Circular and Biobased Performance Materials Symposium
19 June 2019, Wageningen, The Netherlands

Session: Applying biobased polymers for new products
Presentation by: Jérôme Vachon, *SABIC*

Title: **Sustainability initiatives within SABIC with examples of use of bio-based materials for polyolefins**

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Curriculum:
Jérôme Vachon holds a Chemical Engineering degree from CPE Lyon (France) and obtained a PhD in Organic Chemistry from the University of Geneva (Switzerland) in 2006. He conducted a 2 years-post-doctoral research position in the University of Groningen (The Netherlands) in the group of Prof. Ben L. Feringa (Nobel Laureate in 2016) working on molecular machines. In 2008, he joined Prof. Jean-Pierre Dutasta's group in ENS Lyon as Researcher/Teacher. In 2010, he joined SABIC where he is currently working as Staff Scientist in the Materials Science group within the Technology department located in Geleen (The Netherlands). His main research activities include developing new polyolefins materials for application in food packaging, healthcare and automotive where sustainability of the solution is a key parameter. He is the co-author of 24 publications and filed 13 patents.

Abstract:
SABIC is committed to the packaging industry by continuously innovating new materials and developing technology expertise to support our customers with industry's changing requirements and help them achieve their sustainability goals. As one of the leading material supplier in the packaging industry, our dedicated global packaging team works closely with our customers to help them with differentiated applications. In that respect, several sustainability initiatives were conducted within SABIC with (i) reducing materials' weight (ii) using renewable (non-fossil based) feedstocks and (iii) chemical recycling of plastic waste which will be shown in this presentation. For instance, by turning mixed waste plastic into an oil, we can make new plastics for packaging without using fossil fuels and thus contribute for a better circular economy. Finally, two examples will be shown where synergy can be obtained from the combine use of biobased materials (starch and lignin) with fossil-based polyolefins.

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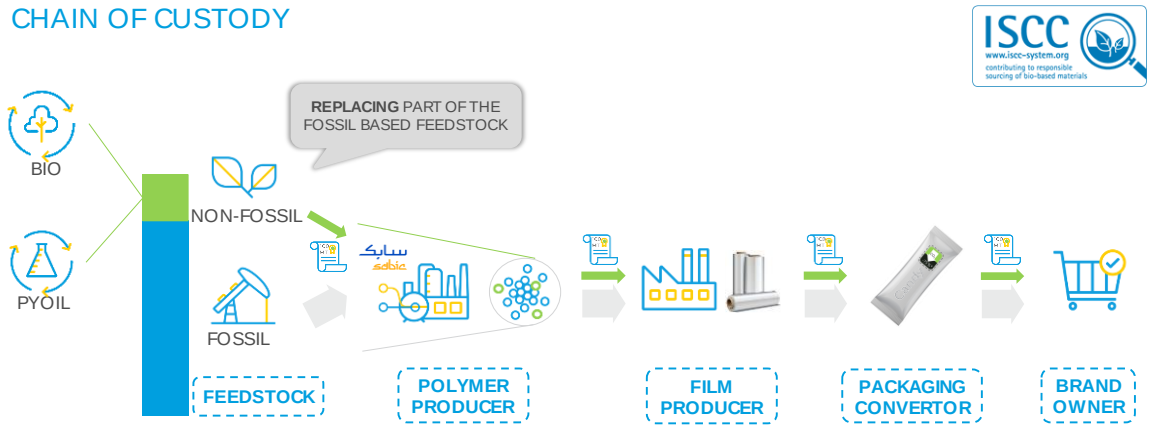
CHAIN OF CUSTODY



CHEMISTRY THAT MATTERS™

SUSTAINABILITY INITIATIVES WITHIN SABIC

WITH EXAMPLES OF USE OF BIO-BASED MATERIALS FOR POLYOLEFINS

Jérôme Vachon, PhD, SABIC Technology Geleen, Material Science

CBPM Symposium, June 2018

CONTENT

PART 1

SABIC CERTIFIED POLYMERS:

