



*Second Generation MethylMethAcrylate*

Jean-Luc DUBOIS



Simon van der Heijden



CEFIC  
Chemical Recycling

October 14<sup>th</sup> 2020

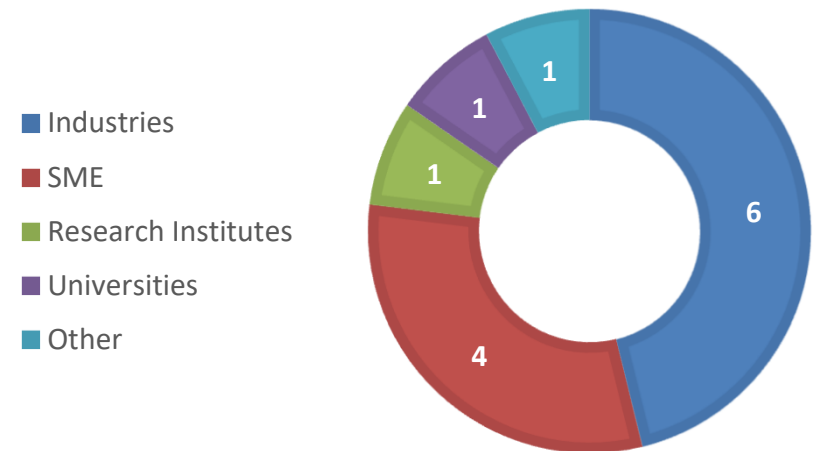


This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 820687.



# MMAtwo project at a glance

- Second generation Methyl MethAcrylate
- Innovation Action – Grant Agreement N° 820687
- 13 partners from 6 different countries
- 8.9 M€ budget (6.6 M€ grant)
- From 01/10/2018 to 30/09/2022
- Key words: Recycling, Depolymerization, PMMA, Thermal, Monomer, Polymer, MMA, Plastic waste, Plastics technologies, Sustainable design, waste management, materials engineering, Circular economy, Sustainable design



