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Production of bioplastic from urban biowaste

DTU Environment

30 April 2019 DTU Environment



Europe: strong interest in bio and circular economy





Brussels, 4.3.2019 COM(2019) 190 final

REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE DECIONS



Background and rationale: urban biowaste availability

- COD in wastewater:
 - 100-120 g COD/capita/day
 - 250-350 L diluted wastewater/capita/day
 - Mostly in primary/secondary sludge
- COD in municipal biowaste:
 - Food waste: 130-140 % more than wastewater
 - Garden waste
- COD in agro- and food-industry

- Current management:
 - Separation of streams, e.g. sourcesegregation
 - Carbon stabilization, e.g. through composting
 - Energy recovery in biogas
- Limitations:
 - Regulation on soil application
 - Quality of compost, digestate
 - Economy

RES URBIS focus and objectives

- 1) To <u>integrate the treatment</u> of all relevant flows of biowaste (sludge, food waste, garden waste)
- 2) To develop an <u>urban bio-waste biorefinery</u> including related bio-based products



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RES URBIS mandate

- 1) To integrate the treatment of all relevant flows of biowaste (sludge, food waste, garden waste)
- 2) To develop an urban bio-waste biorefinery including related bio-based products
- 3) To address the entire technology chain and with respect to regional conditions
- 4) To address the relevant technical and non-technical constraints



WP1 (DTU, WP Leader)

- Task 1.1 Assessment of territorial clusters
- Task 1.2 Life Cycle Assessment (LCA)

Activities:

- Framing data collection
- Material/energy balances
- Preliminary LCA
- Full LCA for 5 clusters
 - Metropolitan Area of Barcelona (ES)
 - Metropolitan Area of Copenhagen (DK)
 - Metropolitan Area of Lisbon (PT)
 - South Wales (UK)
 - Province of Trento (IT)

WP4 (DTU)

- Regulatory aspects of waste handling
- Definition of end-of-life criteria for bioplastic

WP5 (DTU)

- Life Cycle Costing
- Value Chain analysis
- Stakeholder platform



Why focus on PHA?



- Product:
 - PHA is a family of copolymers (polyhydroxyalkanoate)
 - RES URBIS portfolio:
 - Biodegradable films
 - Packaging
 - Specific functionalities and products
- PHA production process:
 - A novel process: open microbial cultures
 - Easier integration into existing facilities
 - Based on waste feedstock
 - Significant cost reduction of PHA

- PHA: 3 x "Bio"
 - Renewable feedstock (but not food)
 - Biological process
- Easily and "truly" biodegradable
- Applications and economics:
 - Large market potential
 - Virgin polymers, not recycled
 - Higher profits with decreasing PHA costs, economy of scale
 - Higher value than biogas and compost
 - Already at TRL 6



Current scale: TRL6

Pilot scale platform of Universities of Venice and Verona at the wastewater treatment plant of Treviso (Alto Trevigiano Servizi, ATS)



Joint PHA production pilot plant, With Rome University «Sapienza»



TRL9: <u>Full commercial</u>. Available to customers.
TRL8: <u>1st commercial</u>. Manufact. issues solved.
TRL7: <u>Demonstration</u>. Pre-commercial.
TRL6: <u>Prototype</u>. Environment, performance.
TRL5: <u>Large scale prototype</u>. Environment.
TRL4: <u>Small scale prototype</u>. Lab.
TRL3: <u>Applied research</u>. Lab test, concept proof
TRL2: <u>Technology formulation</u>.
TRL1: <u>Basic research</u>. No exp proof.
TRL0: <u>Idea</u>. Unproven concept.



Project status

Project finish: 31 December, 2019

- Acid fermentation process optimized
- ✓ PHA produced in the order of kg's
- ✓ PHA tested in products: films and furniture
- ✓ Extraction method established (patent pending)
- ✓ Customer interest surveys completed
- ✓ Review of legislative barriers
- Economy: retrofitting (integration) on existing plants viable, no new plants foreseen
- LCA: global sensitivity (preliminary)



Biobased vs fossil plastic

Definitions





© European Bioplastics

Economy



Land use estimation for bioplastics 2018 and 2023





Biodegradability of plastic

Туре	Where	Expected time horizons	Microplastic formation
Non-degradable	Nature	100 - 1000 years	Yes
	Industrial bioprocesses	5 - 10 years?	?
Degradable	Nature	Weeks – years	?
	Industrial composting	3 – 6 months	?
	Anerobic digestion	1 month – years	?

Degradation processes			
•	Abiotic (photodegradation, mechanical, oxidative,		
	hydrolitic)		

Biotic (microbial, enzymatic)

Factors affecting degradationChemical composition, bonding

- Molecular weight, size
- Hydrophilicity
- Additives
- Polymer stress
- Environmental conditions (moisture, T, O₂, etc)



Biodegradability: in-reactor experiments at DTU





Figure 4.13: Fluorescent microscopy images of Nile Red stained filtered sludge samples. Sample no. 7: *Bacillus licheniformis*; Sample no. 31: UV-treated virgin LDPE and *Bacillus licheniformis*; Sample no. 40: UV-treated bio-LDPE and *Bacillus licheniformis*; Sample no. 55: UV-treated PCL and *Bacillus licheniformis*.



Thanks for your attention!

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