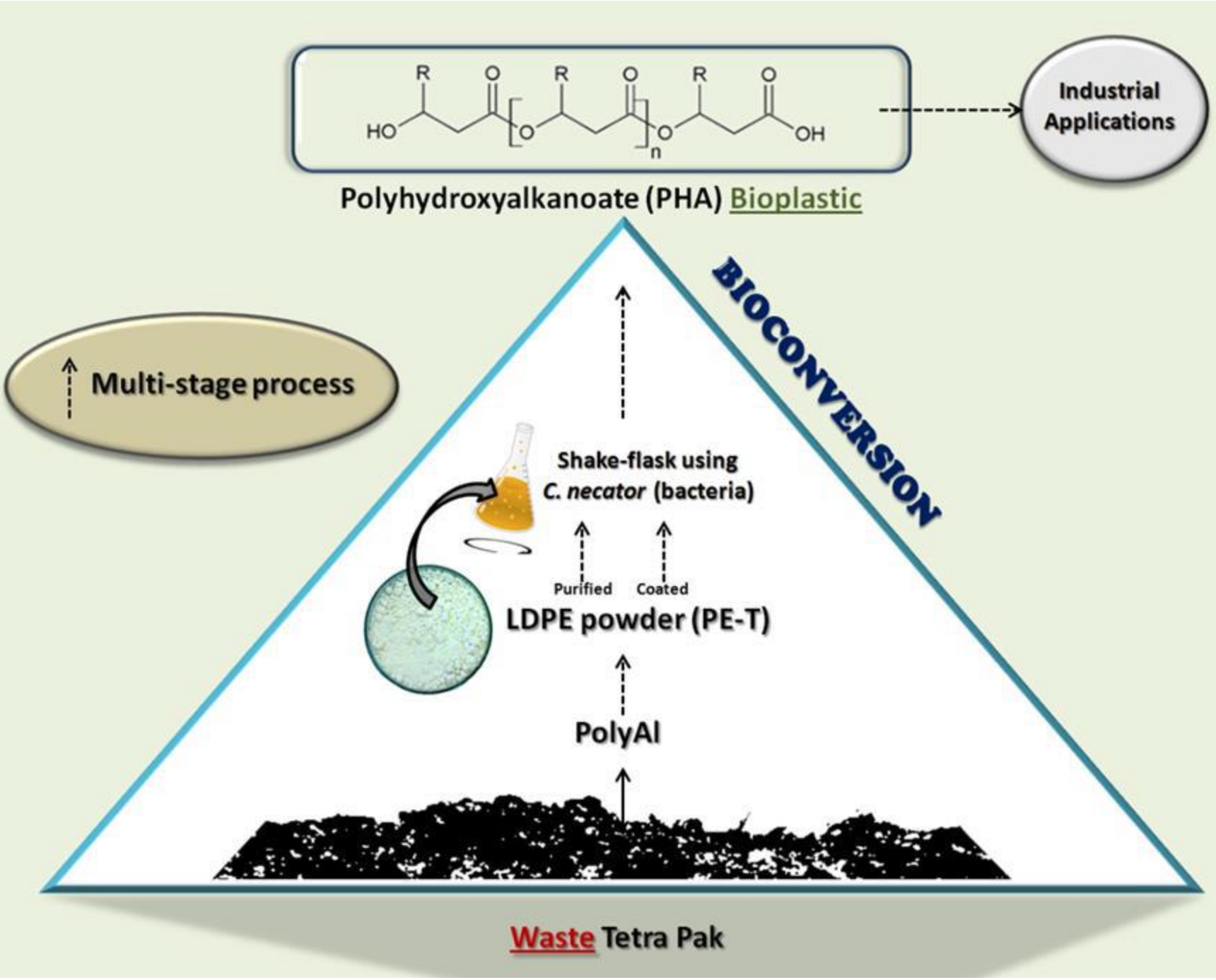


Figure 3. (a) Oxidative fragmented LDPE (sample PE-F); (b) PHA extracted from *Cupriavidus necator* using TSB supplemented with PE-F.

Chimica Oggi - Chemistry Today - vol. 37(6) November/December 2019


Industrial Applications
Polyhydroxyalkanoate (PHA) Bioplastic
BIOCONVERSION
Multi-stage process
Shake-flask using
C. necator (bacteria)
Purified
Coated
LDPE powder (PE-T)
PolyAl
Waste Tetra Pak

polymers
an Open Access Journal by MDPI

Indexed in:
WEB OF SCIENCE

Impact Factor 3.164

Forensic engineering of advanced polymer materials

The forensic engineering of advanced polymer materials (FEAPM), deals with the evaluation and understanding of the relationships between their structure, properties, and behavior before, during, and after practical applications. FEAPM provides a central driving force for the otherwise disconnected works, and should help to precisely design structured polymer materials, and to avoid potential failures of the commercial products manufactured from them.

Special Issue Information:

Web:
https://www.mdpi.com/journal/polymers/special_issues/forensic_polymer_material

Deadline: 20 November 2020

Guest Editors: Prof. Marek M. Kowalczuk and Dr. Wanda Sikorska

CONCLUSION

Both the *ex-ante* investigations as well as the *ex-post* studies are needed in order to define and minimize the potential failure of novel biodegradable polymeric materials before and after specific applications.

Acknowledgements

Co-authors of mentioned publications

Research supported by

POIG.01.03.01-00-007/08-00 POIG.01.03.01-00-018/08

European Union's Horizon 2020 under the
Marie Skłodowska-Curie grant agreement
No 872152, project GREEN-MAP

Agnieszka Bieniek – Wydrzyńska, Rybotycze, 2012

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European Union European Regional Development Fund
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THANK YOU FOR YOUR KIND ATTENTION

CMPW PAN 1954 2014