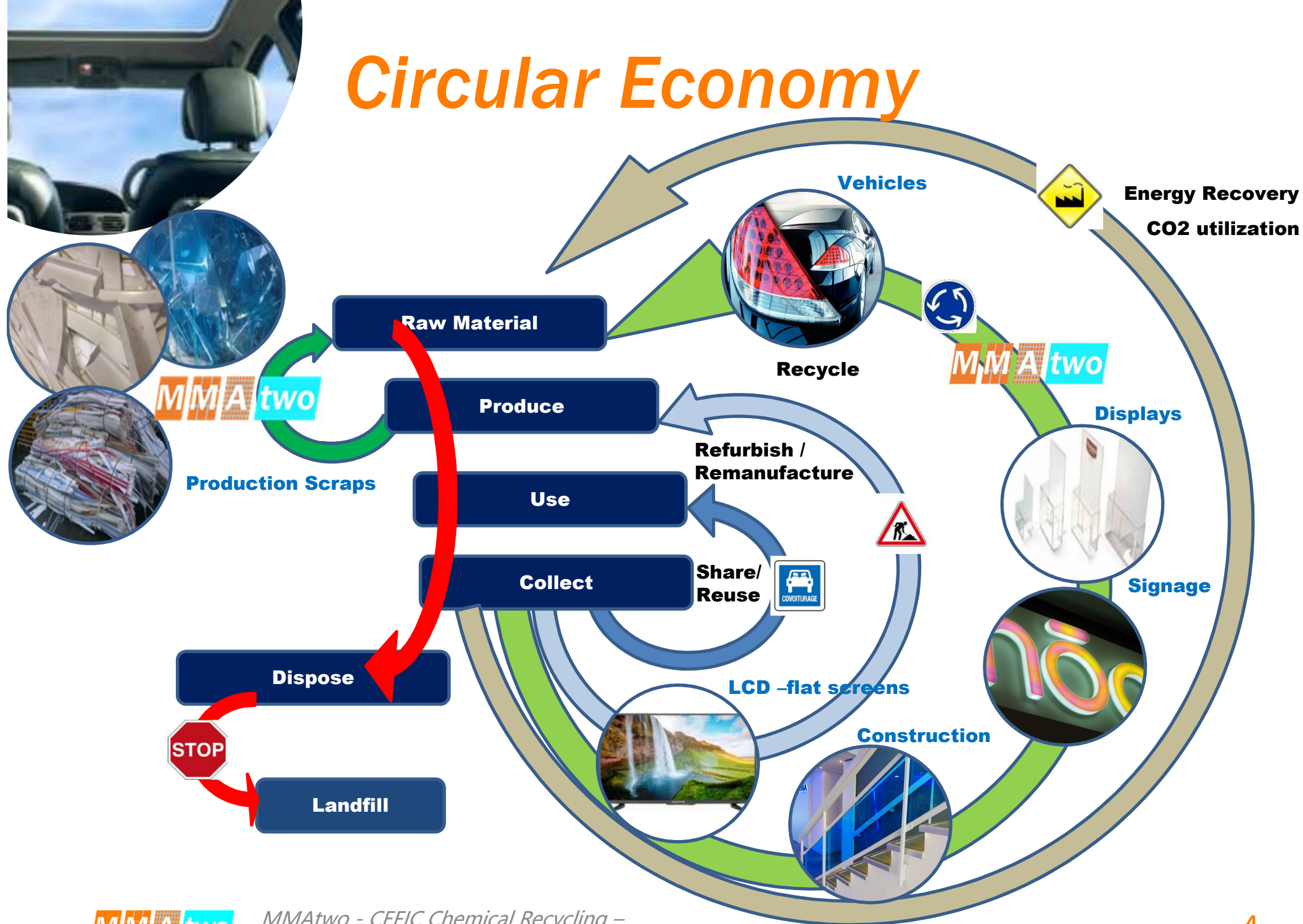


# *MMAtwo major objectives & methodology*

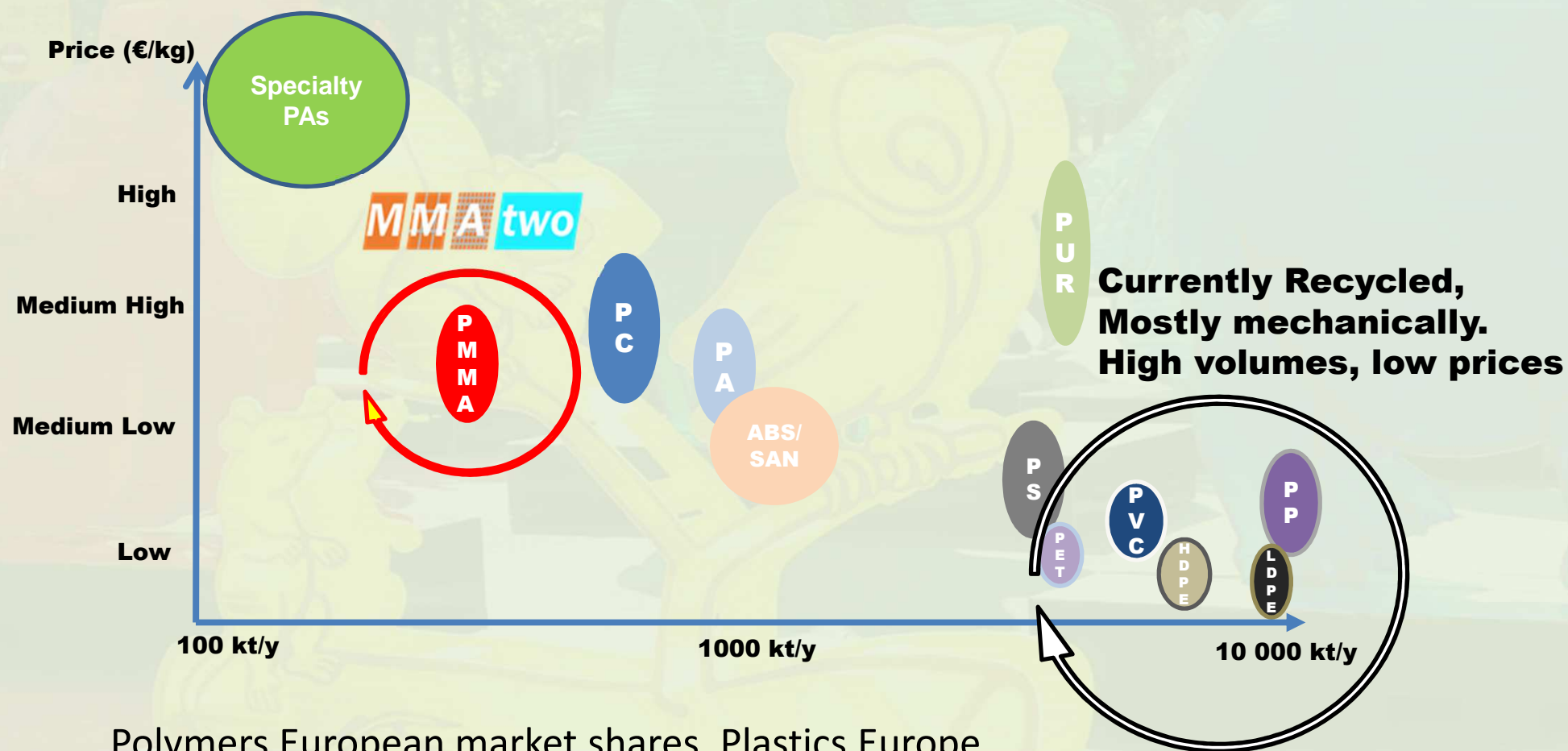
- PolyMethylMethAcrylate, 'PMMA' used in optical, signage, displays, decorative, vehicles, construction, electronic screens etc.
- Production in Europe around 300.000 tons annually; recycling capacity in Europe around 8 000 tons annually.
- Objective: Construction of a new value chain for post-production and end-of-life PMMA waste recycling in collaboration with producers, waste collectors, processors, end-users and the academic community through depolymerization and recovery of MMA, using a lead free environmentally friendly and accessible technology (continuous process).
- Results to be exploited into EU PMMA recycling business(es)



