
Better
Plastics

Better Plastics

PPS4

Circularity by Alternative Feedstocks

Specific Objectives

- Development of biodegradable materials based on the recovery of food waste and biomass;
- Development of sustainable materials and products from agroforestry waste resources
- Development of sustainable functional additives.

Better Plastics

PPS4

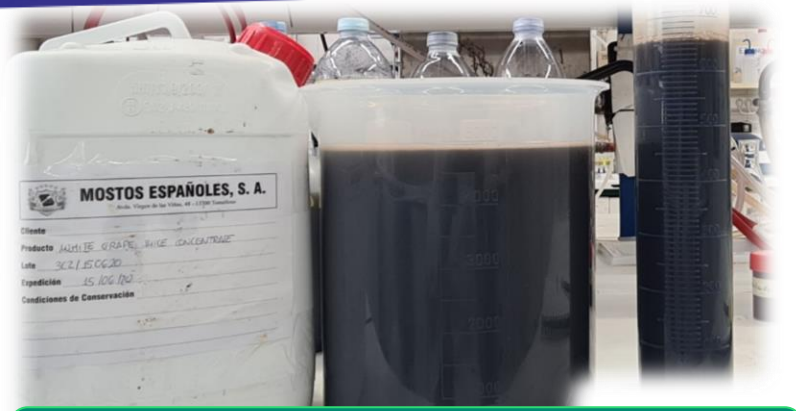
Products/Services or Processes

- Medium chain length polymers (e.g. MCL-PHA) for film production;
- Short chain length polymers (e.g. SCL-PHA) for the production of rigid and semi-rigid packaging;
- Carbon fibre from lignin;
- Industrial adhesives for use in cork and wood agglomerates;
- Sustainable antioxidant plasticizers for PVC production.

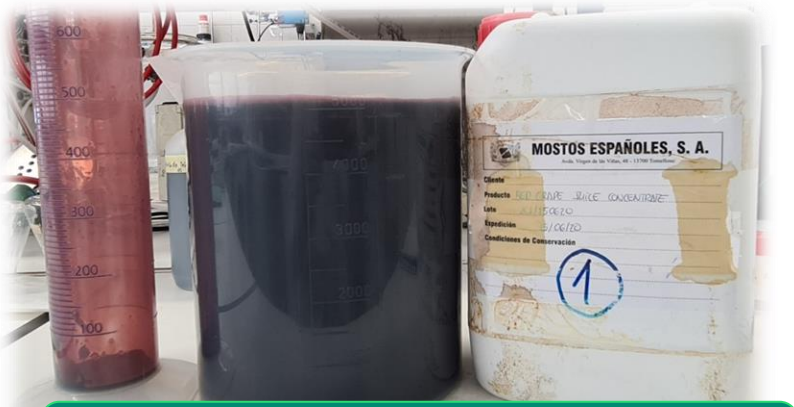
Better Plastics

Wastes

Hidrolisado Lignocelulósico



White Grape Waste



Red Grape Waste

Better Plastics

Food waste

Apple Pulp Residues

Better Plastics

Wastes characterization

Parameter	Apple Pulp Waste	Lignocellulosic Hydrolysate	Red Grape Waste	White Grape Waste
pH	3.59 ± 0.00	0.77 ± 0.02	3.19 ± 0.03	3.50 ± 0.03
Suspended Solids (g/L)	n.d.	1.28 ± 0.39	10.61 ± 0.57	11.78 ± 3.00
Soluble Solids (g/L)	n.d.	90.00 ± 1.42	849.67 ± 2.45	844.00 ± 66.48
Glucose (g/L)	11.5 ± 0.4	0.22 ± 0.00	375.28 ± 25.41	367.96 ± 4.36
Fructose (g/L)	29.1 ± 0.80	n.d.	394.96 ± 52.24	434.81 ± 69.61
Furfural (mg/L)	n.d.	2.41	3.41	7.96
5-HMF (mg/L)	n.d.	3.58	39.57	140.35
Levulinic acid (g/L)	n.d.	2.67	n.d.	n.d.

n.d. – not detected;

Better Plastics

PHA production

Bioreactor cultivation runs

Better Plastics

Production Parameters

Parameters	Apple Pulp	Grape Waste 1	Grape Waste 2
max CDW (g/L)	13.34	53.39	11.51
PHA (g/L)	5.20	0.55	5.65
rPHA (g/L·h)	0.10	0.03	0.10
PHA content (%)	39.00	1.27	49.06