- Bio-renewable
  - Mass balance concept
  - Drop-in solution for cracker

- Circular polymers
  - Chemical recycling concept

PART 2

BIO-BASED POLYMERS

- PE-Starch blends
  - For enhanced barrier

- PE-Lignin blends
  - For antioxidant properties

SABIC TODAY

SABIC AT-A-GLANCE

1976
Company established

34,000
Employees around the world

50
Countries of operations

3rd
Largest global chemical company*

120th
Largest public company in the world*

4
Core businesses

86
US$ B**
Total assets

4.9
US$ B**
Net income

39.9
US$ B**
Annual revenue

≈ 150
New products each year

11,534
Global patent filings

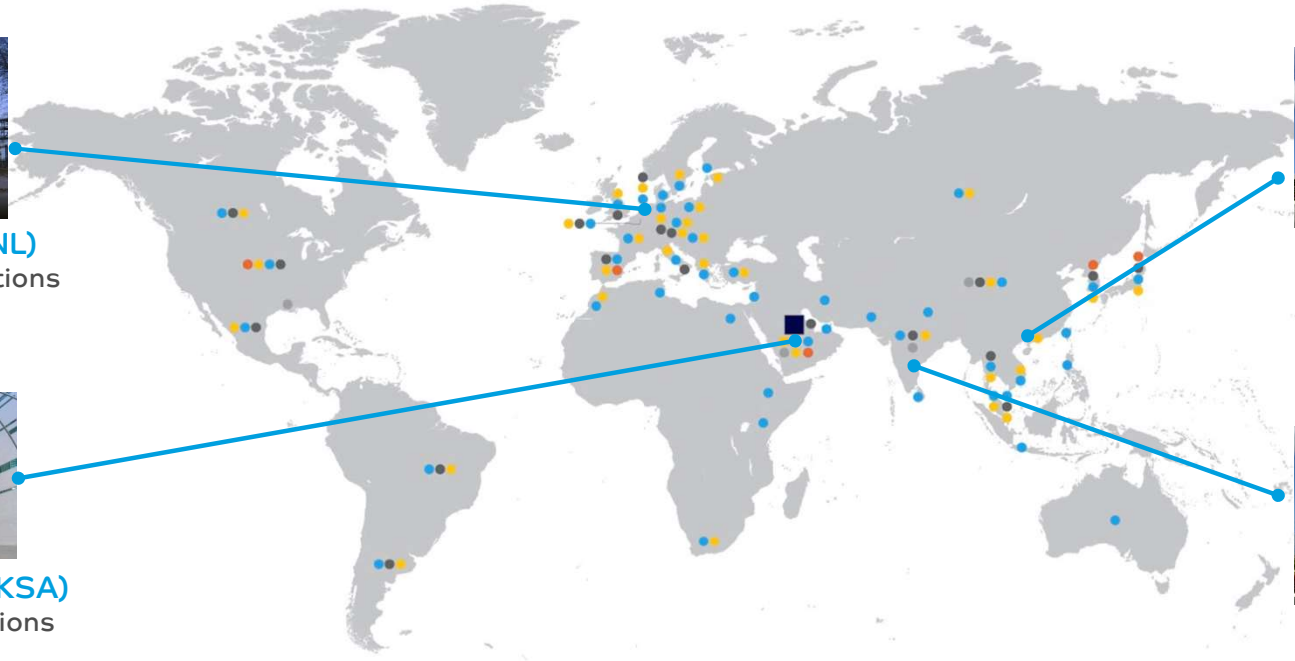
64
World-class plants worldwide

*Forbes 2018 **Billion

SABIC GLOBAL PRESENCE WITH DEDICATED PACKAGING INNOVATION CENTERS

STC-G (Geleen – NL)
New customer solutions for Europe

SPADC (Riyadh – KSA)
New customer solutions for MEAF



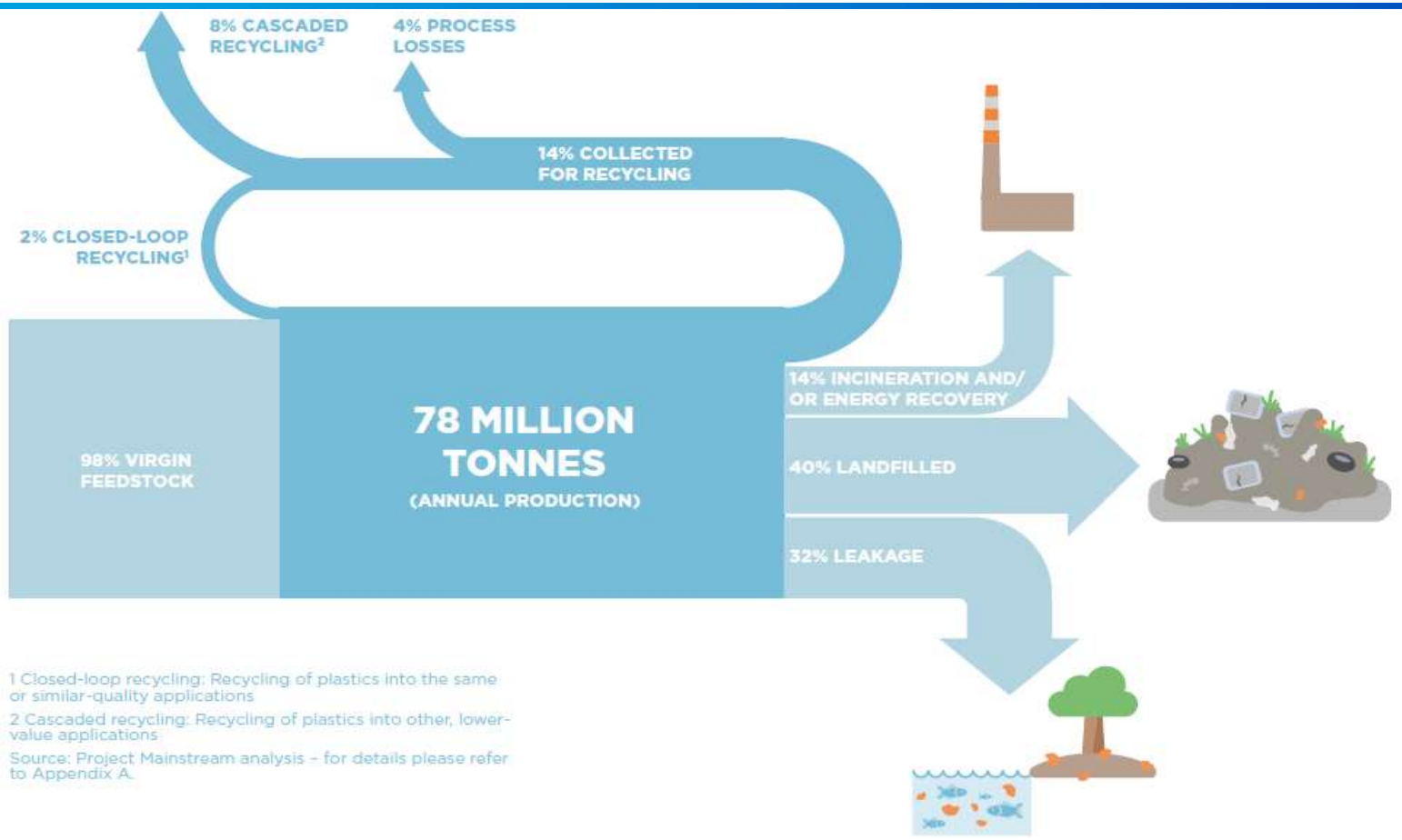
STC-S (Shanghai - China)
New customer solutions for China