# Circular Economy



## PMMA: high value, but low volume

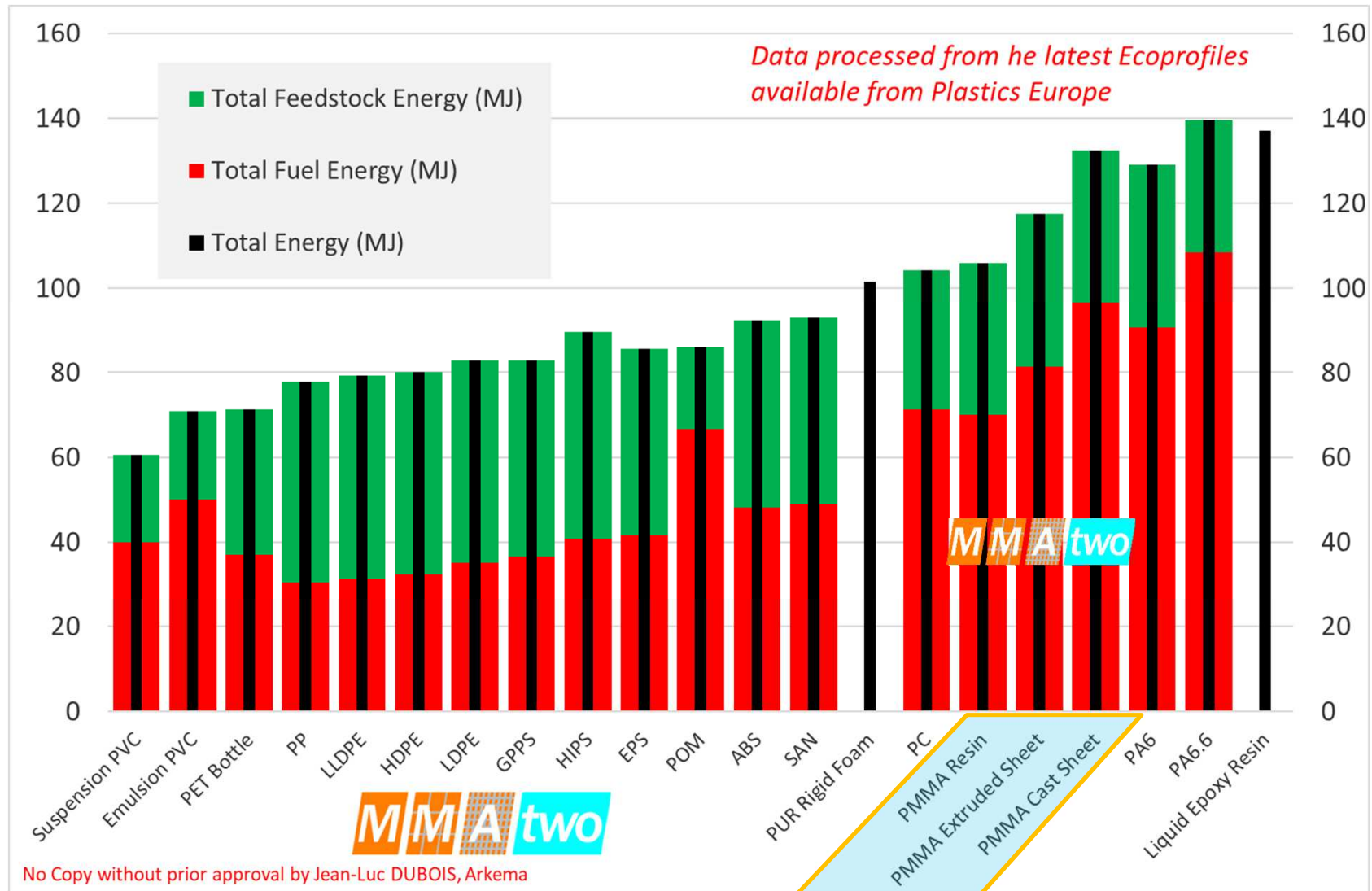


Polymers European market shares, Plastics Europe  
Plastics converter demand by resin type (2016)

Source: JL DUBOIS – November 20th 2018

# Energy Consumption in Polymers production:

## High demand for technical polymers

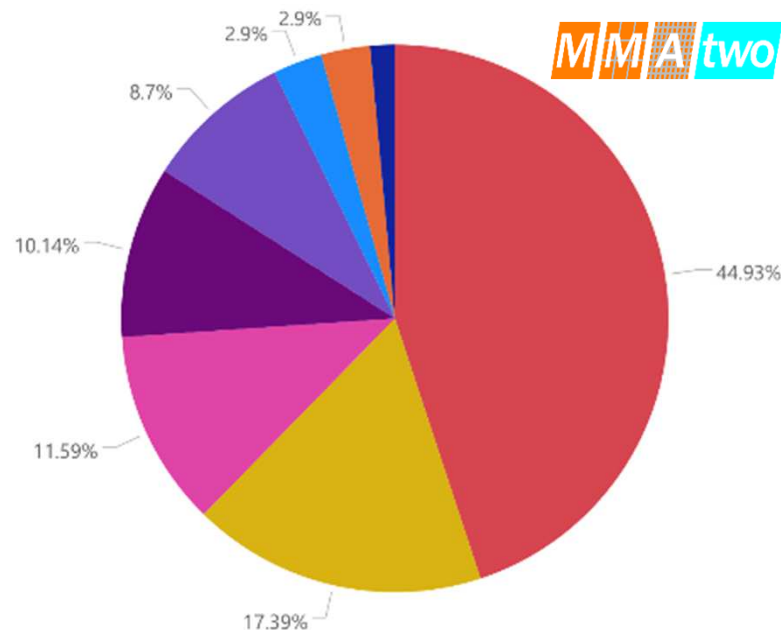






# Waste collection and Pretreatment

In collaboration with **Ecologic** and **Comet**, **Heathland** collected end-of-life PMMA WEEE waste and vehicle waste. PMMA with PVC waste was collected by **Heathland** from **Arkema** and **Delta Glass** and purified using specialized pretreatment technology into a raw material for the first depolymerization runs.



## Waste description

- PMMA sheet scrap
- PMMA sheet regrind
- PMMA LCD scrap
- PMMA injection regrind
- PMMA saw dust
- PMMA glassfibre regrind
- PMMA greenhouse scrap
- PMMA glassfibre scrap

HEATHLAND

**EcoLogic**  
La 2<sup>e</sup> vie des équipements électriques

**comet** traitements

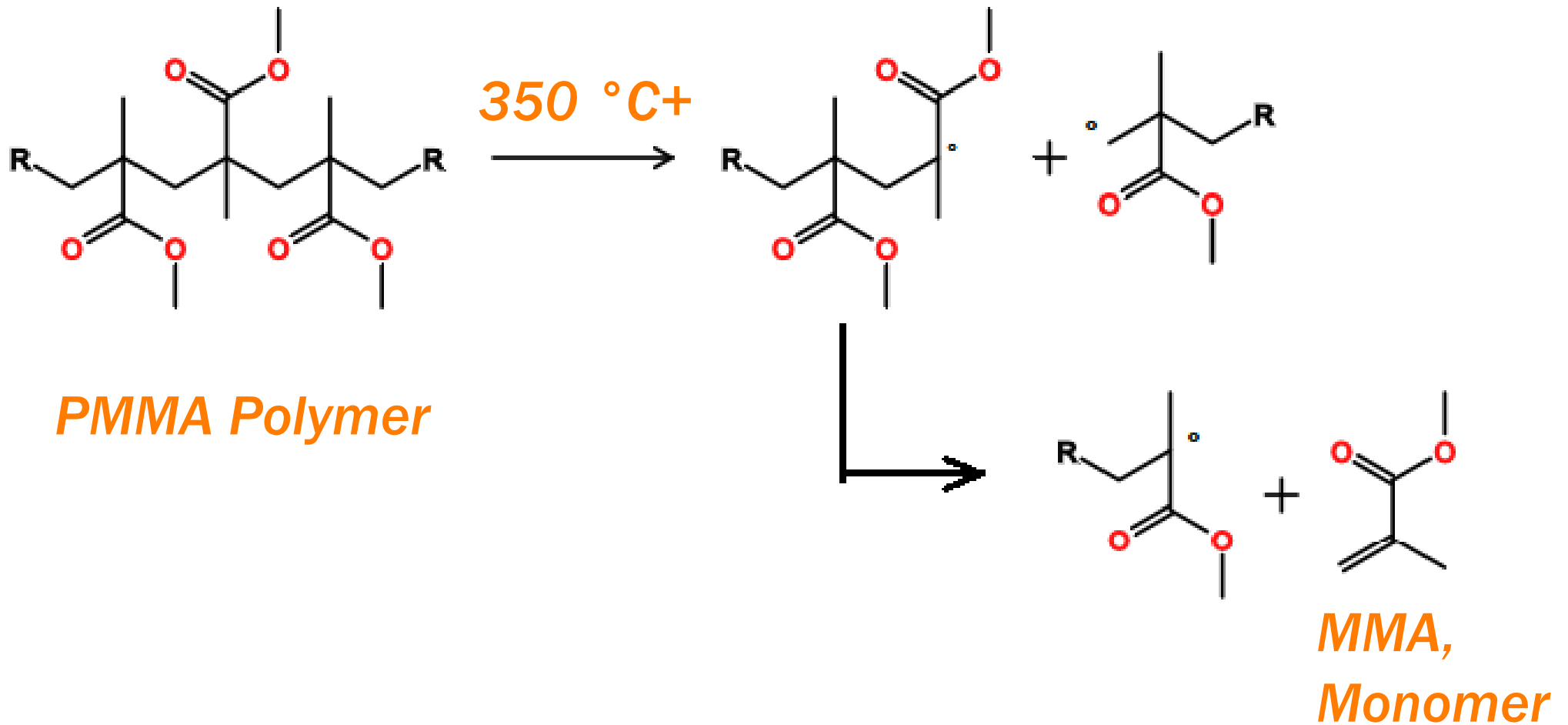
**DELTA GLASS**

**ARKEMA**  
INNOVATIVE CHEMISTRY

**MMAtwo**

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# PMMA Thermal depolymerization process Radical Unzipping Mechanism

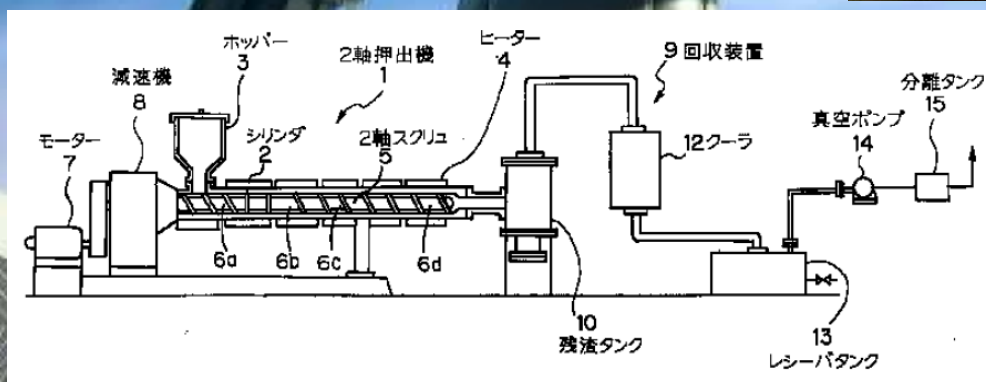




# MMAtwo twin-screw in JSWEurope

## SELECTED TECHNOLOGY

In a patent (priority 1997) JP3410343, **Japan Steel Works** describes an extruder type equipment, in which the depolymerized products is discharged at the end of the screw and solid residues are collected separately.



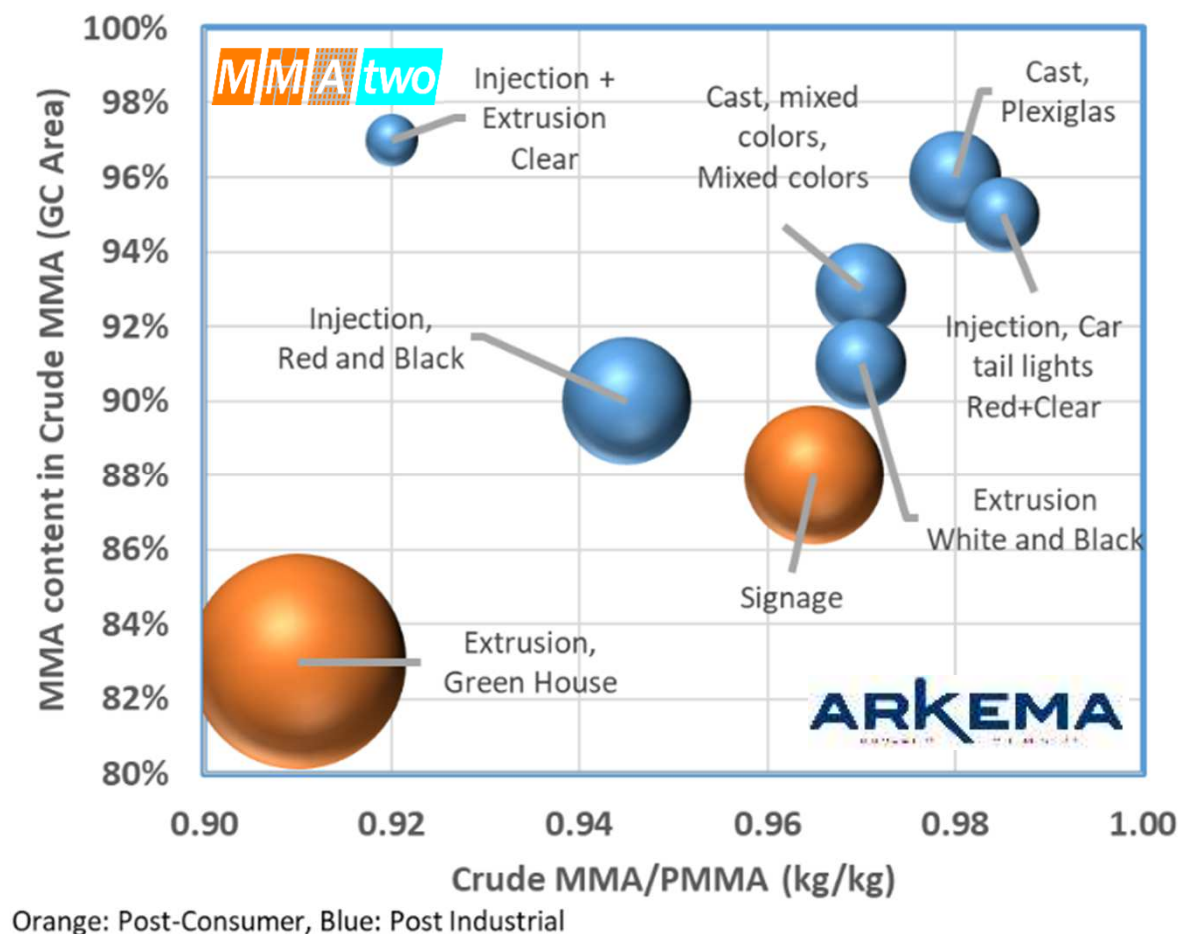
See the video describing the pilot  
on [www.MMAtwo.eu](http://www.MMAtwo.eu)