Better Plastics

PHA characterization

Parameters	Apple Pulp	Grape Waste 1	Grape Waste 2
max CDW (g/L)	13.34	53.39	11.51
PHA content (%)	39.00	1.27	49.06
PHA (g/L)	5.20	0.55	5.65
rPHA (g/L·h)	0.10	0.03	0.10
PHA composition (%)	HHx -2 HO - 16 HD - 63 HDd - 7 HTd - 12	HHx -2 HO - 20 HD - 45 HDd - 21 HTd - 12	HHx -3 HO - 22 HD - 53 HDd - 12 HTd - 10

Better Plastics

ADESIVOS DE BASE NATURAL PARA AGLOMERADOS

- **Formaldeído**
- **Fontes fósseis**

Toxicidade para o ambiente, os trabalhadores e os utilizadores finais

Better Plastics

ADESIVOS DE BASE NATURAL PARA AGLOMERADOS

- Derivados de pinho, ácidos diméricos
- Óleos vegetais usados
- Polióis de origem natural
- Proteínas

Baixo conteúdo em fontes "fósseis"

ADESIVOS DE BASE NATURAL PARA AGLOMERADOS

Absorção de água

Póliol	# Identificativo placa	Formulação	Condições de prensagem	Inchamento (%)
	19	6% de polyol 1.1 + 6% isocyanate + 20 ml water	132º C; 10 min	11
	36	3,75% de polyol 1.1 + 3,75% isocyanate + 20 ml water	132º C; 10 min	15
	48	6% de polyol 1.1 + 6% isocyanate + 20 ml water	160º C; 8 min	22
	46	1,5% de polyol 1.1 + 1,5% isocyanate + 20 ml water	160º C; 8 min	37
Póliol 1.1	52	6% de polyol 1.1 + 6% isocyanate + 20 ml water	160º C; 10 min	6
	50	1,5% de polyol 1.1 + 1,5% isocyanate + 20 ml water	160º C; 10 min	43
	39	6% de polyol 1.1 + 6% isocyanate + 20 ml water	180º C; 8 min	19
	42	3,75% de polyol 1.1 + 3,75% isocyanate + 20 ml water	180º C; 8 min	29
	51	1,5% de polyol 1.1 + 1,5% isocyanate + 20 ml water	180º C; 10 min	42
	40	3,75% de polyol 2.2 + 3,75% isocyanate + 20 ml water	132º C; 8 min	21
	27	6% de polyol 2.2 + 6% isocyanate + 20 ml water	132º C; 10 min	24
Poliol 2,2	34	3,75% de polyol 2.2 + 3,75% isocyanate + 20 ml water	132º C; 10 min	25
	54	3,75% de polyol 2.2 + 3,75% isocyanate + 20 ml water	160º C; 8 min	28
	21	6% de polyol 2.2 + 6% isocyanate + 20 ml water	160º C; 10 min	7
	22	3,75% de polyol 2.2 + 3,75% isocyanate + 20 ml water	160º C; 10 min	32
	57	6% de polyol 3 + 6% isocyanate + 20 ml water	132º C; 8 min	19
Poliol 3	49	3,75% de polyol 3+ 3,75% isocyanate + 20 ml water	160º C; 8 min	33
	38	1,5% isocyanate + 20 ml water	160º C; 10 min	45
	33	3,75% isocyanate + 20 ml water	180º C; 8 min	32
none	58	1,5% isocyanate + 20 ml water	180º C; 8 min	51
	13	3,75% isocyanate + 20 ml water	180º C; 10 min	39

Better Plastics

ADESIVOS DE BASE NATURAL PARA AGLOMERADOS

Após mais de 100 formulações....

Polióis de base natural e óleos vegetais usados

>96% das matérias-primas de base natural

Bio-ligante + Proteínas

Better Plastics

PPS4

Circularity by Alternative Feedstocks

Valorisation of lignin, which exists in large quantities as a residue from the production of cellulose pulp, for the production of short green carbon fibres