STC-B (Bangalore – India)
Predictive engineering & modeling properties

GLOBAL HEADQUARTERS
PRODUCT APPLICATION CENTERS
DISTRIBUTION, STORAGE FACILITIES AND LOGISTICAL HUBS
TECHNOLOGY AND CORPORATE RESEARCH AND INNOVATION CENTERS
INTERNATIONAL SUBSIDIARIES & SALES OFFICES
MANUFACTURING AND COMPOUNDING COMPANIES

SABIC CERTIFIED BIO-RENEWABLE POLYMERS

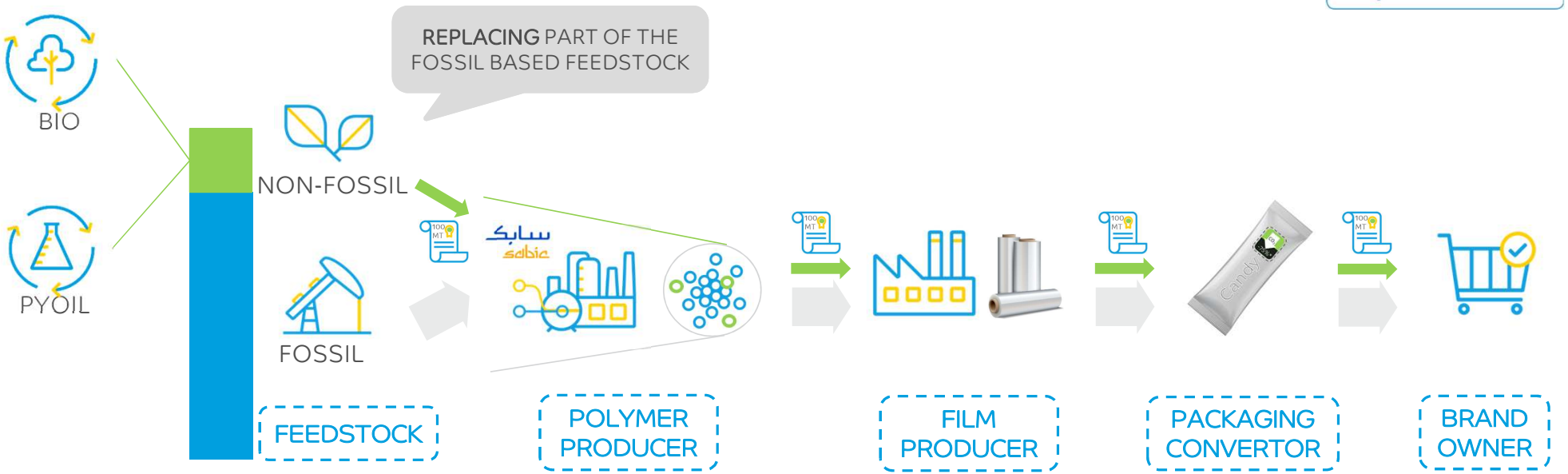
MOVING OUT FROM A LINEAR ECONOMY IN GLOBAL PASTIC PACKAGING



SOURCE: ELLEN MAC-ARTHUR FOUNDATION – THE NEW PLASTIC ECONOMY – RETHINKING THE FUTURE OF PLASTICS – JANUARY 2016
AMI – BIAX FILM CONFERENCE, VIENNA, AUSTRIA, JUNE 2018

CERTIFIED PP & PE SOLUTIONS – MASS BALANCE CONCEPT

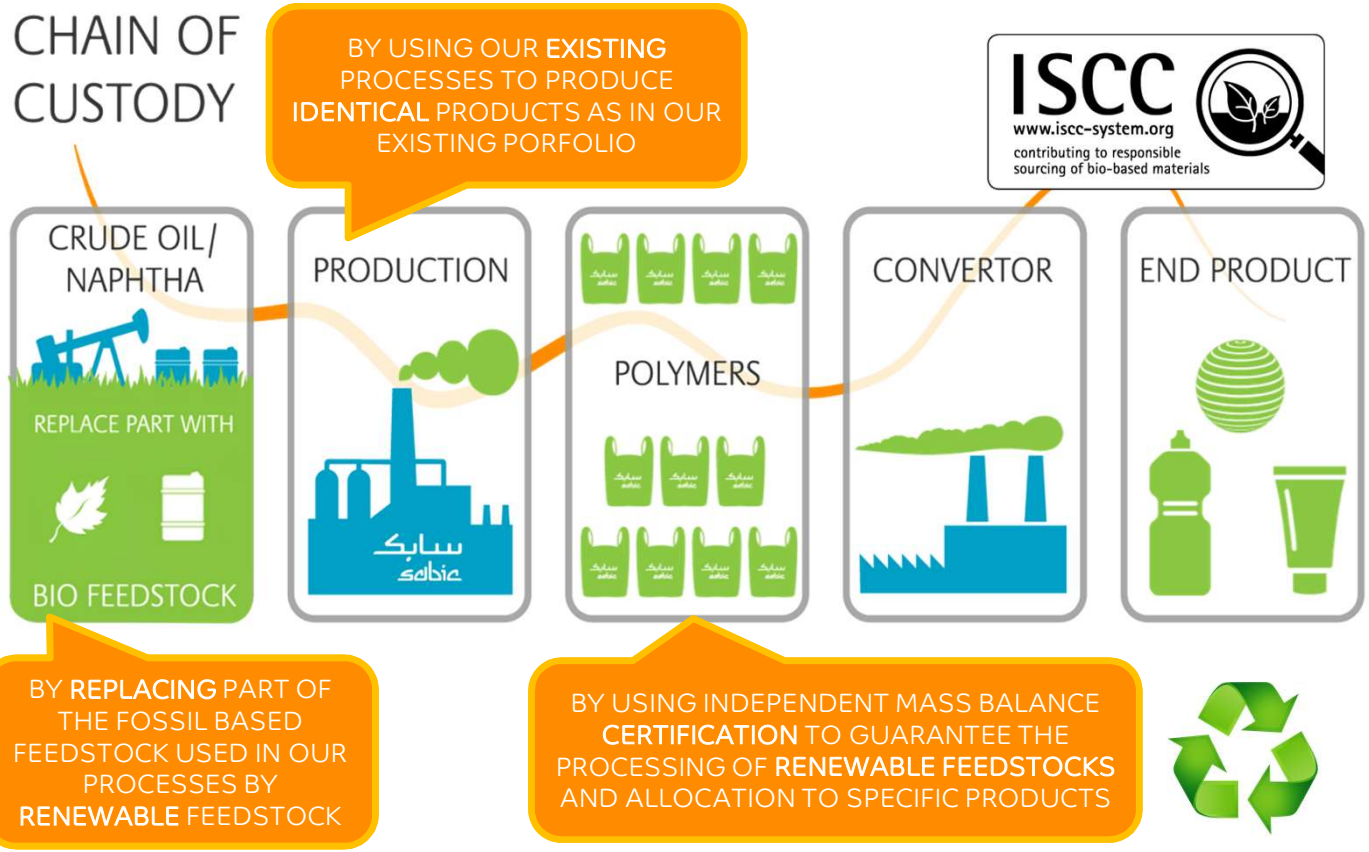
CHAIN OF CUSTODY



OUR SOLUTION: SABIC CERTIFIED RENEWABLE PE AND PP

RENEWABLE FEEDSTOCK

- We partially replace fossil feedstocks by renewable feedstocks.
- Produced from waste oils (e.g. tall oil from wood pulp): 2nd Gen. Feedstock
- Renewable feedstock is not in competition with the food chain. Lower carbon footprint.
- By using our existing infrastructure there are no changes in the value chain, not even in recycling.
- We can produce (the first) renewable PE and PP. Fully recyclable



VALUE CREATION WITH PARTNERS

EACH KG OF RENEWABLE PE/PP REMOVES UP TO 2 KG OF CO_2 FROM THE ATMOSPHERE WITH FOSSIL DEPLETION REDUCTION POTENTIAL BY UP TO 80%

SABIC INVITES YOU TO ROLL-OUT THIS CONCEPT

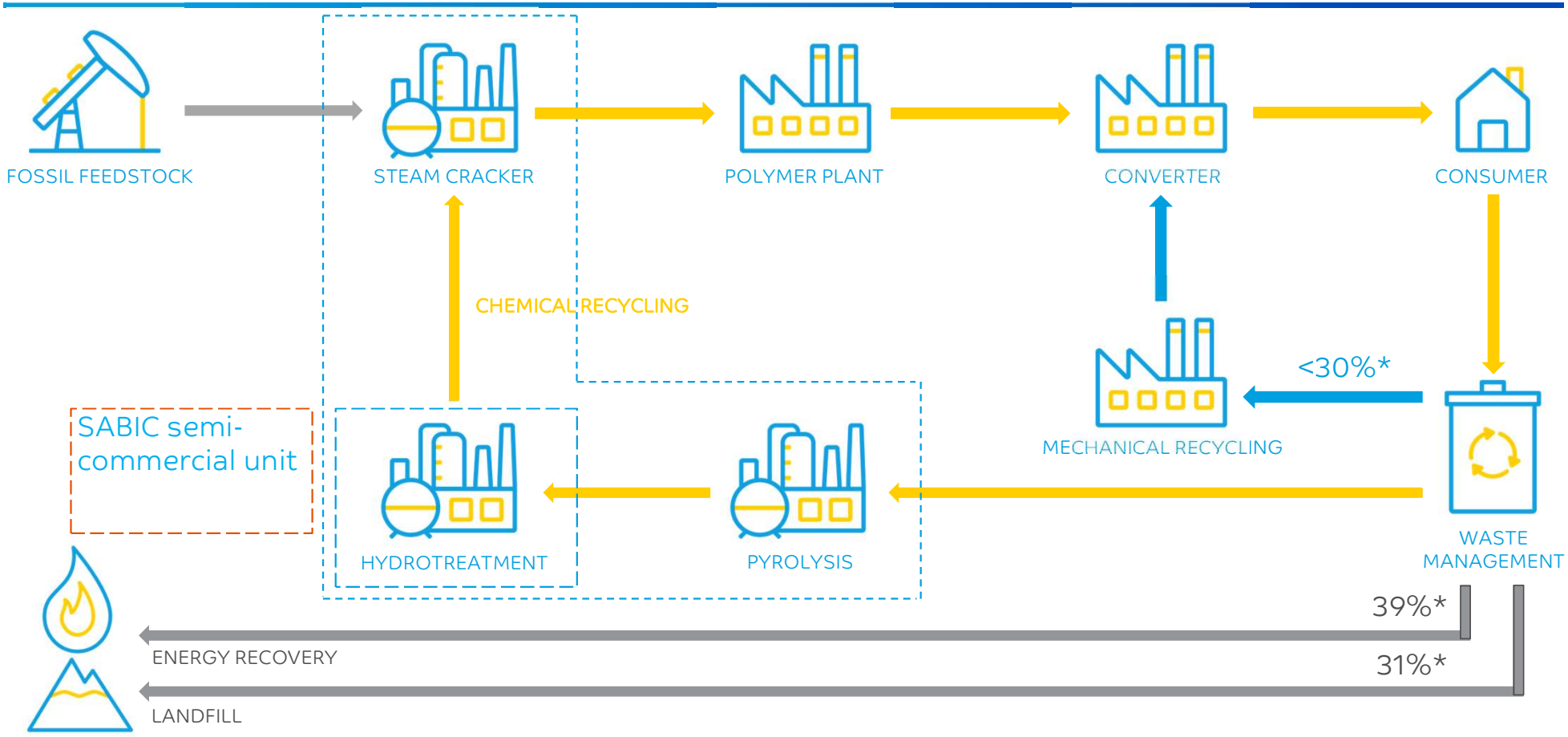
SOURCE : BY COURTESY OF SIG, ALPAGREEN PACKAGING & MARVILEX
IMPACT ASSESSMENT METHOD: RECIPE MIDPOINT (H) V1.13 / EUROPE H PER KG OF PLASTIC

SUSTAINABILITY INITIATIVES WITHIN SABIC

SABIC CERTIFIED CIRCULAR POLYMER

A NEW FEEDSTOCK

THE CONCEPT "FROM LINEAR TO CIRCULAR"



*A European Strategy for plastics in Circular Economy 2018

Classification: General Business Use

BENEFITS OF FEEDSTOCK UPCYCLING

ENABLING TO HELP MEET YOUR CORPORATE SUSTAINABILITY TARGETS

SABIC'S CERTIFIED CIRCULAR POLYMERS

NEW

PURE AND SAFE
NO COMPROMISE ON PRODUCT PACKAGING QUALITY
BIG WINDOW OF PACKAGING APPLICATIONS, INCLUDING F&B CONSUMER PACKAGING

DROP-IN SOLUTION
PROCESS NEW PACKAGING ON EXISTING EQUIPMENT WITHOUT MODIFICATIONS
DOWN GAUGING OPPORTUNITIES

TRULY RECYCLABLE
NO LIMITATIONS IN NUMBER OF RECYCLING STEPS

SABIC PIONEERS IN CIRCULAR POLYMERS THROUGH CHEMICAL RECYCLING

SABIC IS THE FIRST IN THE INDUSTRY THAT IS COMMITTED TO SCALE UP CHEMICAL UPCYCLING OF MIXED PLASTIC WASTE TO THE ORIGINAL POLYMER.

PRESS RELEASE

DAVOS, SWITZERLAND, January 24, 2019

SABIC AND CUSTOMERS LAUNCH CERTIFIED CIRCULAR POLYMERS FROM MIXED PLASTIC WASTE

- SABIC and customers Unilever, Vinventions and Walki Group will introduce ISCC certified circular polymers in 2019 during a market foundation stage.
- SABIC's certified circular polymers will be produced in The Netherlands from a recycled plastic waste feedstock developed by PLASTIC ENERGY and offer a drop-in alternative for customers looking at meeting the needs of various challenging applications.
- The initiative to upcycle mixed plastic waste back to the original polymer supports SABIC's and its feedstock supplier and customers commitment to providing innovative solutions for a circular economy.

Unilever

walki

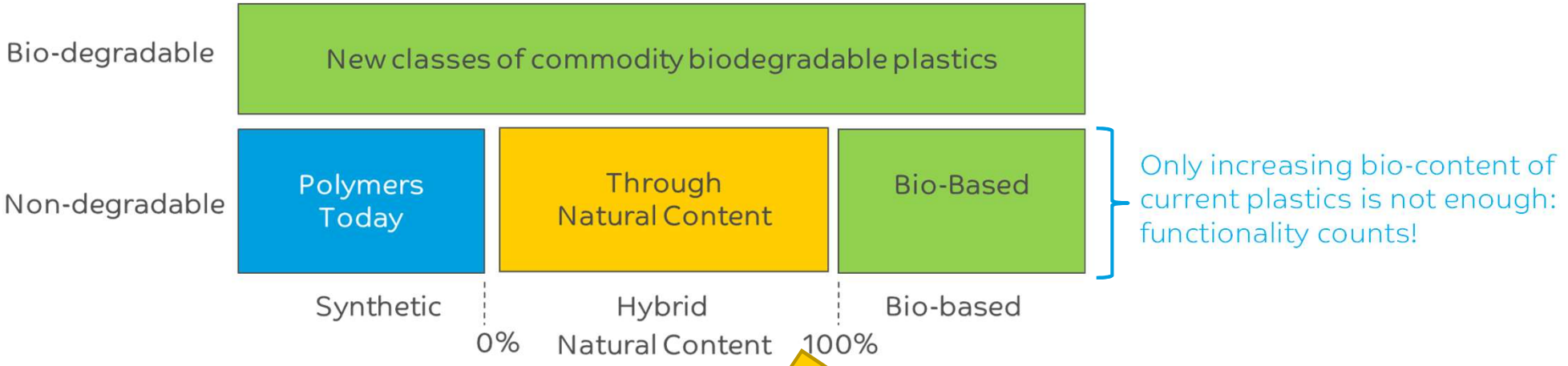
VINVENTIONS

Tupperware®

https://www.pressreleasefinder.com/SABIC/SABICPR374/en/

WHAT ABOUT BIOBASED POLYMERS?

SUSTAINABILITY OPTIONS FOR COMMODITY PLASTICS



Sugar, Starch:

- Crops intented for human and animal consumption: Compete with arable land
- Food price and environmental degradation impacts!

Research efforts concentrated on ligno-cellulosic bio-mass from sources that do not compete with food crops

Sugar

Ex. Sugar cane, sugar beet

192 MT*

Starch

Ex. Rye, rice, corn, wheat, barley, potatoes

85 MT**

Ligno-cellulose

Ex. Forestry waste, straw, energy crops

Multi MT potential to be used

*: 2017 figures in https://www.statista.com/topics/1224/sugar/

**2015 figures in http://www.starch.dk/isi/stat/rawmaterial.asp

WHY PE-STARCH?

Combining the advantages of polar and apolar polymers

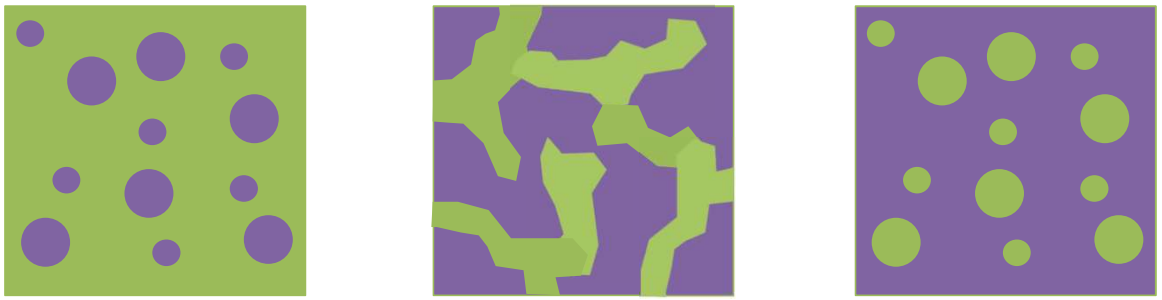
Idea: Create a co-continuous blend of polyethylene and thermoplastic starch

- Advantage: - Add polarity to PE for printability
  - High barrier properties w.r.t. O_2 and CO_2
  - Add green content ~ 50% starch
  - Add interface for easy processing
- Disadvantage: - Degradation of starch above 160 °C

Be aware: PE-starch is not biodegradable!!

TUNING MORPHOLOGY

Barrier towards O_2 increasing



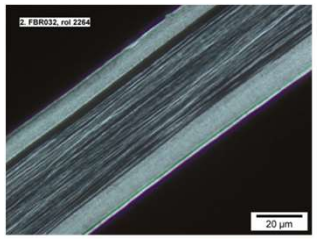
disperse **cocontinuous** **disperse**

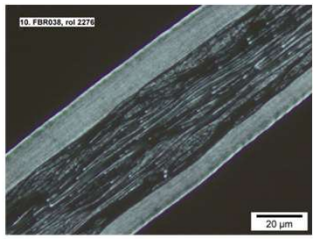
Barrier towards water

Poly(ethylene)

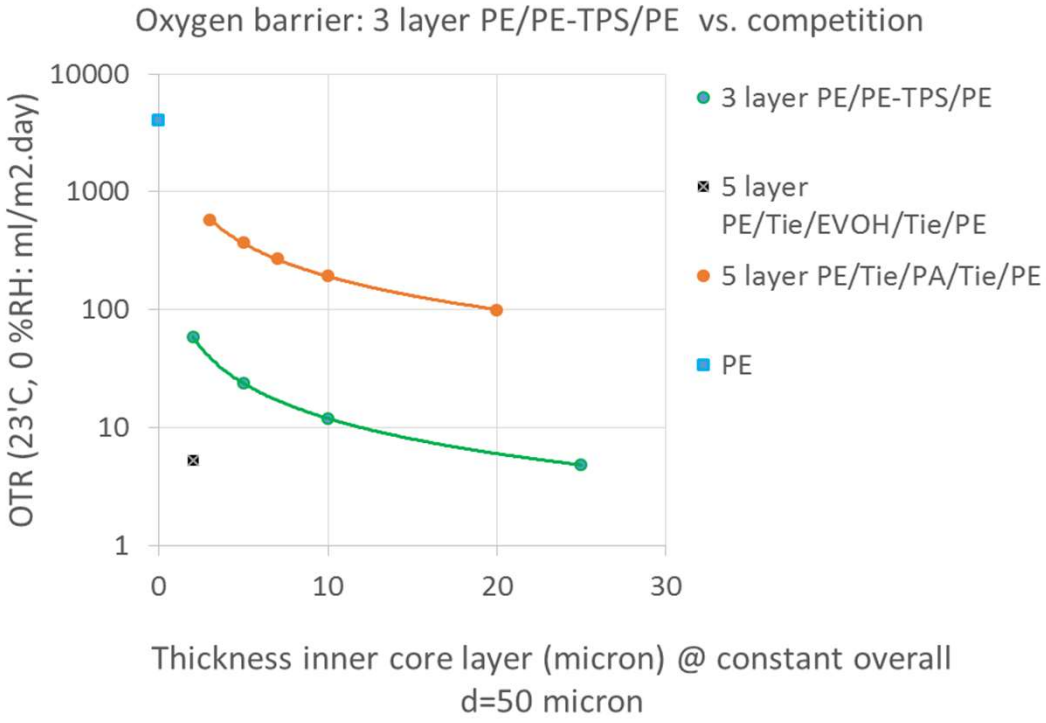
Starch

A co-continuous blend of TPS and PE in core layer was successfully made using blown film processing technology.



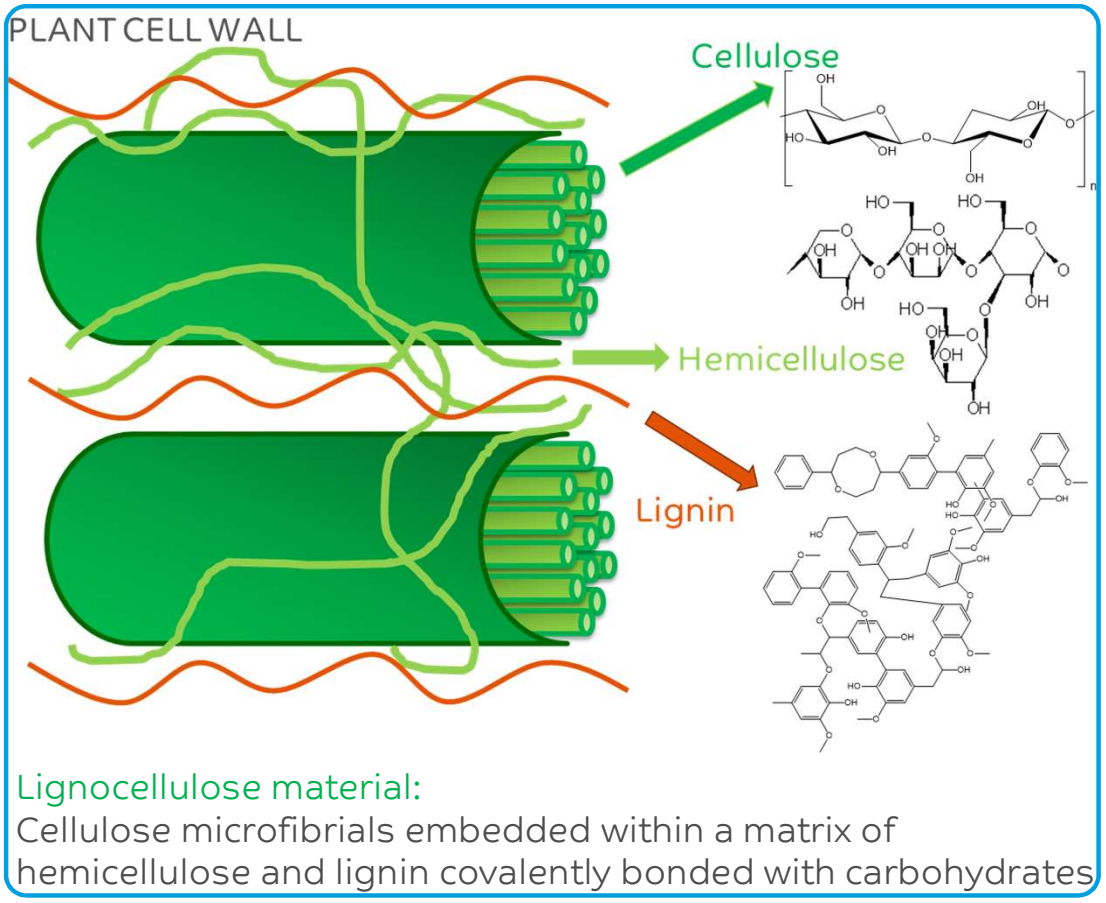


PE-TPS PROPERTIES: ENHANCED OXYGEN BARRIER



- Material properties such as permeability, surface haptics and printability tuned via addition of bio-polymer
- Applications like blown film, film casting, extrusion coating, foaming at temperatures below 160 °C yields energy savings
- Especially suited for multilayer film extrusion
- Improvement of the CO_2 balance/ LCA
- Higher performance polyolefin based compounds with improved mechanical and barrier properties

BIOMASS CONVERSION: LIGNIN WASTE GENERATION



Lignocellulose material:
Cellulose microfibrials embedded within a matrix of hemicellulose and lignin covalently bonded with carbohydrates

One of the most abundant organic polymers on Earth (after cellulose):

- Dry matter from woody plants consists primarily of cellulose, hemi-cellulose and 20 to 35 wt% of lignin
- Main commercial source of lignin is from the pulp and paper industry
- Lignin = phenylpropenoid oligomers (1 – 20 kDa)
- Provides to the plant
  - (i) mechanical support
  - (ii) water barrier
  - (iii) pathogen or fungi protection
- Main commercial source of lignin is from the pulp and paper industry

Sustainability issue
"Waste" lignin is used as energy generation, sequestered as 'biochar', disposed as waste

W. O. S. Doherty et al., *Indus. Crops Prod.* **2011**, *33*, 259

COMPOSITE PREPARATION PE/LIGNIN

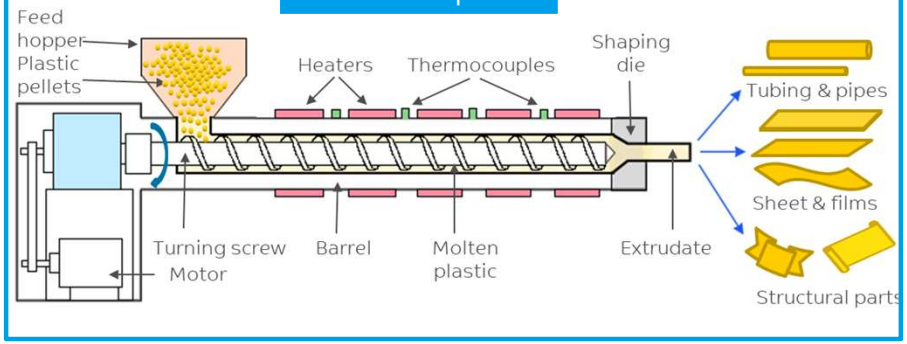
Zero Waste Ligno-Cellulosic Bio-Refineries