# Depolymerization

Several PMMA waste products (post-industrial and post-consumer) have been depolymerized by **Arkema** at bench scale. High mass yields with high monomer content can be achieved with most of the grades.

**JSW Europe** modified the existing twin screw extruder to operate at high temperature for the depolymerization trials. Heating-up test and gas leakage inspection of new barrel assembly were completed and the extruder is ready for being connected with a condenser for recovering the monomer.







# *MMAtwo first depolymerization pilot tests completed (June 2020)*



Recycled Methyl Methacrylate through PMMA depolymerization





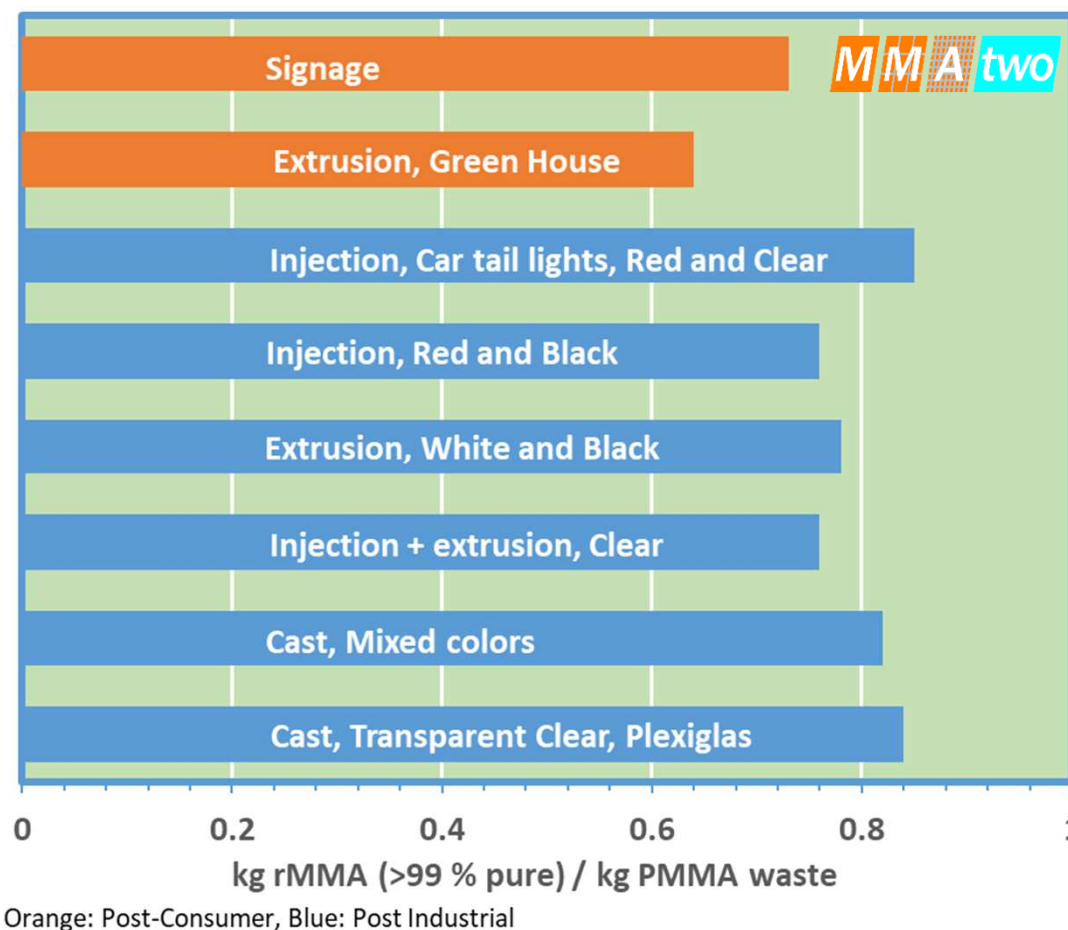
# Mass Balance: Plastic to Monomer/Polymer yields (data from MMAtwo)



The crude MMA samples obtained at bench scale were further purified by **Speichim** to above 99 % purity grade.