Products/Services or Processes

Better Plastics

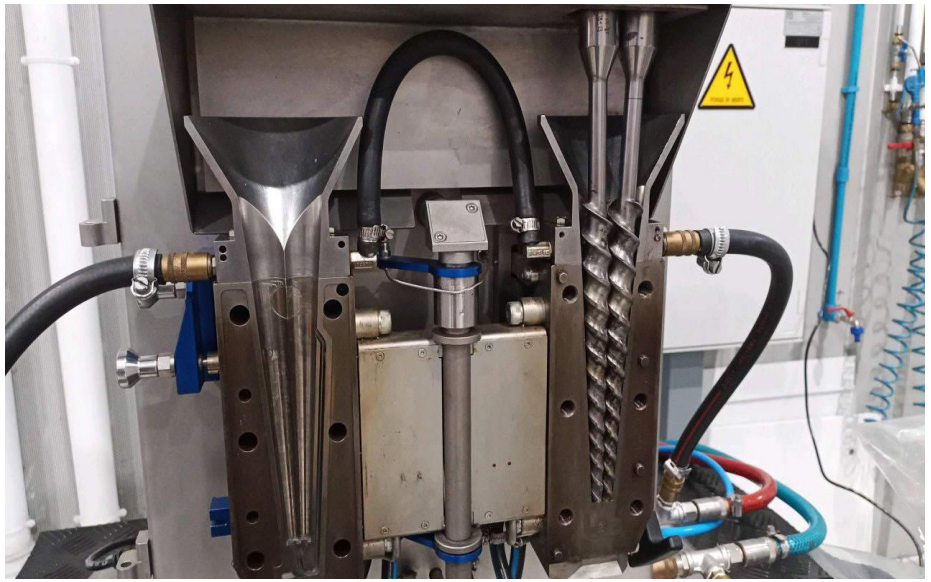
Framework

- **Lignin composites**: Dispersion of lignin in the polymer to form lignin composites.
- **Lignin filaments**: Produce filaments with a controlled diameter and flexibility.
- **Filament thermostabilization**: Stabilize filaments inducing orientation.
- **Filament carbonization**: Produce green fibers for carbon fiber precursors.

Better Plastics

Lignin Composites

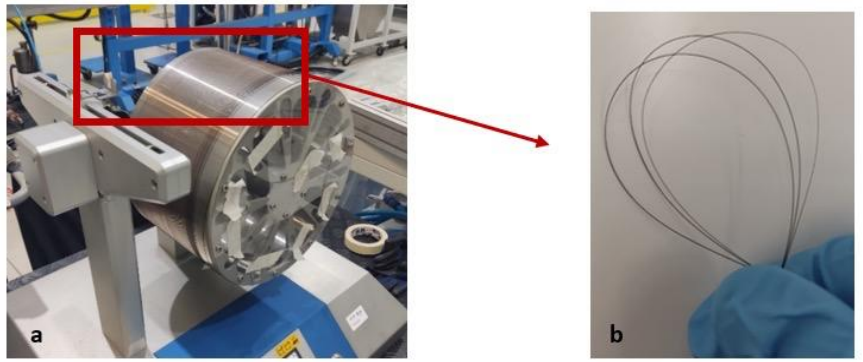
- Melt mixing of lignin with polymer in a micro-compounder Xplore MC15
- Mixing time (recirculation): 10 min
- screw velocity of 50 rpm
- acceleration of 50 rpm^2



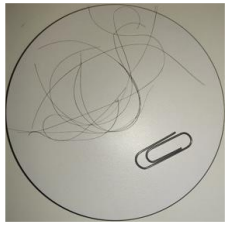
Lignin composites → Lignin filaments → Thermostabilization → Carbonization → Green Fibers

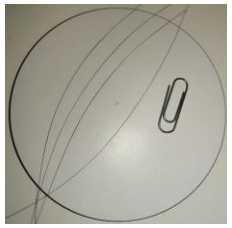
Lignin Filaments

- Extruder Die - 250 µm ∅
- ∅ of extruded filament ~ 160 µm
- Filament compositions wt%:
  - PET-G 50/50 Lignin
  - Pet-G 40/60 Lignin
  - PC/ABS 50/50 Lignin




PET-G-60LHP

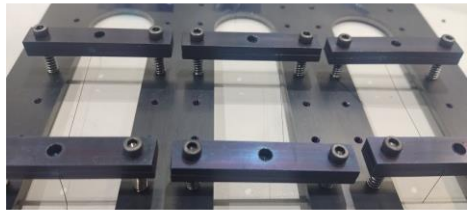

PET-G-50LHP

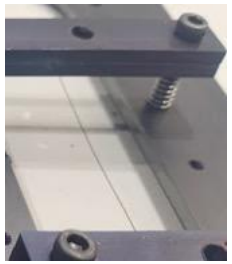

PC/ABS-50LHP

Lignin composites → **Lignin filaments** → Thermostabilization → Carbonization → Green Fibers