Cryogenic grinding

Mini Extruder

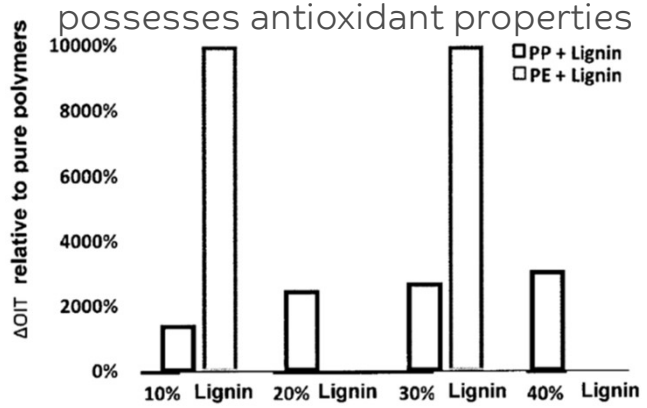
Injection Molding

Scale up



ANTIOXIDANT PROPERTIES OF PE-LIGNIN BLENDS BY OIT

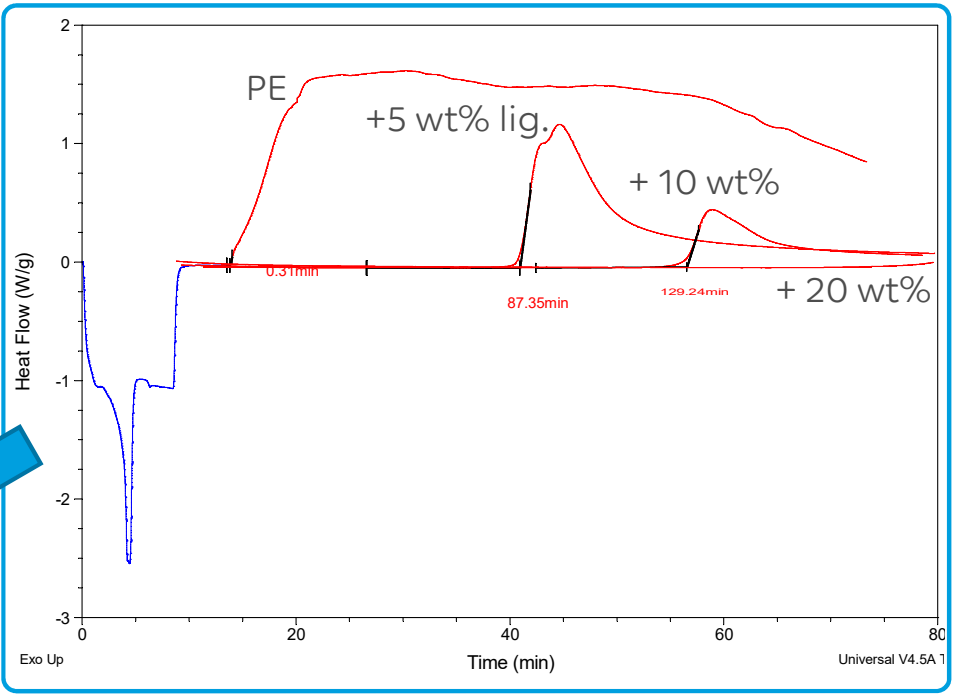
PE blends with lignin having pH < 7 possesses antioxidant properties



SUZANO PAPELE E CELLULOSE S.A. (CA3033412A1)

PE-Lignin (pH ~ 3,7)

Sample code	OIT (min)	ΔOIT
PE reference	0,3	-
PE – Lignin 5wt%	87	17400%
PE – Lignin 10 wt%	129	25800%
PE – Lignin 20wt%	>180	>36000%
PE – Lignin 30wt%	>180	>36000%
PE- Lignin (pH 5,5) 5 wt%	31	6200%



PE-Lignin blends possesses great anti-oxidant properties and precludes the need of synthetic ones

ACKNOWLEDGMENTS

Renewable feedstocks

Lucio Baccaro

Chemical Recycling

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Bart Vanhoof

PE-Starch

Hans Martens

Maria Soliman

PE-Lignin

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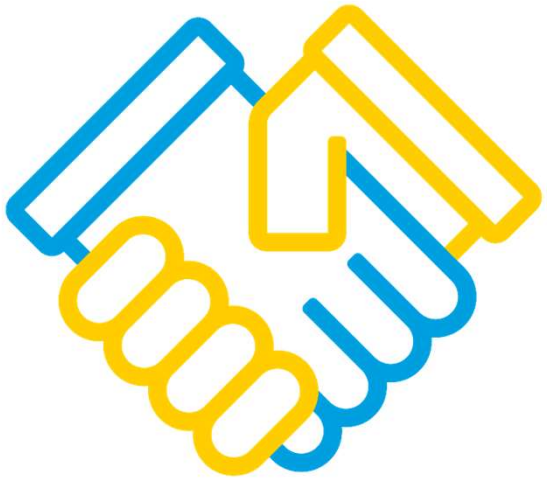
Dolinda van der Pluijm

Richard Gosselink (WFBR)



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سابك
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THAT MATTERS
THANK YOU