



A New Value Chain for PMMA (PolyMethylMethAcrylate) Depolymerization

Jean-Luc DUBOIS



™Trademark of Trinseo PLC or its affiliates

Fast Facts



22

MANUFACTURING
SITES GLOBALLY



\$3.7 Billion

2023 NET SALES



3,100

EMPLOYEES

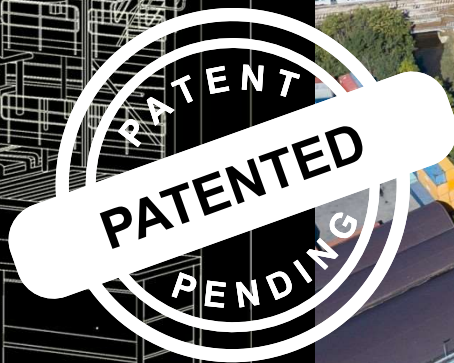
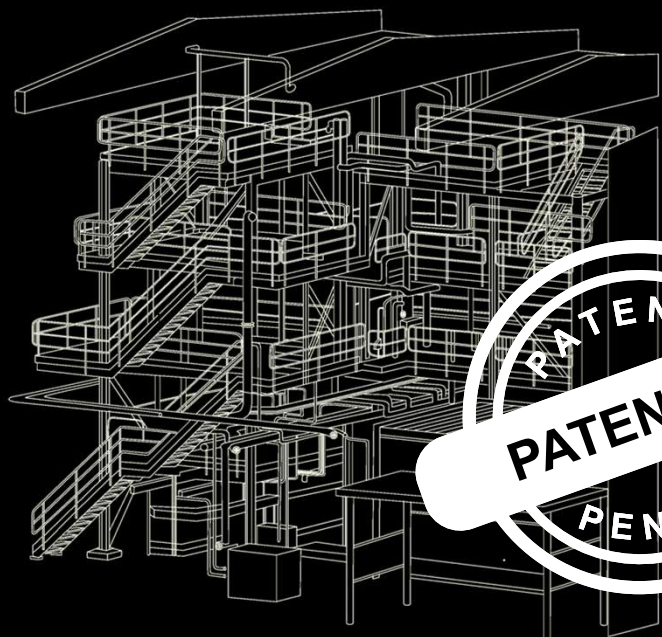


11

R&D FACILITIES

In Rho, Italy

- New PMMA depolymerization demonstration plant started in Rho, Italy.





First Depolymerized PMMA Cast Sheets at Trinseo

LinkedIn post – May 3rd 2024

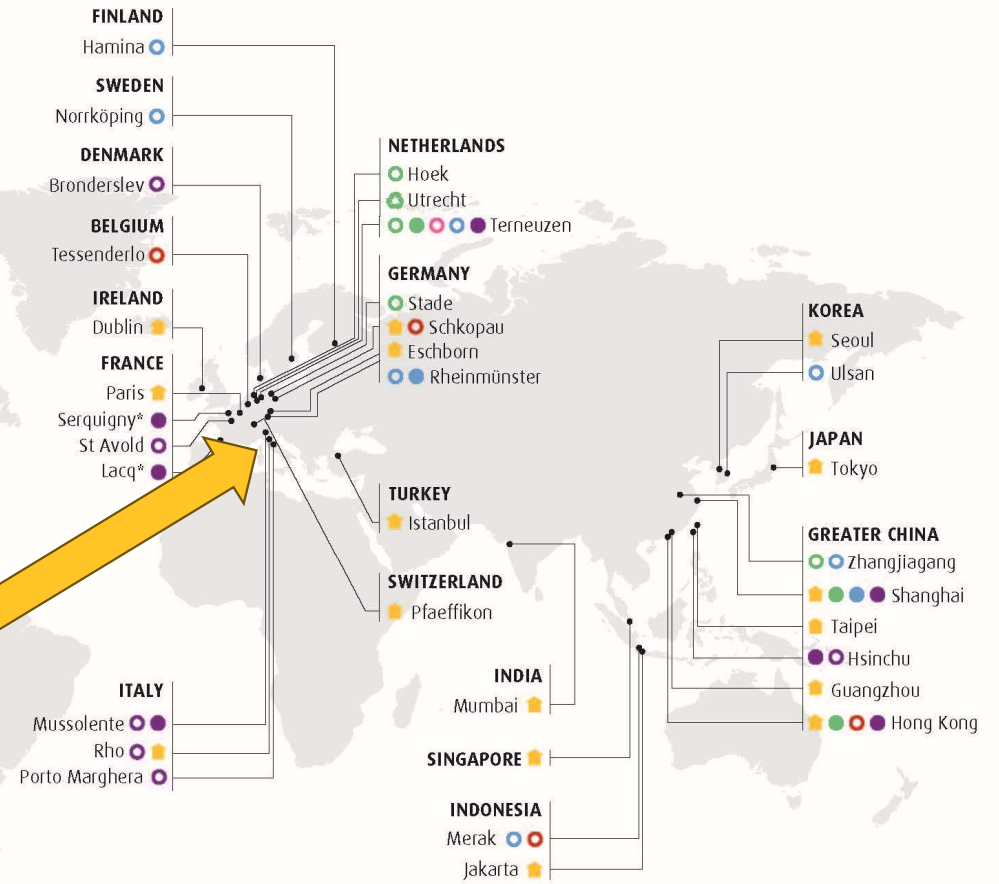
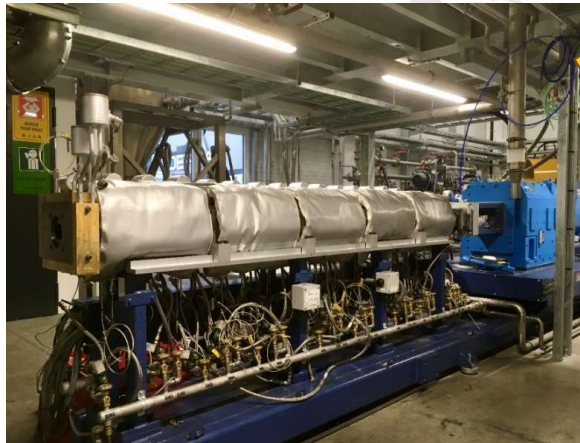
Global Footprint

- Plastics Solutions ●●●●
- Feedstocks ●
- Latex Binders ●●
- Polystyrene ●●
- Engineered Materials ●●
- Corporate and Sales Offices ★
- Global Operating Center ★

- = Manufacturing
- = Recycling Facility
- = R&D

* R&D activity takes place at an external shared site

- U.S.A.**
- Midland, MI ●●●●●
 - Wayne, PA ●●●●●
 - King of Prussia, PA ●●●●●
 - Florence, KY ●●●●●
 - Louisville, KY ●●●●●
 - Bristol, PA ●●●●●
 - Belen, NM ●●●●●
 - Dalton, GA ●●●●●



https://trinseo.widen.net/s/kgf8zjj2md/pmma-depolymerization_inauguration_video-english