Better Plastics

Thermostabilization of Lignin/Polymer filaments





PETG-50LHP

PETG-60LHP

PCABS-50LHP

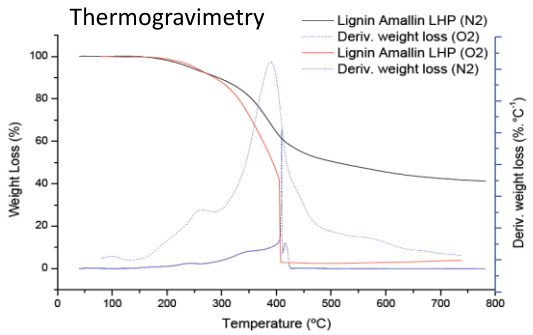
Better Plastics

Characterization

Thermal Analysis

Lignin

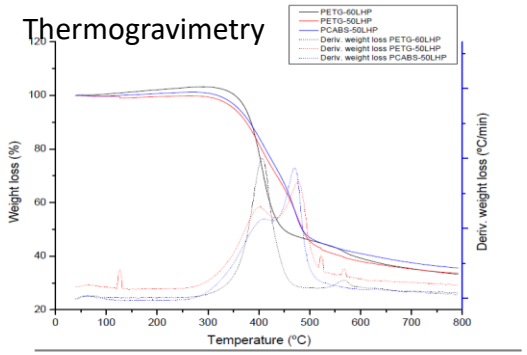
Thermogravimetry



Lignin (test atmosphere)	Residual mass at 120 °C (%wt)	Residual mass at 250 °C (%wt)	Residual mass at 750 °C (%wt)
LHP (O_2)	99.69 ± 0,07	92,85 ± 0,26	No residue
LHP (N_2)	99.75 ± 0,08	94,90 ± 0,72	42.4 ± 1.6

Composites

Thermogravimetry

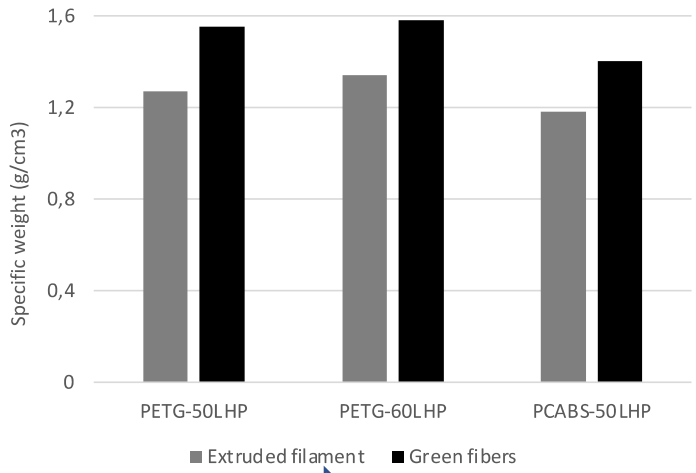


Residual Mass

Sample	Residual mass @ 750 °C (%wt) (extruded fibers)	Residual mass @ 750 °C (%wt) (stabilized fibers)
PETG-50LHP	28.9 ± 0.7	34.7 ± 1.3
PETG-60LHP	38.9 ± 1.2	34.5 ± 3.2
PCABS-50LHP	25.4 ± 0.6	37.2 ± 1.8

Stabilized Fibers

Specific Weight



Lignin composites → Lignin filaments → **Thermostabilization** → Carbonization → Green Fibers