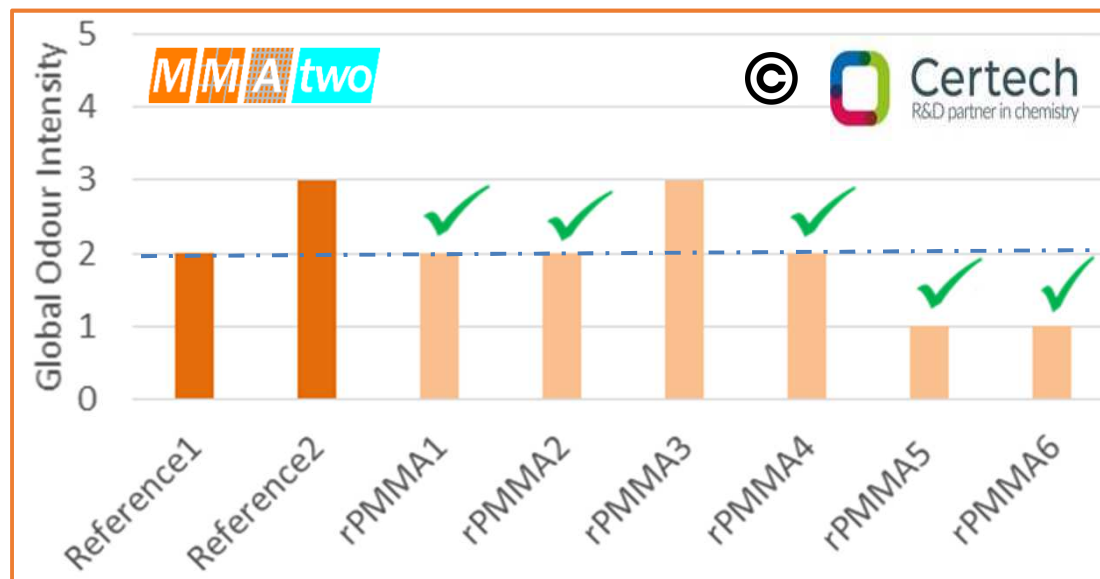
The mass yield of high purity monomer from PMMA waste ranges from 64 to 85 wt %. All PMMA wastes were successfully converted to high quality (>99 %) monomer.

Source: MMAtwo Newsletter N° 2  
Available on MMAtwo website





## *r-MMA end uses*



Global odour intensity determination by human panel was performed at Certech:

5 out of 6 rPMMA polymerised using rMMA from various sources (industrial scrap and post-consumer) have a global odour intensity lower or equal to that of Reference1 which is PMMA from virgin MMA. Reference2 is a copolymer doped with odorous impurities typical of PMMA depolymerisation.

Delta Plados progressed with works on 3 different products from the recycling process, providing a base for consecutive lab trials and application in end-products.



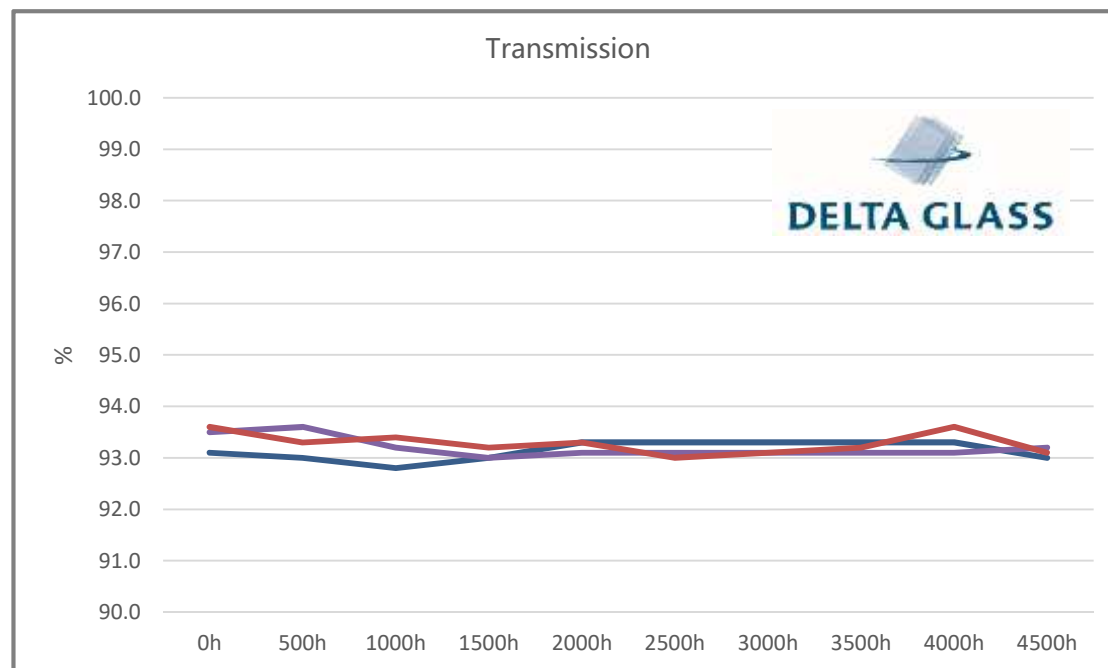


# *Polymer to Polymer validation*

## *Cast sheet from recycled MMA*

**Delta Glass** performed an accelerated weathering test on PMMA sheets made from rMMAs, optical transmission (%) at 4500 h, aging being identical to the reference virgin material.