Affich

Trinseo's New PMMA Depolymerization Demonstration Plant in Rho, Italy



Awards and Recognitions

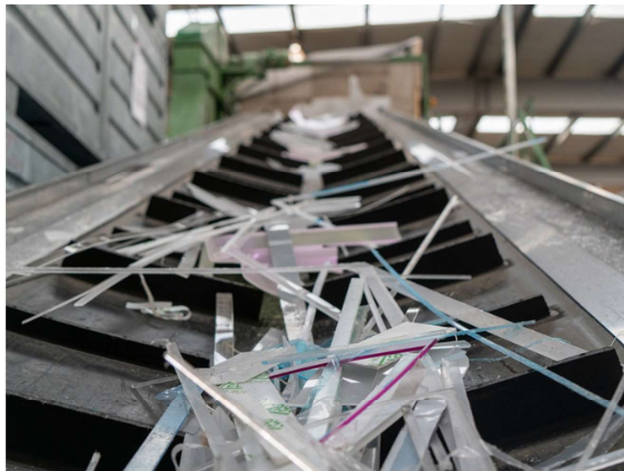


Project of the Month (April 2024)



Pioneering tech recycles end-of-life plastic waste

The EU-funded MMAtwo project introduced a technology to process polymethyl methacrylate waste and convert it into materials for use in a second life.



© Trinseo

Related projects



Innovation Team Best Practices (June 2023)



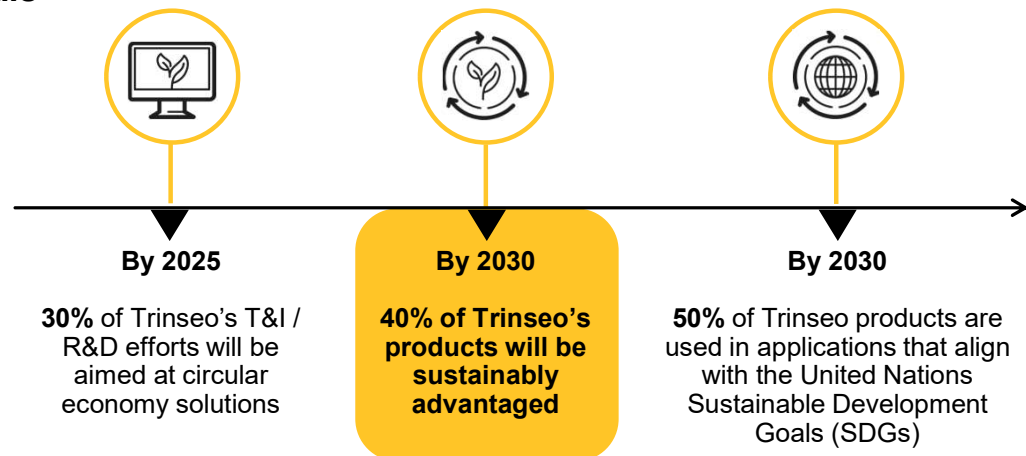
In 2020, Trinseo embarked on an ambitious, measurable, and achievable long-term sustainability journey

- 5 categories
- 15 goals
- 10 years

5 Categories



15 Goals

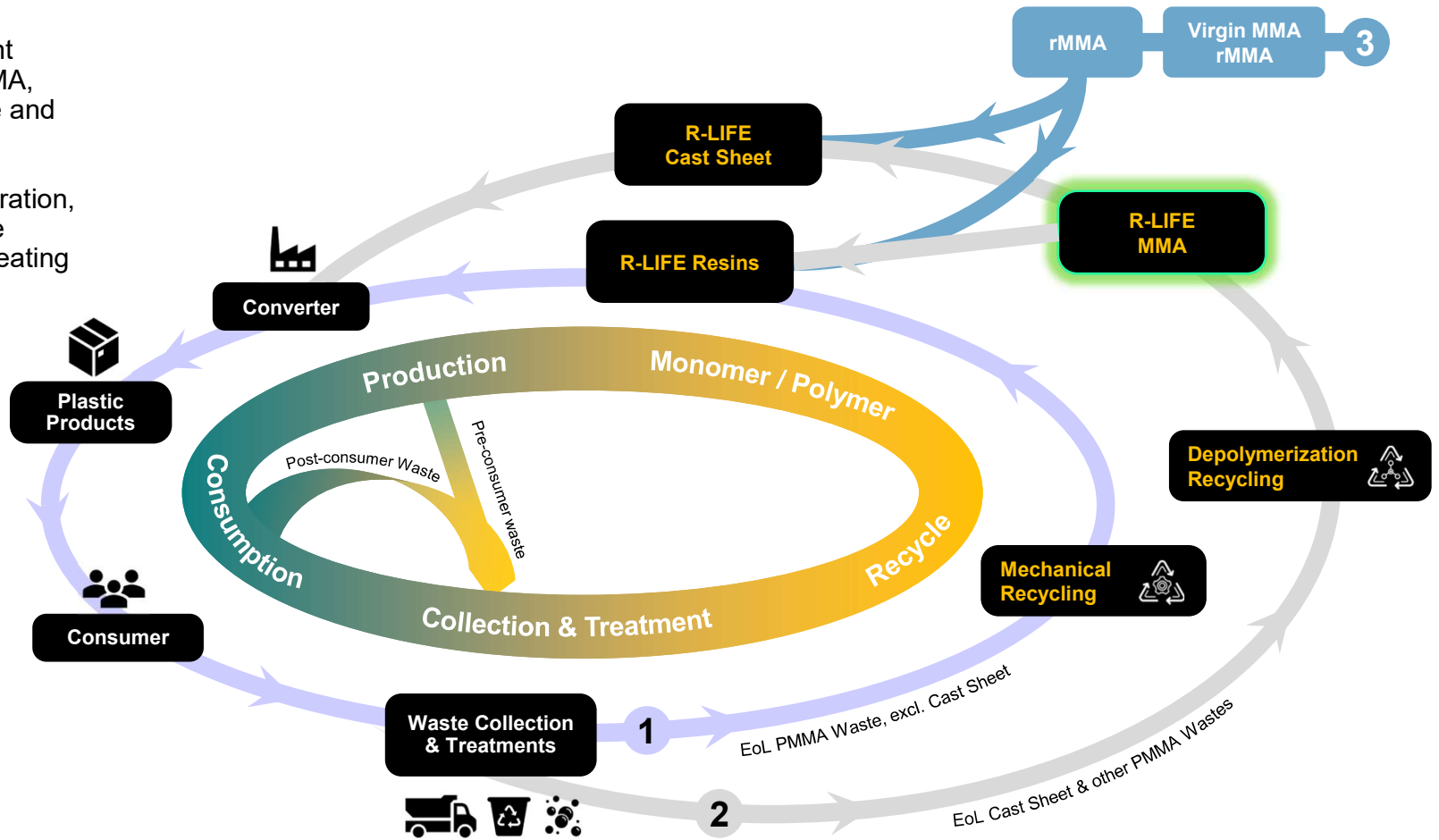


Recycling Technologies for PMMA

Trinseo provides different recycling routes for PMMA, depending on the nature and quality of the wastes.

With our backward integration, we also engage in waste collection, sorting and treating series.

- 1 Trinseo's Mechanical Recycling Route
- 2 Trinseo's Depolymerization Recycling Route
- 3 External Source Route



PMMA R-Life Product Portfolio

Brand name		Grade	Recycled type and content	Market
Altuglas™/ Plexiglas® R-life	Resins	V825T	CR50	Auto
Altuglas™/ Plexiglas® R-life	Resins	V825T	CR90	Auto
Altuglas™/ Plexiglas® R-life	Resins	V825T	MR35	Auto
Altuglas™/ Plexiglas® R-life	Resins	V825T	MR50	Auto
Altuglas™/ Plexiglas® R-life	Resins	V046	MR50	Building & Constructions
Altuglas™/ Plexiglas® R-life	Resins	V046	CR50	Building & Constructions
Altuglas™/ Plexiglas® R-life	Resins	V046	CR88	Consumer Goods
Altuglas™/ Plexiglas® R-life	Resins	VML-H	CR50	Consumer Goods
Altuglas™/ Plexiglas® R-life	Resins	VML	CR50	Consumer Goods
Altuglas™/ Plexiglas® R-life	Resins	VML	CR80	Consumer Goods
Altuglas™ R-life	Sheets	MP	CR100	General Purpose
Altuglas™ R-life	Sheets	MP	CR60	Sanitary



Performance Characteristic

- Optical quality
- Highest clarity, colorless
- High weathering & UV resistance (no coating required)
- Light weight
- Easy processing



Typical Application

- Optical light guides
- Automotive lighting
- Instrument lighting
- Exterior trims
- Capstocks
- Optical lenses
- Furniture
- Displays
- Packaging

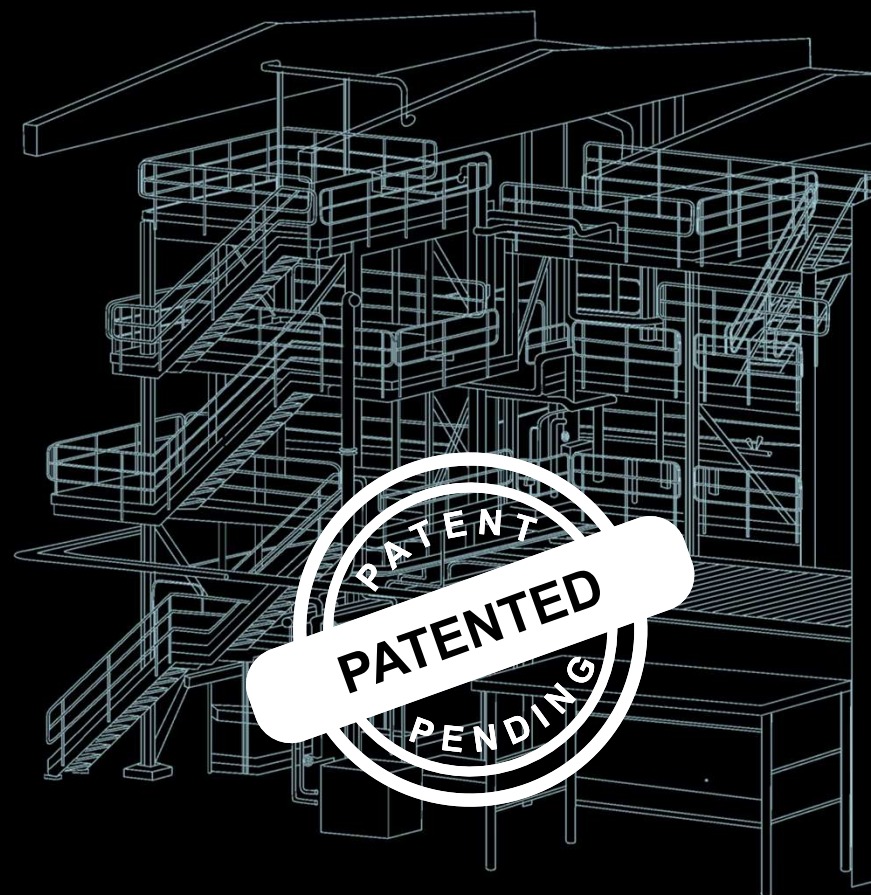
PMMA Depolymerization



- Trinseo launched its Depolymerization Demonstration Plant
- Located in Italy, this continuous, advanced recycling and purification facility provides:



1. High quality recycled MMA
2. High purity & high yield
3. High flexibility to run with a wide range of waste streams



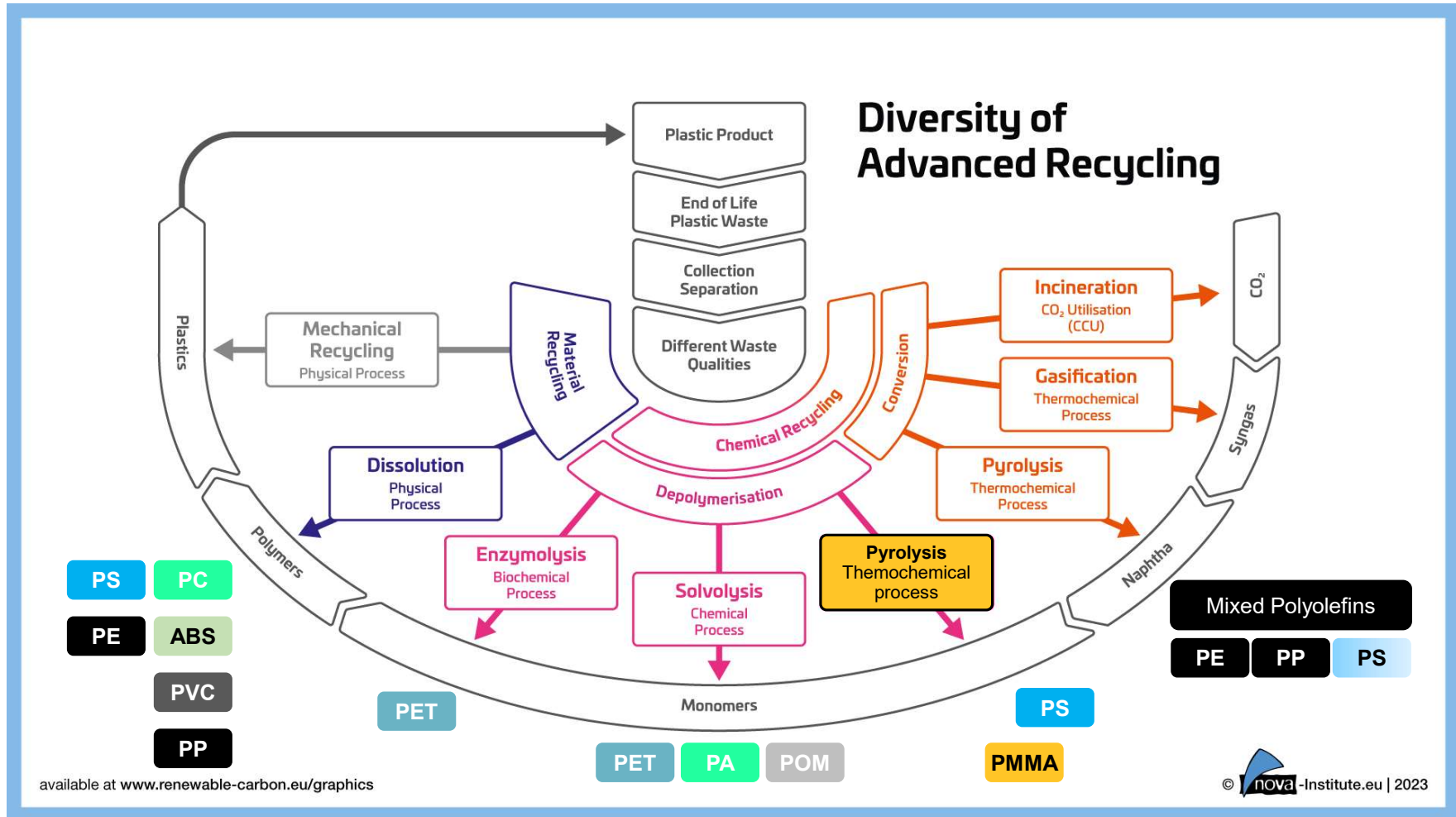
<https://investor.trinseo.com/home/news/news-details/2023/New-Trinseo-PMMA-Depolymerization-Plant-Reimagines-Plastics-Value-Chain-With-Sustainability-In-Mind/default.aspx>

PMMA Depolymerization Technologies and Processes

Jean-Luc DUBOIS

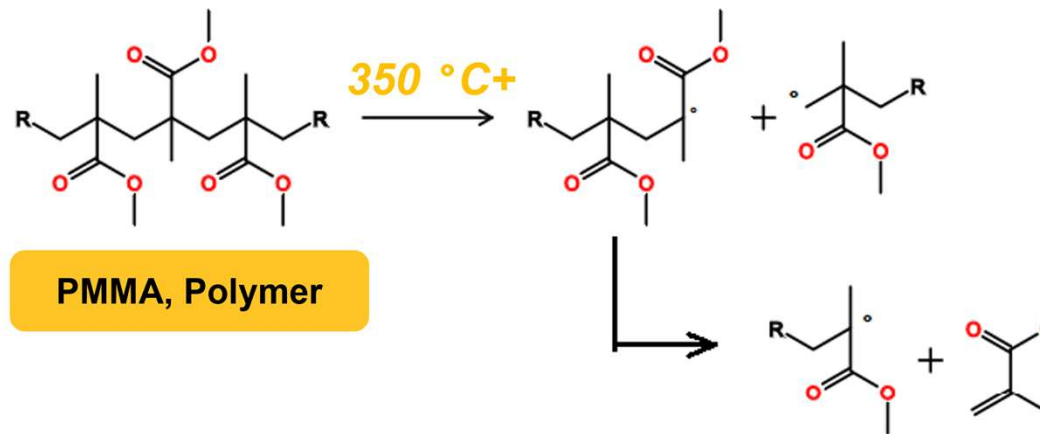


PMMA Depolymerization through Pyrolysis



PMMA Thermal depolymerization process

- Pyrolysis = Heat treatment in absence of oxygen
- PMMA Thermal depolymerization process: **Radical Unzipping Mechanism**



PMMA, Polymer



MMA, Monomer

Similar process for:

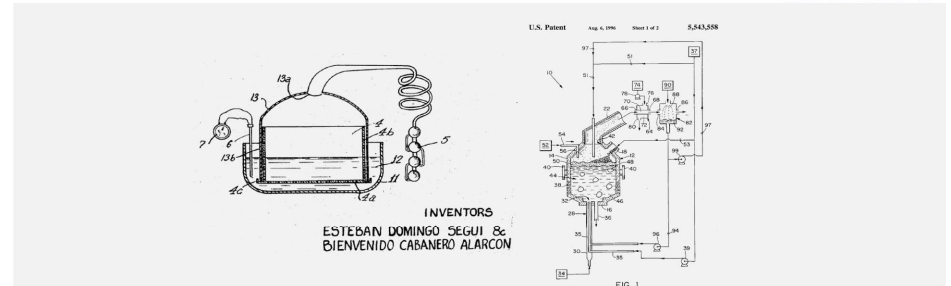
- PolyStyrene to Styrene monomer*
- Mixed PolyOlefins to liquid products*



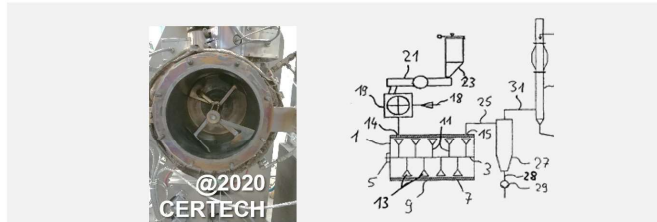
Dry Distillation Still Reactor



Rotating Drum Reactor



Molten Metal Reactor



Rotating Paddle Reactor



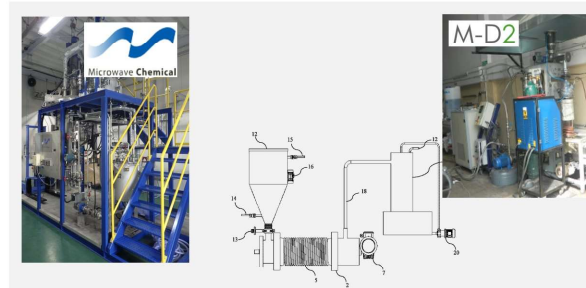
Twin-Screw Reactor



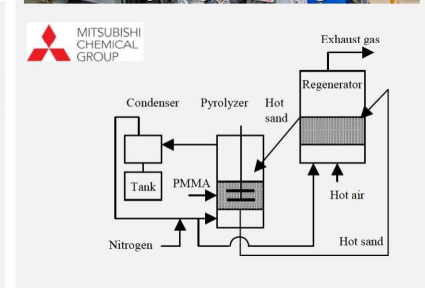
Stirred Tank Reactor



Auger Reactor (w or w/o Circulating Solid)

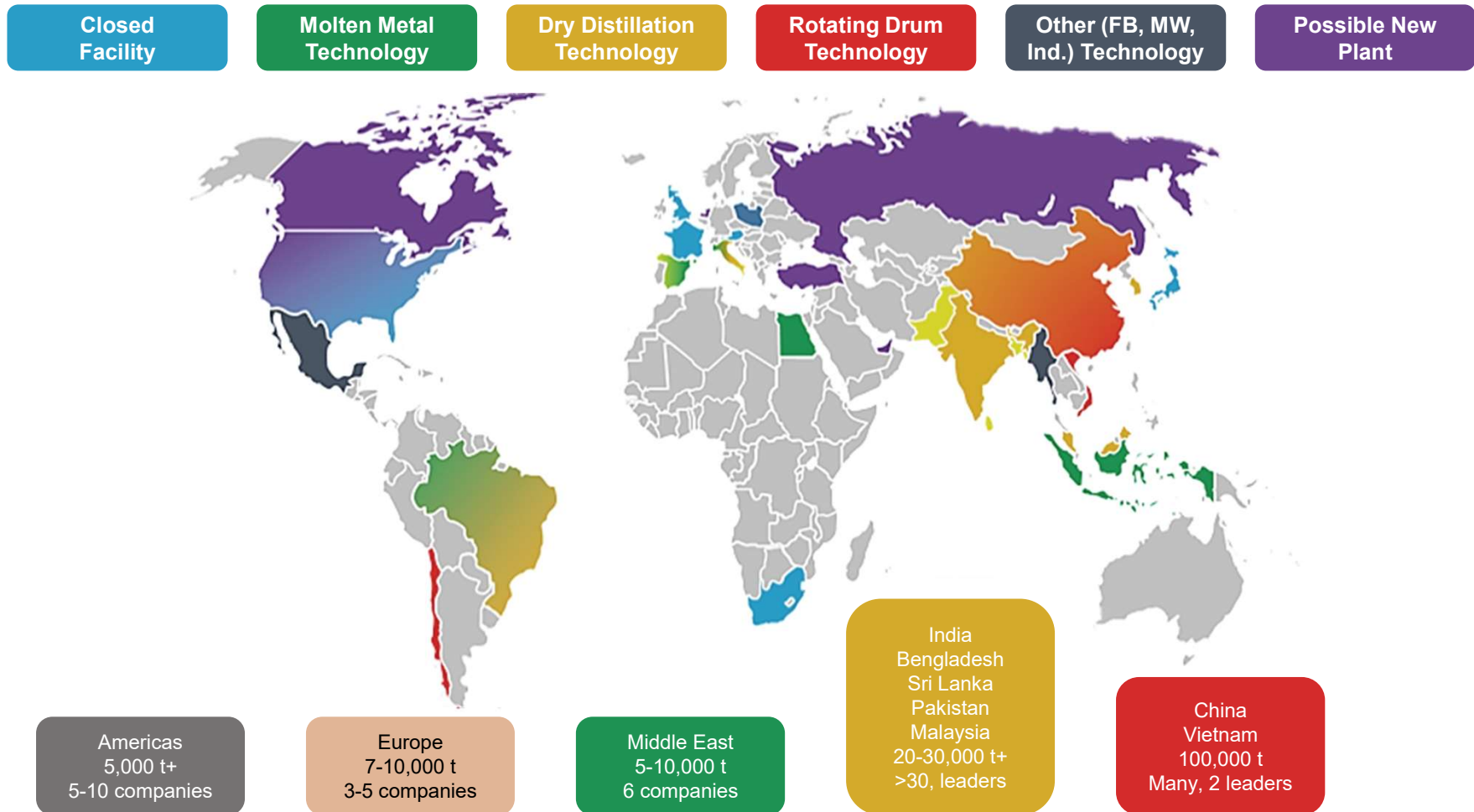


Microwave & Induction Reactors



Fluid Bed Reactor

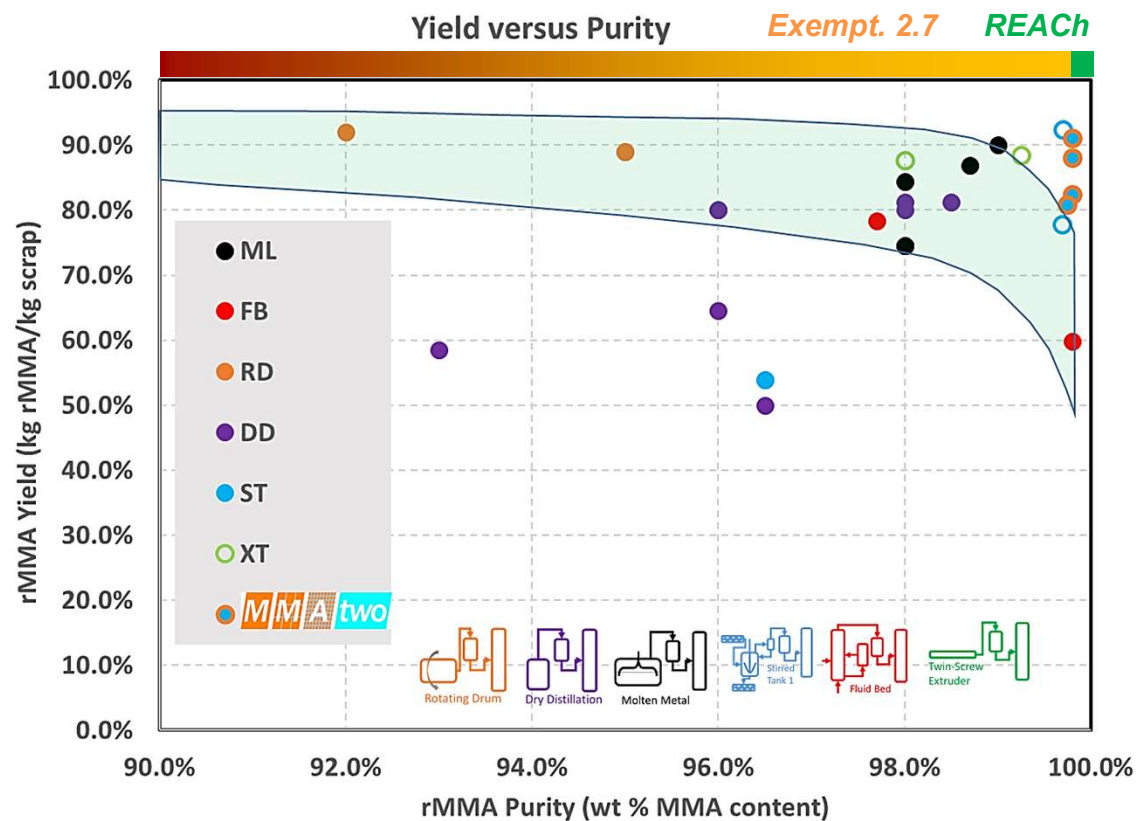
Regenerated Methyl Methacrylate World Map



Benchmarking and Survey of Alternative Technologies

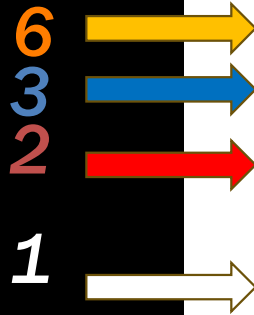
• MMA Regeneration plants: rMMA Yield versus Purity

- ML: Molten Lead
- FB: Fluid Bed
- RD: Rotating Drum
- DD: Dry Distillation
- ST: Stirred Tank
- XT and MMAtwo: Twin-Screw Extrusion



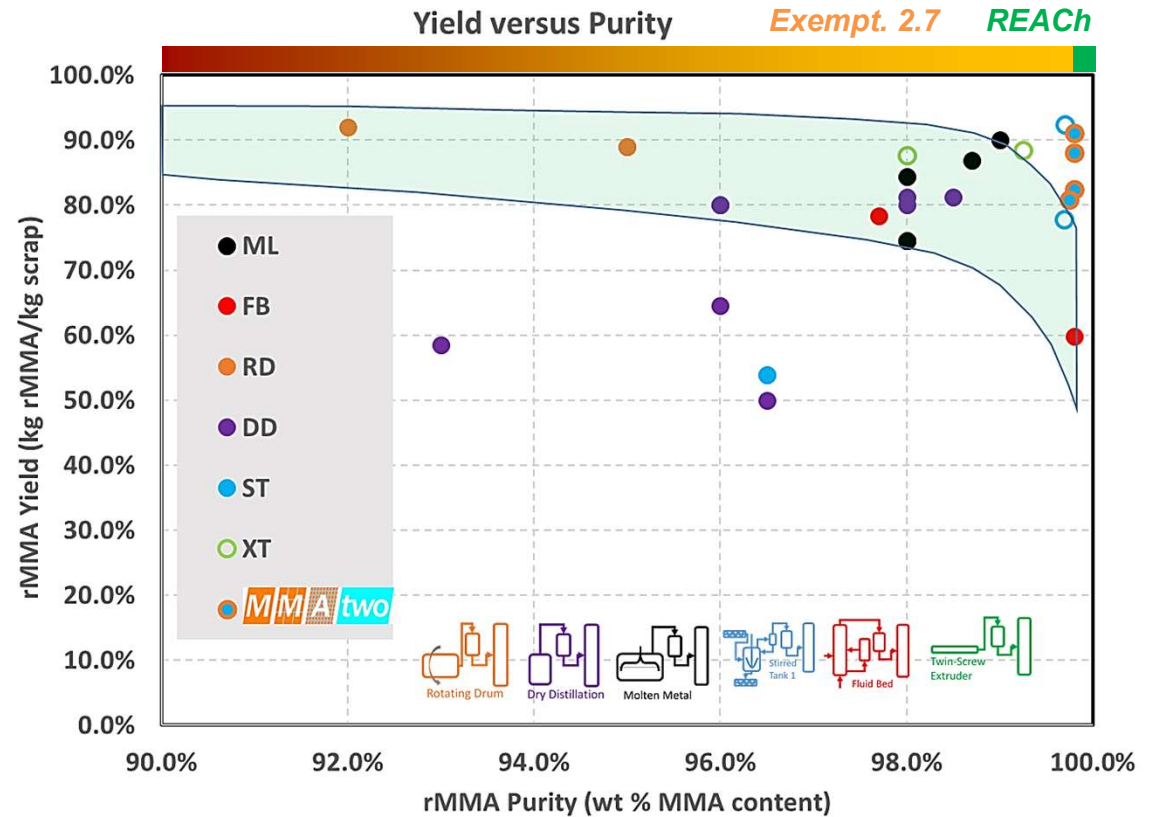
Benchmarking and Survey of Alternative Technologies

of Regenerations,
while keeping 50 %
of the materials in
the economy



True RECYCLING: 90 % mass yield per cycle, means that 50 % of the weight is retained in the economy after 6 regenerations $0.9^{(6)}$.

MMA Regeneration plants: rMMA Yield versus Purity

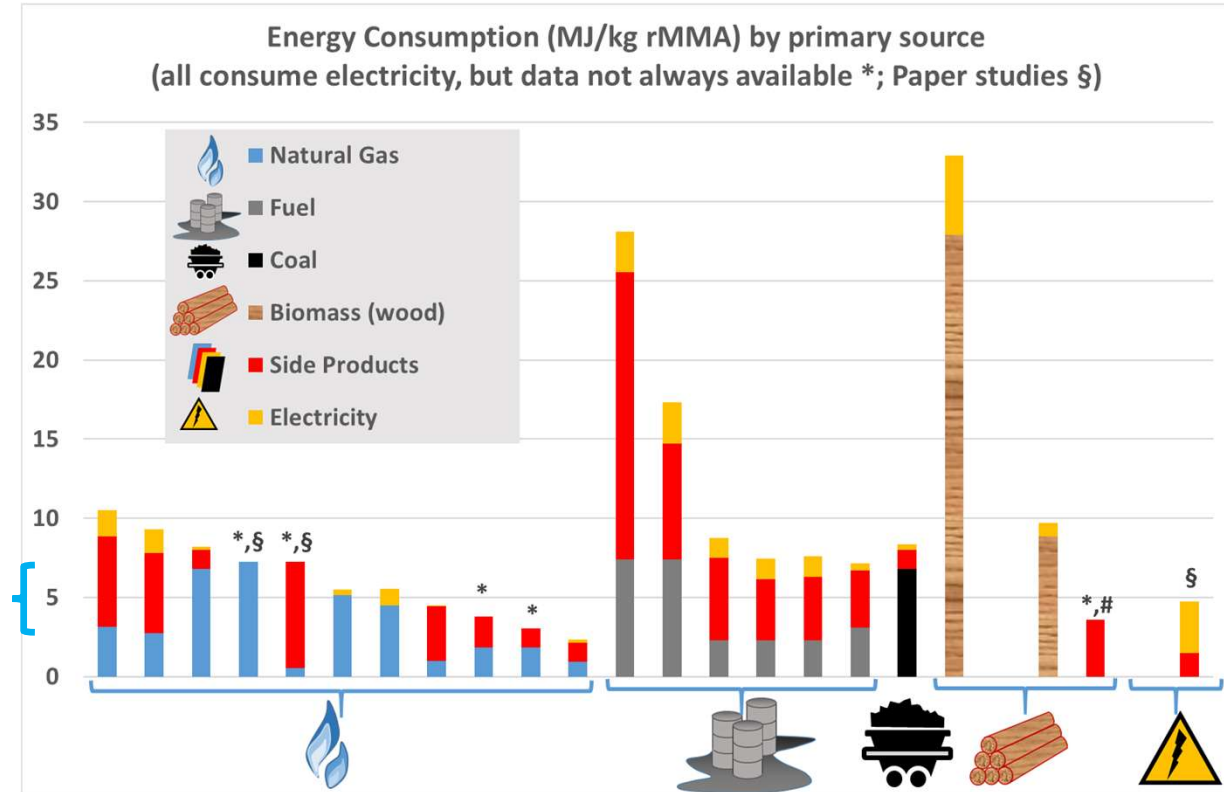


Benchmark of MMA Regeneration plants:

- Primary and Total Energy Consumption

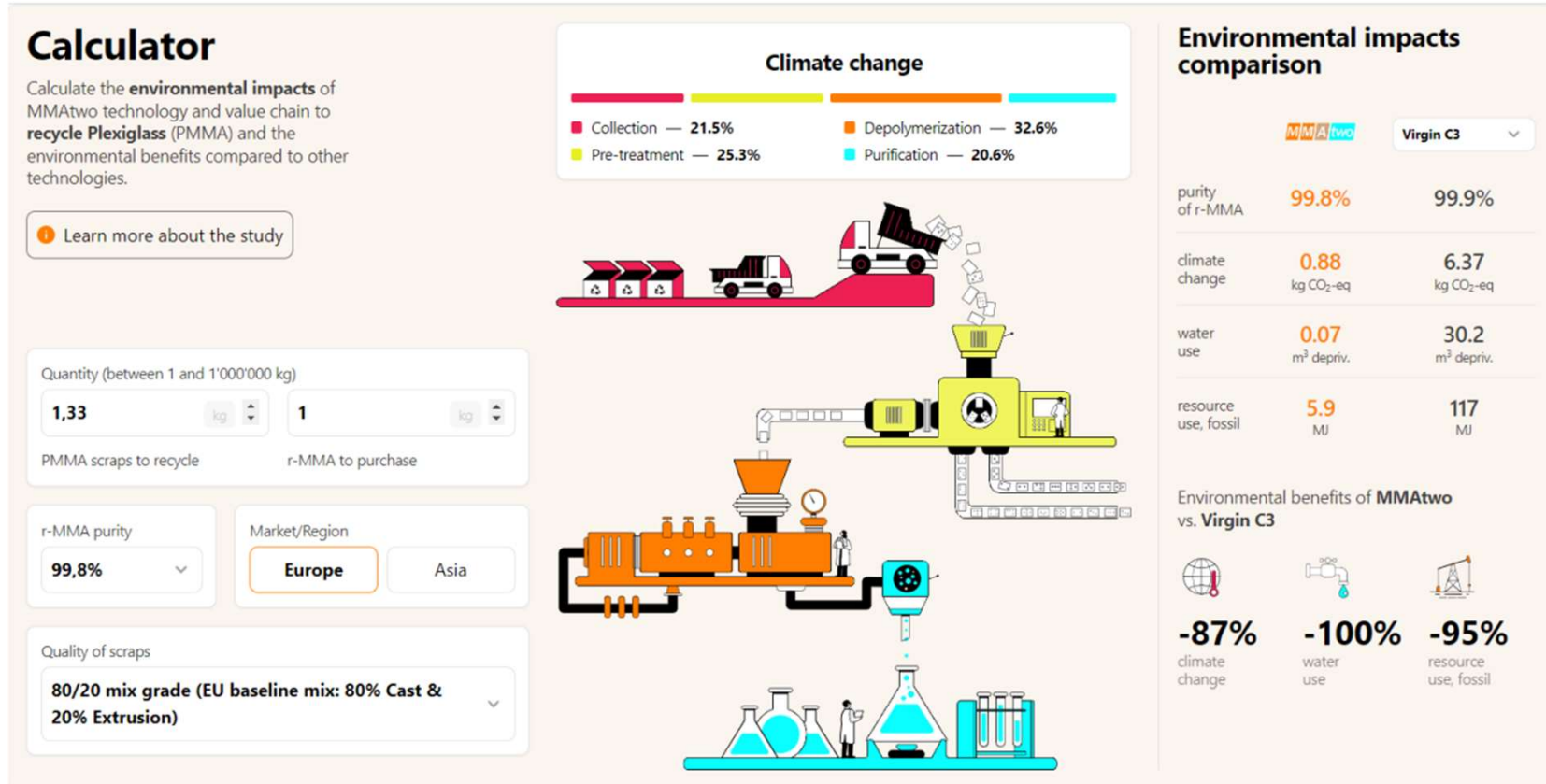
other missing data

MMAtwo



Virgin MMA vs MMAtwo

- Virgin MMA (C3 process (Acetone), Europe at **99.9%** vs MMAtwo (mix 80/20 Cast/Extrusion) at **99.8%**



[MMAtwo - Environmental Benefits Calculator \(mmatwo-footprinter.eu\)](https://mmatwo-footprinter.eu)

*These environmental indicators are the computed values of cumulated emissions generated by the technologies being discounted of cumulated emissions due to energy valorisation of side products. When the resulting number is small, the uncertainty on the net value is large due to the subtraction of 2 large numbers, and comparison should be done with caution.

r-MMA end uses Technical properties (continuous improvement during MMAtwo)

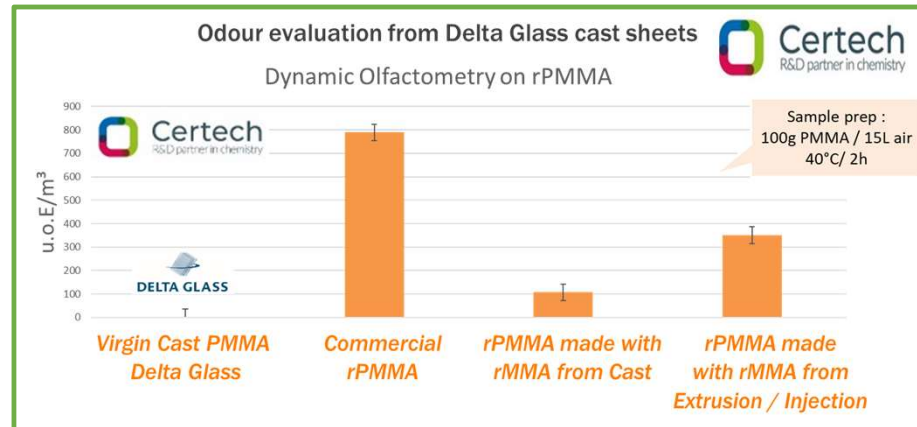
Transparent PMMA cast sheet from rMMA



Odour: Dynamic Olfactometry

MMAtwo

TRINSEO



Accelerated Yellow Index test, ASTM E313 – 10500 h

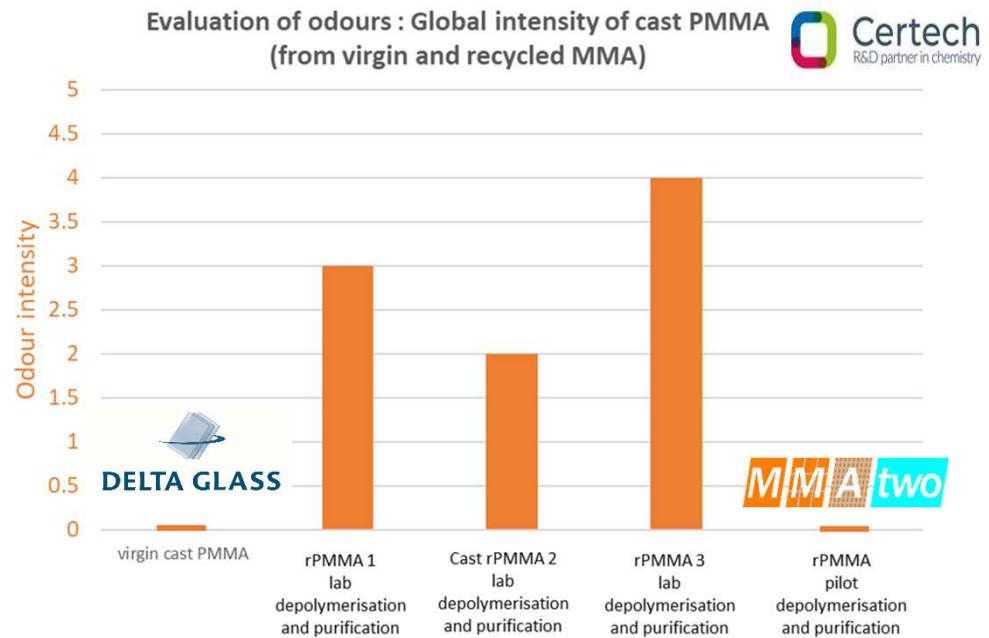


Evaluation of the rMMA in Optical Grade PMMA Applications

- 1st Caravan Window



- Odour Evaluation from Delta Glass Cast Sheets



- rMMA from pilot plant, and purified in Speichim (at 99.8 %)
- The first sheets of rPMMA were produced and tested for use in a caravan window.
- The rPMMA meets all quality requirement.**

Expected rMMA Purity - About $\frac{3}{4}$ polled market players expect $\geq 99.5\%$



rMMA demand for different types of applications

rMMA, Beads, Resins, Cast...
Injection, Extrusion, Cast-sheets, Solid Surface, Coatings, Binders...

Optical properties vs
Mechanical or Thermal properties

Open-Loop Recycling vs
Closed-Loop Recycling –
example from End-of-Life
Vehicle to new cars.



Technical challenges with rMMA available on the market

Odor from product, Yellowing,
Glass Transition Temperature,
Vicat Temp.(Thermal prop.)...

Food-Contact certification

REACH Registration number

Other certifications

Environmental Footprints
(carbon, energy, water, critical
raw materials)



Impact of the PMMA wastes and the process

Some PMMA wastes generate
much more impurities

Depolymerization processes
can generate new impurities

Purification technologies can
remove some impurities



Depolymerization technology should be transparent for the end-user.

No need to know all the details.

Tell us what you need, and let
us make it...

Collect and Supply your own scraps to grow the PMMA sustainability

Want to know more?

Risk Analysis on PMMA Recycling Economics

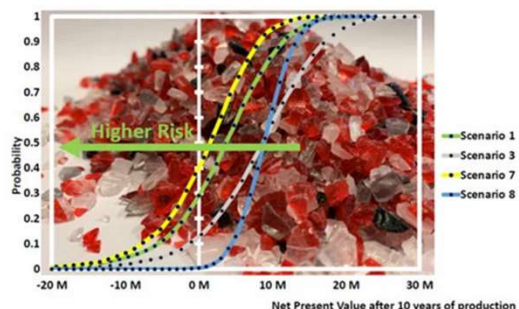
by Jacopo De Tommaso[†] and Jean-Luc Dubois^{*}

ARKEMA France, 420 Rue d'Estienne d'Orves, 92705 Colombes, France

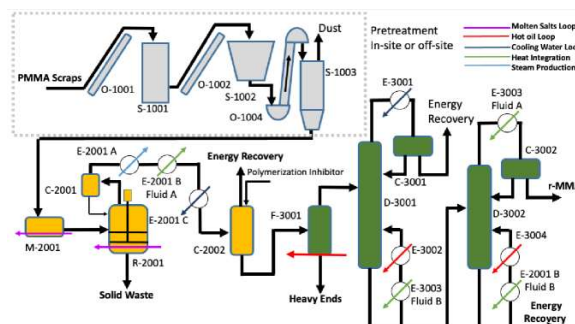
^{*} Author to whom correspondence should be addressed.

[†] Current address: Chemical Engineering, Polytechnique Montréal, Montréal, QC H3T 1J4, Canada.

Polymers **2021**, *13*(16), 2724; <https://doi.org/10.3390/polym13162724>



ARKEMA



Paper

Connecting polymer synthesis and chemical recycling on a chain-by-chain basis: a unified matrix-based kinetic Monte Carlo strategy

Kyann De Smit, Yoshi W. Marien, Kevin M. Van Geem, Paul H. M. Van Steenberge and Dagmar R. D'hooge

Polymer synthesis and subsequent depolymerisation/degradation are linked at the molecular level.

The article was first published on 22 Jul 2020

React. Chem. Eng., 2020, *5*, 1909–1928

<https://doi.org/10.1039/D0RE00266F>



Open Access

Review



ARKEMA

Progress in Reaction Mechanisms and Reactor Technologies for Thermochemical Recycling of Poly(methyl methacrylate)

by Eli K.C. Moens, Kyann De Smit, Yoshi W. Marien, Alessandro D. Trigilio, Paul H.M. Van Steenberge, Kevin M. Van Geem, Jean-Luc Dubois and Dagmar R. D'hooge

Polymers **2020**, *12*(8), 1667; <https://doi.org/10.3390/polym12081667> - 27 Jul 2020

DE GRUYTER

STEM

POLYMER CIRCULARITY ROADMAP

RECYCLING OF POLY(METHYLMETHACRYLATE) AS A CASE STUDY

Edited by Dagmar R. D'hooge, Yoshi W. Marien and Jean-Luc Dubois



DE GRUYTER

UN Sustainable Development Goals (UNSDG)

Thank you for your attention.

More information on R-Life MMA



9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION

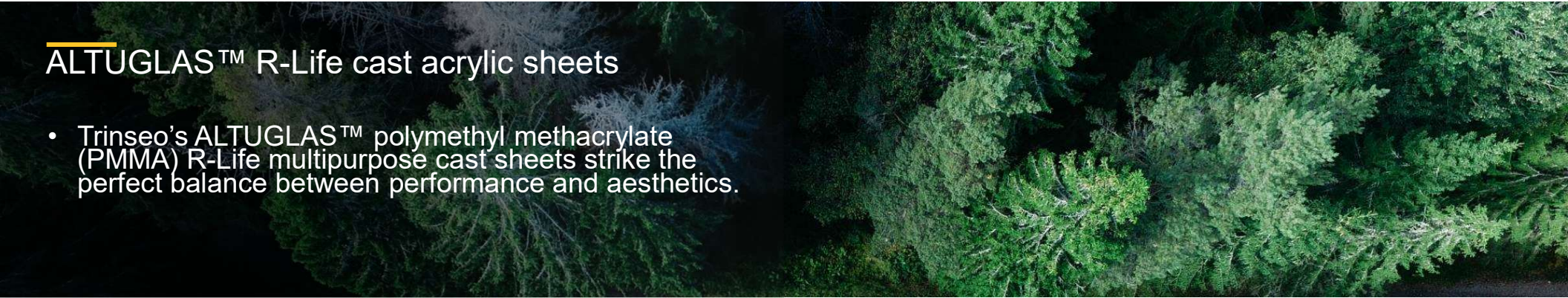


13 CLIMATE
ACTION



17 PARTNERSHIPS
FOR THE GOALS





ALTUGLAS™ R-Life cast acrylic sheets

- Trinseo's ALTUGLAS™ polymethyl methacrylate (PMMA) R-Life multipurpose cast sheets strike the perfect balance between performance and aesthetics.

- **Multi-purpose:**

- 100% rMMA content
- CO₂ Reduction – 47%
- Made in Europe
- Same performance as all prime version
- Grades for mobility, shopfitting, POS/POP, signage, internal architecture, furniture and design
- In clear, opal, white, black, and transparent colors
- Thicknesses from 2 to 12mm
- Easy to distinguish from prime with dedicated packaging

- **Sanitary:**

- 60% rMMA content
- CO₂ Reduction – 28%
- Made in Europe
- Adhere to ISO norm 7823-1 and NF EN 263
- Grades for sanitary
- In European white
- Thicknesses 3.2mm and 4mm

- **Success story**

- Trinseo Supports Art Installation by Miguel Chevalier Built for Major 2024 Sporting Event in Paris with Acrylic Sheet Containing 100% Recycled Feedstock

- [English language version](#)

- [Mood video](#)

https://trinseo.widen.net/s/rtwtxqg9d8/20240528_altuglas_r_life_fast_fact_sheet_eng_v01