Plastics in a Circular Economy

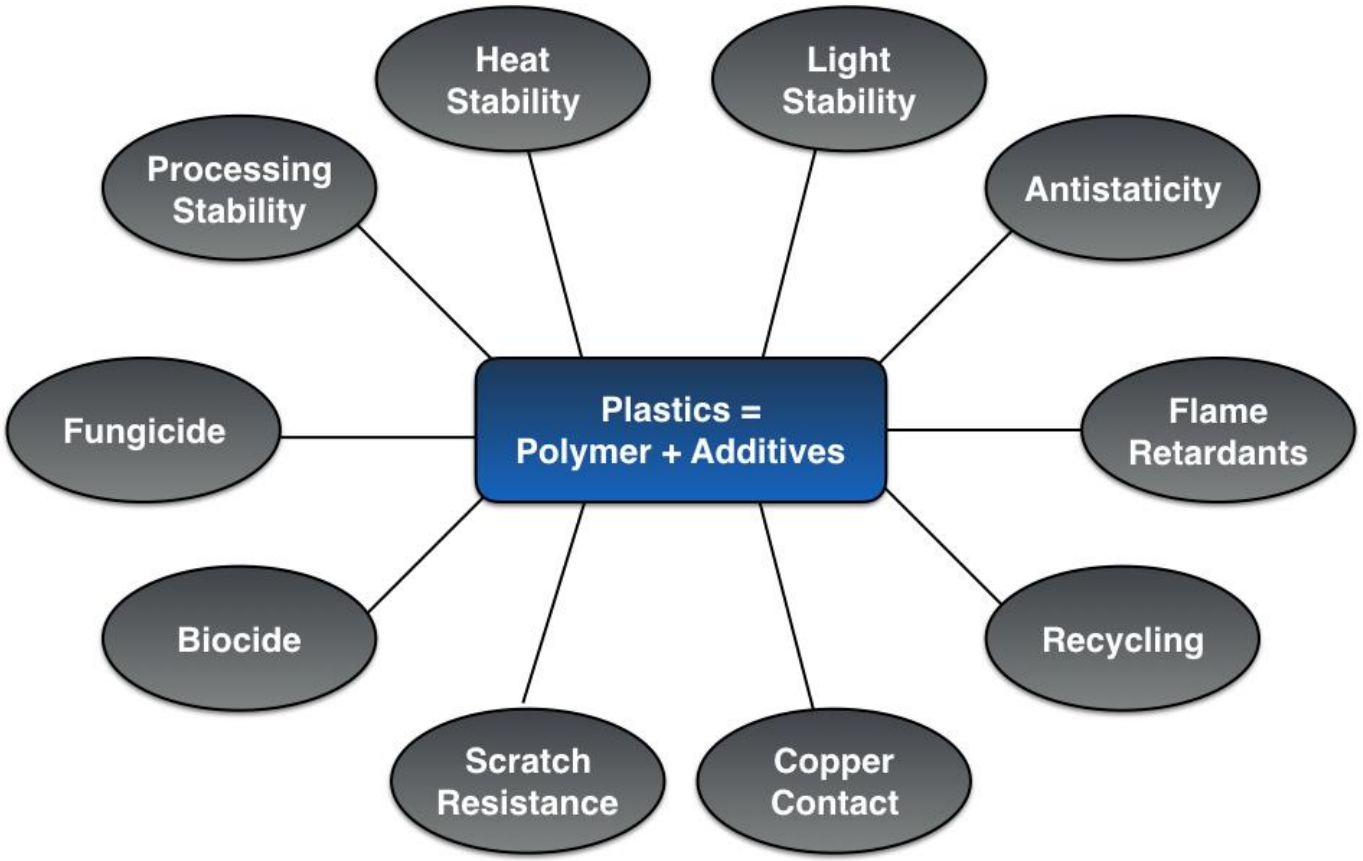
Conclusions

- Our experimental results have shown promising characteristics for the lignin composite filaments, including good thermal stability and an increased density and carbon content after thermostabilization

- While more research is needed to further optimize the production process and improve the properties of the fibers, our work opens up exciting possibilities for the use of lignin in carbon fiber production

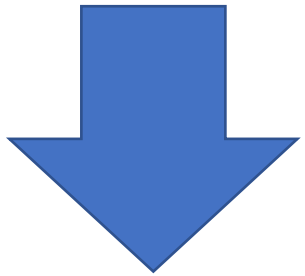
Better Plastics

ADITIVOS



Foram produzidos aditivos para formulação de polímeros:

-Antioxidantes
- Anti-estáticoS
- Plastificantes



Lotes de produção para uso na formulação de PVC (perfis) e PE (filmes)