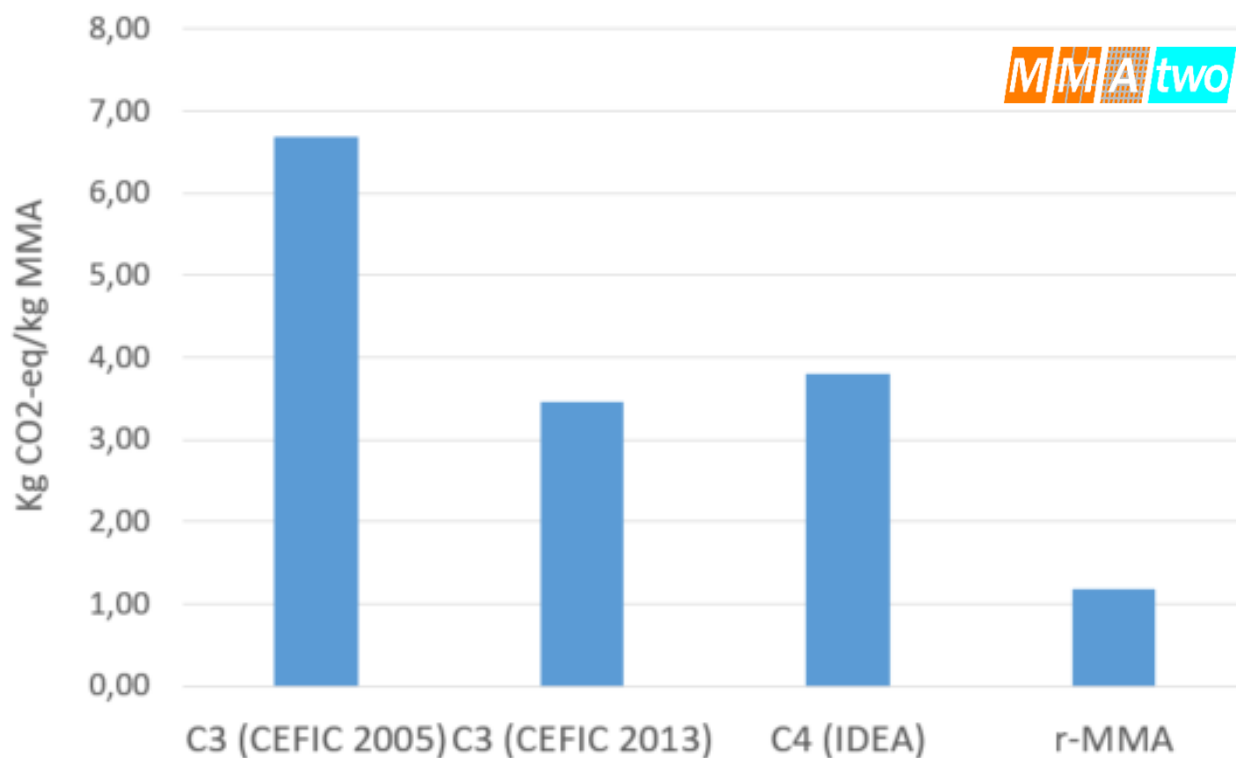
### Transparent PMMA cast sheet from rMMA







# First Environmental life cycle assessment and life cycle costing



## Preliminary results

### Benchmark routes analyzed

- C3 Acetone cyanohydrin (EU): CEFIC data. 2005, 2013
- C4 Isobutene (JP) : IDEA db
- rMMA lead-bath (EU): 2 reports

### Carbon footprint

Compared to virgin production:

- -69% C4 route
- -66% C3 route (CEFIC 2013)

Quantis **ARKEMA**  
INNOVATIVE CHEMISTRY

# Recycled Methyl Methacrylate World Map

Closed  
facility

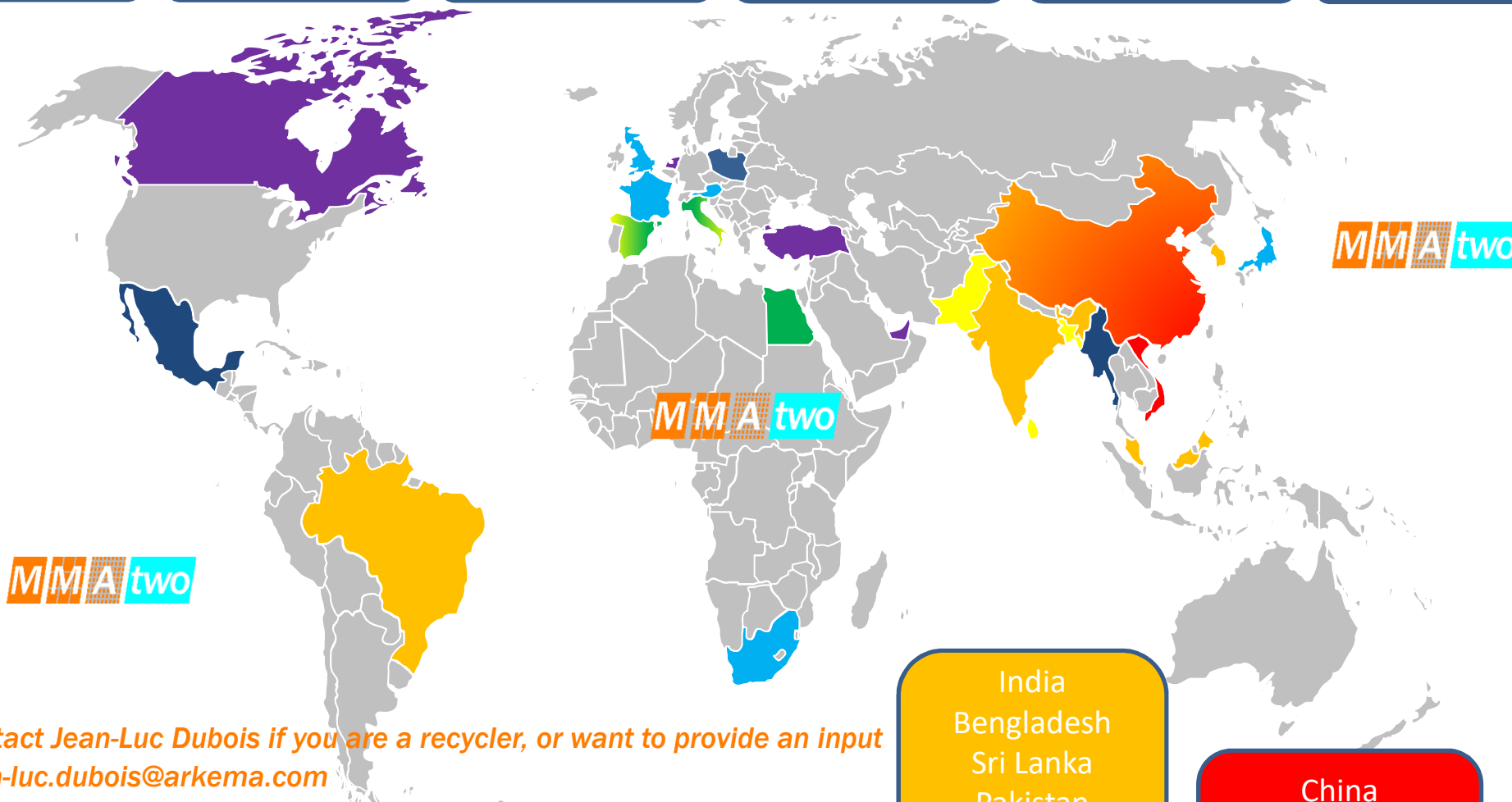
Molten metal  
Technology

Dry distillation  
Technology

Rotating Drum  
Technology

Unknown (yet)  
Technology

Possible new  
plant



Contact Jean-Luc Dubois if you are a recycler, or want to provide an input  
[Jean-luc.dubois@arkema.com](mailto:Jean-luc.dubois@arkema.com)