Better Plastics

ADITIVOS

ANTI-OXIDANTS

Bio-oils, alkylphenols fraction

↓

Evaluation of antioxidant activity by gel time

↓

Preparation of batches for polymer formulation

ANTI-STATICS

Chemical modification of vegetable oils

↓

Evaluation of anti-static activity

↓

Preparation of batches for polymer formulation

PLASTICIZERS

Preparation of plasticisers with tall oil fatty acids, rosin, residues

↓

Preparation of batches for polymer formulation

↓

Mechanical properties

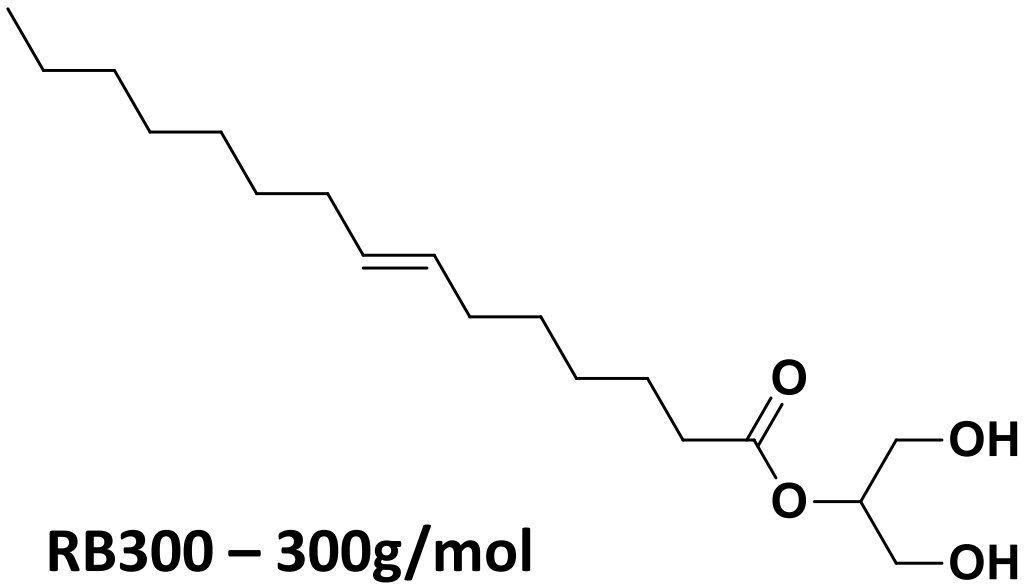
PROTOTYPES

Better Plastics

RESIDUES OF BIOMASS/EDIBLE OIL/CARDANOL	QUANT. (G)	RESIN (G)	INITIATOR (3%)	ACCELERATOR (ML)	GEL TIME (H/MIN/S)
BIO-OIL	01288	12.0496	0.1204	0.0699	0:12:01
BIO-OIL/SOYBEN-OH	01235/0.1160	12.0740	0.1134	0.0521	0:15:19
BIO-OIL/SOYBEAN-OH	0.1682/91.6	12.7191	0.1076	0.0686	0:22:10
BIO-OIL/SOYBEAN-OH	0.158	12.6996	0.1052	0.0562	0:54:32
BIO-OIL/CARDANOL	0.1165/0.0342	12.0374	0.1123	0.0513	0:14:31
BIO-OIL/CARDANOL	0.1175/0.0736	12.0401	0.1021	0.0649	0:16:39
BIO-OIL/SOYBEAN-EST	0.1094/0.0597	12.0478	0.1230	0.0510	0:13:22
BANANA TREE RESIDUES	0.1096	12.0916	0.1086	0.0530	0:07:11