Americas  
2 000 t+  
5-10 companies

Europe  
7-10 000 t  
3-5 companies

Middle East  
5-10 000 t  
2-3 companies

India  
Bangladesh  
Sri Lanka  
Pakistan  
Malaysia  
20 -30 000 t+  
>30, leaders

China  
Vietnam  
100 000 t  
Many, 2 leaders



MMAtwo - CEFIC Chemical Recycling –  
14/10/2020

Recycled MMA World Map  
 Prepared by Jean-Luc DUBOIS (Arkema)  
 with Simon Van der Heijden (Heathland)

# To learn more about MMAtwo...

Website address <https://www.mmatwo.eu>  
Register at the contact page

**MMAtwo**

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## RECENT NEWS & EVENTS

**Virtual Workshop on Polymer Recycling**  
September 15, 2020

**Aug 18 2020**

**PMMA recycling**  
The project: Recycled 18 tonnes of PMMA  
The impact: 18 tonnes of PMMA recycled

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**Jun 18 2020**

**First pilot tests on PMMA depolymerization**

MMAtwo partners, MMAtwo results

Last June 16th, 2020, the MMAtwo consortium completed the first 2 days of

**May 11 2020**

**[Newsletter] May 2020**

Non classé

MMAtwo second newsletter is available here.

**Dec 9 2019**

**[Newsletter] October 2019**

Non classé

MMAtwo first newsletter is available here.

### [Workshop] Polymer recycling

Non classé

The MMAtwo consortium is pleased to announce the MMAtwo virtual workshop on

### [News] First pilot tests on PMMA depolymerization

MMAtwo partners, MMAtwo results

Last June 16th, 2020, the MMAtwo consortium completed the first 2 days of

### [Newsletter] May 2020

Non classé

MMAtwo second newsletter is available here.

### [Newsletter] October 2019

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Major China capacity additions to push derivatives to Europe 32

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**PRICE & MARKET TRENDS**

**Europe**

## MMAtwo recycling projects starts

A key next stage would be to see if the technology handles tougher, post-industrial materials

**Katherine Sale London**

Despite the ongoing recession caused by the pandemic, the EU-backed MMAtwo recycling project has managed to continue its research, starting up a depolymerisation unit including a first in the field pre-treatment plant, according to the project's chairman.

MMAtwo produced in June the first samples of recycled methyl methacrylate (R-MMA) in June and Jean-Luc Dubois said there had been a number of technological advancements in the project, which is set to use twin-screw depolymerisation technology.

Nearly all MMA is polymerised to make homopolymers and copolymers; the largest application is casting, moulding or extrusion of polymethyl methacrylate (PMMA) or modified polymers.

The MMAtwo project is backed with financing from the EU and led by producers and research institutions.

"There was a plant previously using this process (twin-screw depolymerisation), but that could only process top quality MMA. We wanted something that could process everything," said Dubois, who is also scientific director at French chemicals major Arkema.

He added that several polymethyl methacrylate (PMMA) waste products (post-industrial and post-consumer) had already been depolymerised by Arkema at bench scale as high mass yields with high monomer content can be achieved with most of the grades.

This is an area where MMAtwo has seen more success than initially expected and, despite some minor delays linked to the pandemic, the project has managed to process more types of waste products than initially thought.

Despite the progress, the project remains in a pilot phase, however. It produced 700 kilograms of R-MMA in June during the first test.

**Next - partnering, testing**

The next stage would be to continue further runs, with partnering MMA producers taking part in the project using the samples in production.

PMMA samples have been produced from batch and they have been compared to virgin material.

Most samples within the range can cope with odour issues and behave the same way as virgin product in terms of performance, when put under accelerated aging tests.

A key next stage would be to see if the technology can handle tougher, post-industrial materials, which may contain copolymers or inorganics such as screens from computers or televisions.

A good opportunity to come from the recent coronavirus pandemic is the widespread investment in PMMA sheets, used as protective shields in hospitals, restaurants as well as shops, said Dubois.

The material is ideal for recycling due to the use of pure, transparent acrylic sheet, according to Dubois.

**Waste collection**

Collection of waste is still a major objective for the project, which is looking at the potential to establish a comprehensive infrastructure across the 27 countries in the EU.

"For any business, your life-line is your feedstock - all revenue is based on what you can collect and convert," said Simon van der Heijden, co-founder of plastics recycling firm Heathland, part of MMAtwo, and coordinator of the project.

The project has successfully identified the multiple waste streams in the EU, and is currently collecting 9,000 tonnes across the bloc, an amount expected to increase considerably as the project continues, end-of-life product remains the main challenge.

"End of life is more hidden, and harder to collect efficiently," added Van der Heijden.

He added that the pre-treatment process being tested by Heathland has become one of the project's milestones this year, and a "first of its kind" in Europe.

"All PMMA that is depolymerised needs to be pre-treated; however, to do this automatically is new - waste collection and straight into pre-treatment, into suitable feedstock to depolymerise. Innovative separation technology and automated," he said.

The two key areas that will gather momentum in the market for recycled MMA are: government targets and the price of the product versus virgin monomer.

**EU legal framework**

Despite this being a partially funded EU project, there is no legislation currently in place for this sector. Much of the government targets are related to packaging, and so impact products such as polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET).

"PE/PP worldwide production is more than 10 times that of PMMA, it's easier to collect and [it is] a lower-value material," said Dubois.

"You consume a lot of energy to depolymerise PE. You don't save that much energy. But you do when you produce and recycle PMMA: it is a material harder to collect but its value is higher

**WP2, PMMA depolymerization to crude MMA**

Source: Arkema

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# Advisory Board contacts

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**H R Fowler (ZA)**

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**Peter Kelly (BE)**



**Andrew Bragg (UK)**



## Advisory Board



*Interested in the project*



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