Better Plastics

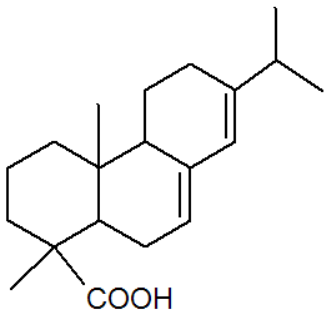
Plastificantes à base de resíduos



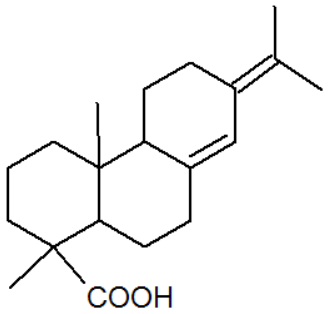
RB300 – 300g/mol

Better Plastics

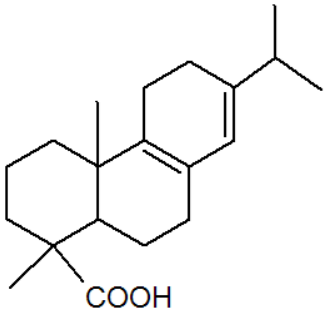
Plastificantes à base de colofónia



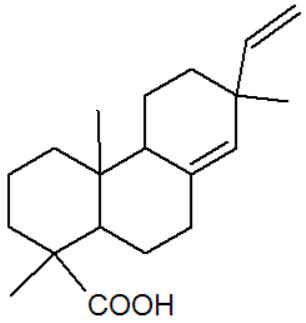
Abietic Acid



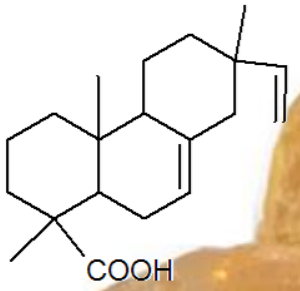
Neoabietic Acid



Palustric Acid



Pimaric Acid



Isopimaric Acid

EGR450 – 450g/mol

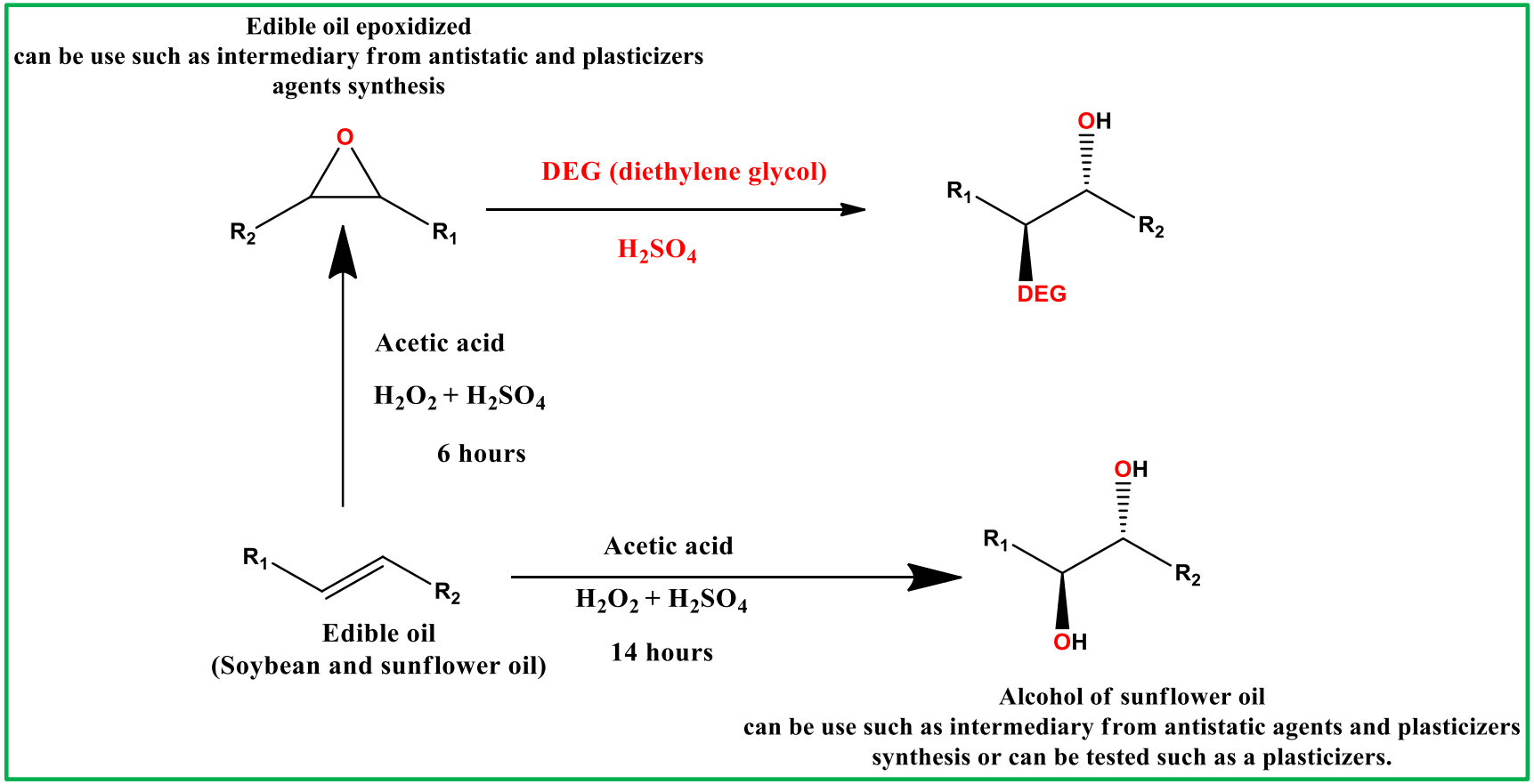
GTR1000 – 1000g/mol

PTR1300 – 1300g/mol

Plastics in a Circular Economy

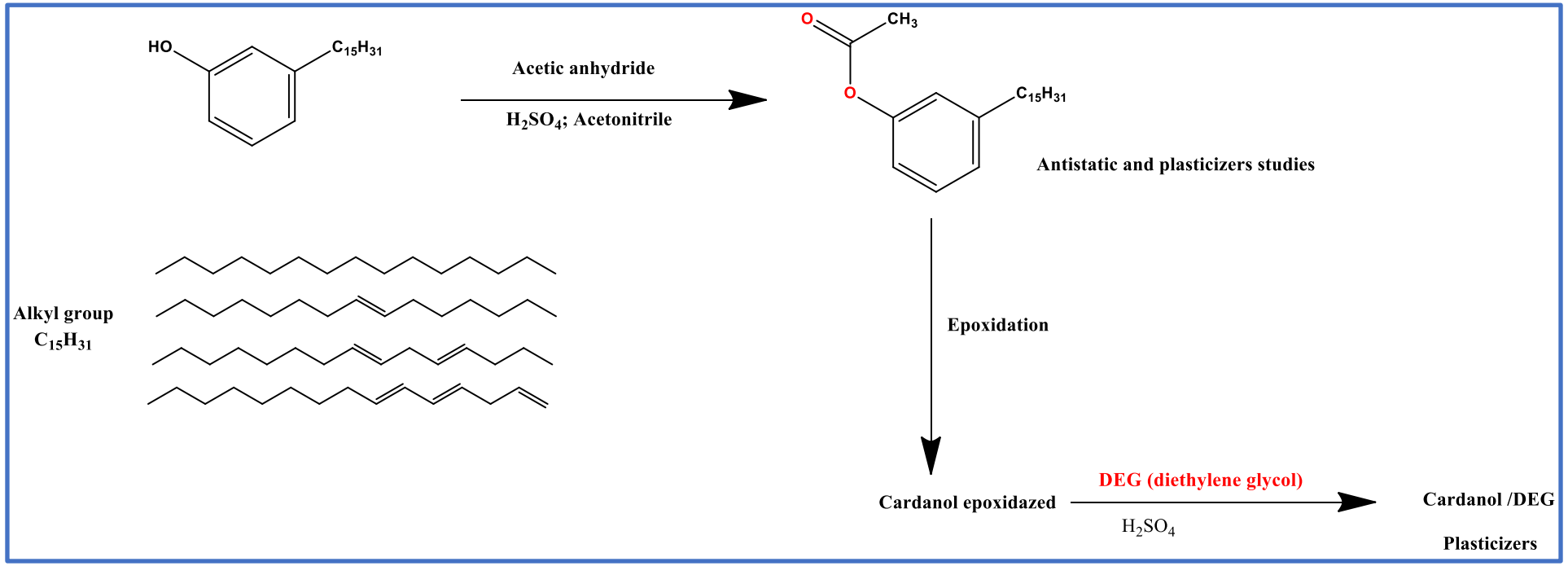
Better Plastics

Preparação de componentes antiestáticos e plastificantes



Better Plastics

Preparação de componentes antiestáticos e plastificantes



Better Plastics

Próximos passos

- Finalizar a produção de lotes para testes industriais
- Teste dos aditivos com PVC e PE
- Avaliação das propriedades dos materiais
- Produção de protótipos

Ações de Divulgação

Tipo	Plano de Execução
Publicação de Artigos científicos em revistas e livros da especialidade em cooperação ENESIIs e Empresas	Publicados 2 artigos, estão em preparação/planeados 5 papers
Participação em congressos e conferências Técnico-Científicas	4 conferencias, estão planeadas mais participações
Participação em Feiras /Workshops	3 workshops
Teses de Mestrado e Doutoramento	3 PhDs, 1 MSc
Pedidos Provisórios de Patente (*)	A decidir até ao final do projecto
Outreach	Acções de divulgação cientifica

Better Plastics

Innovation Ecosystem | PPS 4

vizelpas Flexible Films

Plasoeste Sociedade Transformadora de Plásticos, Lda.

intraplás

REPSOL

CIE Plasfil

klc TECHNICAL PLASTICS

ISOLAGO

TÉCNICO LISBOA

FCT FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

piep

1 2 9 0 UNIVERSIDADE D COIMBRA

Universidade do Minho

Better Plastics

Plastics in a Circular Economy

Cofinanciado por:
COMPETE 2020 Lisb@20[20] PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional