



Recycling of Food Packaging Waste into Non-Food Packaging Applications

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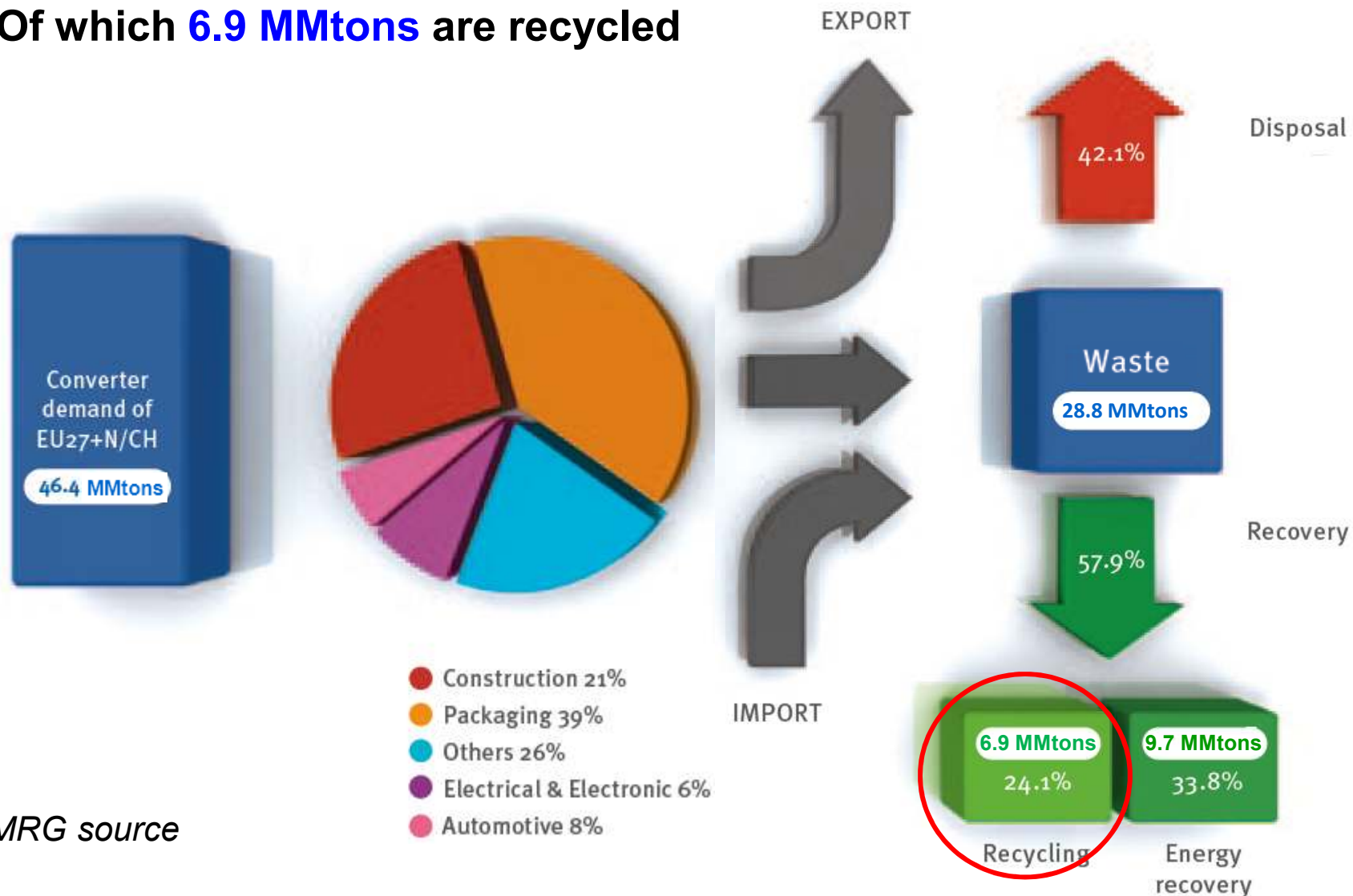


Packaging Waste Recycling: Current Market Snapshot

- **Packaging Post-Consumer Waste dominated by PET, PE & PP bottles.**
- **High variety of commingled polymers from kerb collection: not only PE, PP and PET**
- **Ramping up recycling of other post-consumer waste i.e. Complex Films and Multi-layer containers). Ex: PE/PA, PE/PET, PE/EVOH ...**
They are still mostly burned, landfilled or exported, or re-used in low-end applications.
- **Pots, Tubs and Trays are packaging not yet considered as a potential feedstock for added-value recyclates**
- **Important export outside Europe but Chinese Green Fence Policy stops export => Build up of post consumer waste in WE.**
- **Effort to reduce post-industrial packaging waste by in-house recycling at converters**
 - **Multi-layer packaging with one layer dedicated to on-line recycled trim off and waste**
 - **Down gauging.**

Market: Polymers Life Cycle

- 28.8 MMtons/a plastic waste in European Union (2010)
- Of which **6.9 MMtons** are recycled



PEMRG source

Trends of Waste Management in WE.

Governmental push for :

- No landfill
 - Less incineration
 - **More mechanical recycling** (preferred option)
- } **more waste to recycle, incl contaminated waste**
- Less industrial waste production => **Shortage of high quality feedstock for recyclers**
 - More non-bottle post-consumer waste recycling: Pots, Tubs, Trays, Multi-layer containers and films & mixed plastics
=> **more contaminated waste to be recycled**

End Use demand for:

- Higher consumption of recycled plastics **in more demanding applications**
- **Better quality** recyclates



Recycling Streams of Post-Consumer and Post-Industrial Packaging Waste:

- **Incineration** with **highly efficient energy recovery**
- **New feedstock efficiency:** To make new polymers from waste
e.g. polyethylene
- **New Fuel:** By pyrolysis of plastic wastes.
- **Closed loop mechanical Recycling**
i.e. Food packaging to food packaging
- **Cradle to Product Mechanical Recycling:**
i.e: Food Packaging to Non-Food packaging applications

But

What are the key requirements of Non Food Packaging Applications that recycles from food packaging waste must meet ?

Key Requirements for Recycling of Food Packaging Waste Into Non-Food Packaging Applications:

In food packaging:

- Food contact approval,
- Drinking water approval
- Transparency (films)
- Clean, no contamination
- Organoleptic
- Appearance/aesthetics.
- Easy Processability
(i.e : extrusion blow moldability)
- Drawability (films & containers)

In non food packaging applications:

- Aesthetics:
 - Surface finish
 - Colorability
- No odor or pleasant odor
- Dimensional stability
- Easy to process: e.g. easy to blow mold (constant MFI) & to injection mold (Medium to high MI)
- **Mechanical strengths:**
 - Tensile strength
 - Elongation at break

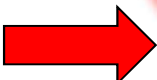

Impact strength is utmost important.

Needs and Solutions for Mechanical Recycling Into Non Food Packaging Applications

Needs

- Availability of larger quantities of **high quality** feedstock (waste)
- Improved mechanical & processing properties of recycled polymers: Objective: Get close to virgin polymers

Solutions for higher consumption and retention of quality of recyclates

- Avoid contaminated waste by selecting only good quality sources (*mainly post industrial*) **BUT** *is there enough quantity ?*
- More efficient recycling process:
 - *Less time consuming and less costly operations such as sorting, washing, cleaning...*
- Use of polymer waste with higher contamination rates by  

Contamination: A Major Cause of Poor Quality Recycled Polymers.

- Recycling damages the molecular weight of polymers : hard for recycled polymers to reach the performance level of virgin polymers

MOREOVER

- Contamination makes recycled polymers brittle.
- Contamination root causes are multiple.
- Contamination of polymers by other polymers is more frequent and more recurrent than thought, even at low concentration
- Examples: PE contaminated with PP, } same density
 PP contaminated with PE, }
 PE or PP contaminated with PET: e.g.: PET dust }
 PE or PP contaminated with PA, } from multi- layer
 bottles and films
 PE or PP contaminated with EVOH, }

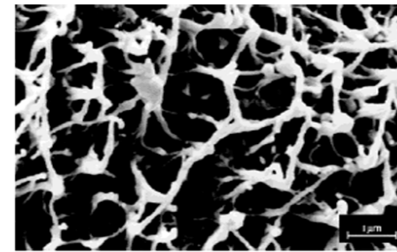
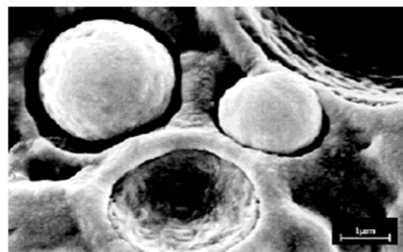
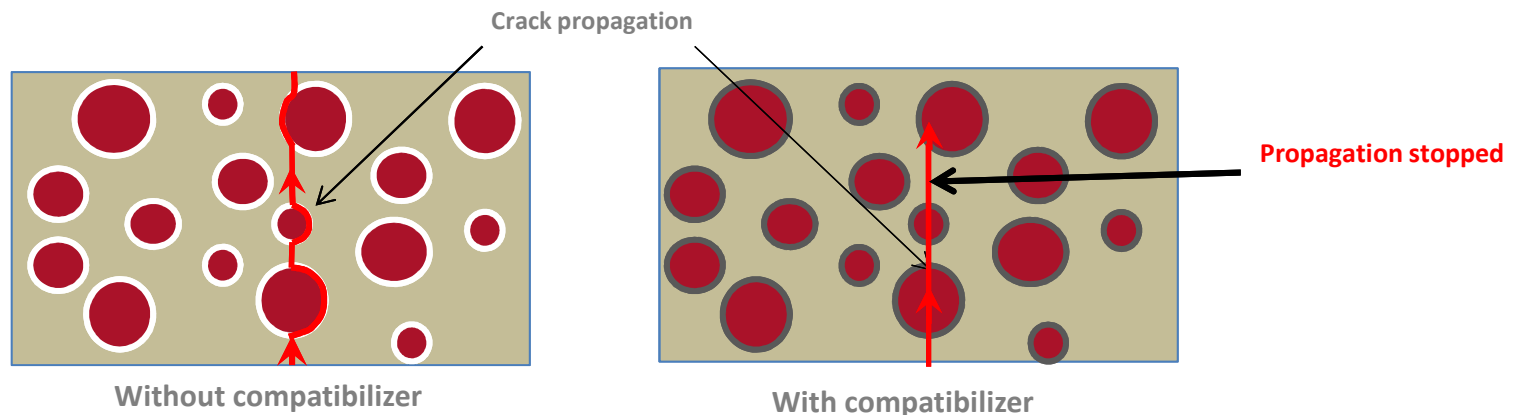
What Value Do Compatibilizers Bring?

- **Upgrade impact strength and processability despite low addition levels.**
Impact strength is a key mechanical property to take into consideration for recycled polymers. It is more meaningful than tensile strength and elongation at break
Low impact strength recycled polymers can't replace 100% virgin polymer.
They also risk to lower the impact strength of blend: virgin polymers + recycled polymers.
- **Retention of mechanical properties even when high contamination contents (up to 30%)**
- **Reduction of time consuming and costly recycling steps needed to lower contamination levels.**
E.g: No need of dilution to reduce contaminant rate down to 5-7%

Why compatibilizers ?

A mean to improve poor properties of recycled plastics (*caused by lack of compatibility between most polymers*) :

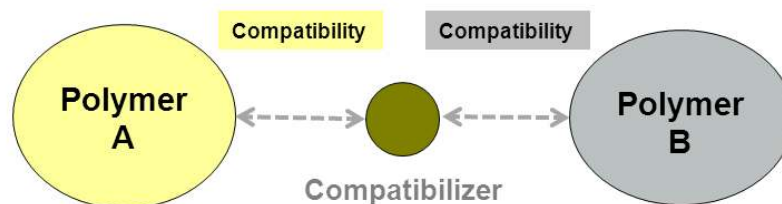
- Strengthening of weak interface between dispersed particles and continuous phase :



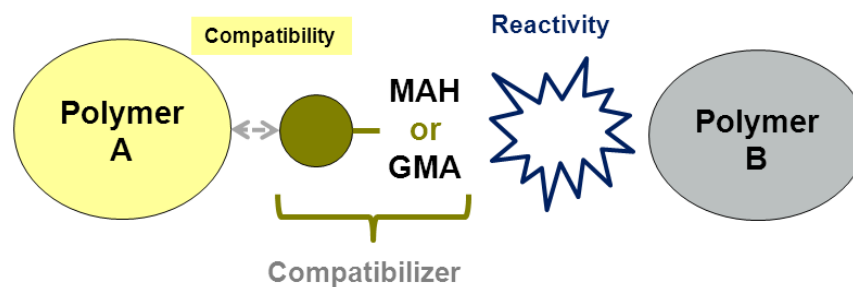
Example: 70% PE + 30% PA

- Consequent higher strength and improved processability

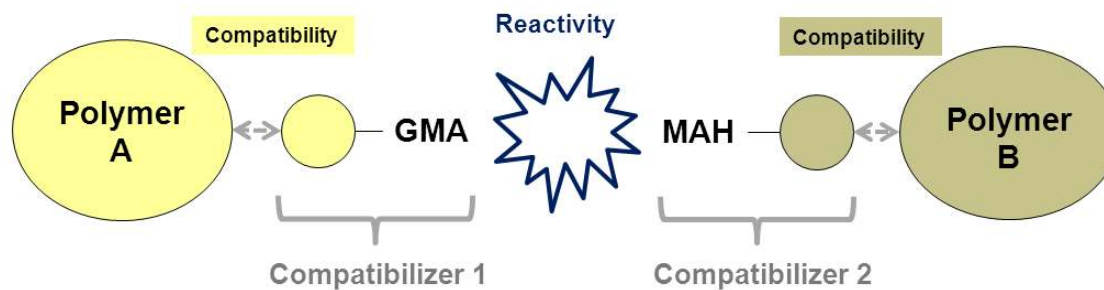
How Do DuPont Compatibilizers Work ?



or



or



DuPont Compatibilizers

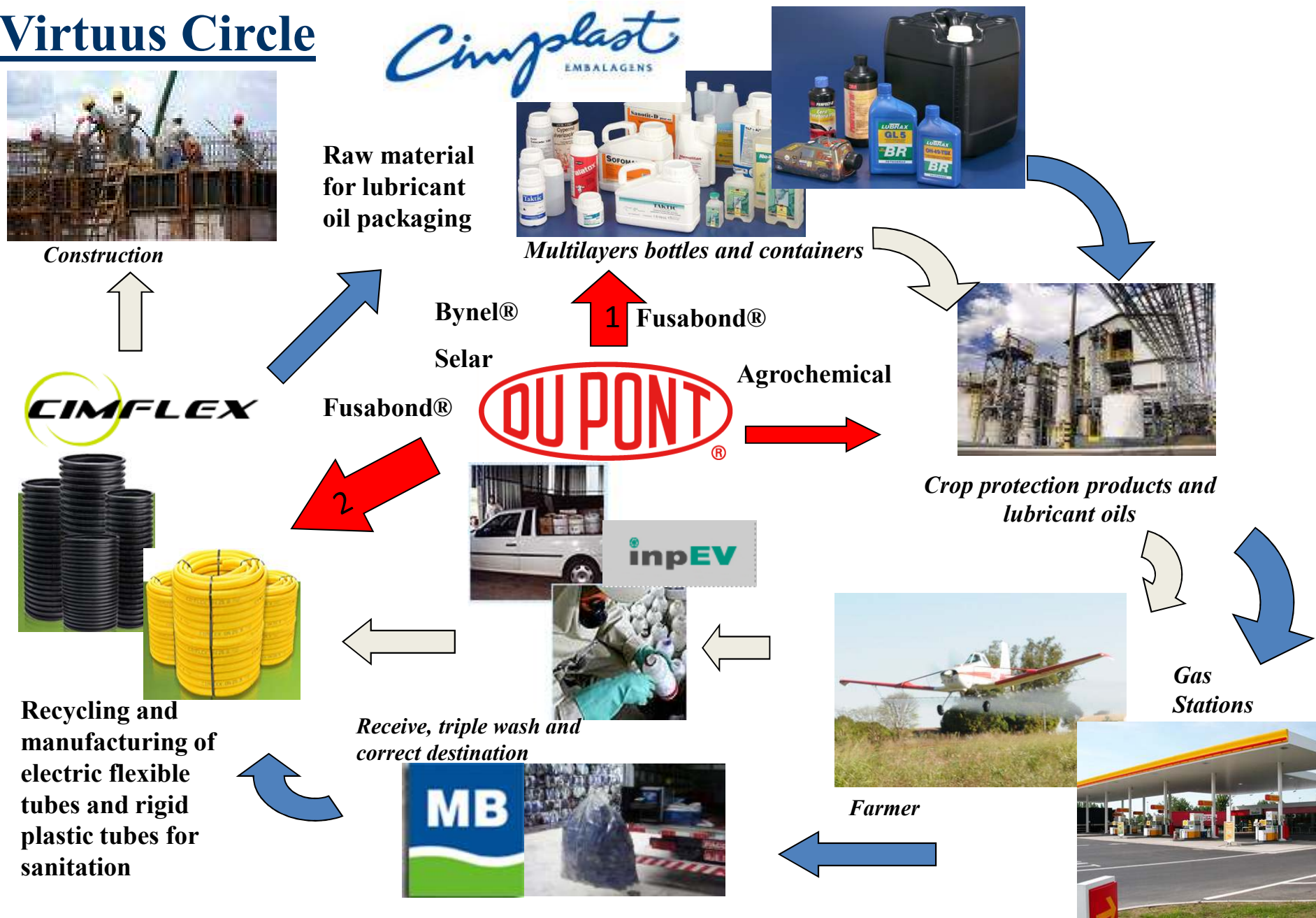
Examples of Recycled streams	DuPont compatibilizers
PE-PA or PE-EVOH (case of packaging films and containers like gas tanks)	<i>Fusabond® E226, M603</i>
PP-PA or PP-EVOH (case of packaging films)	<i>Fusabond® P353, N525, N416</i>
Polyesters-PE (case of packaging films and PE closure contaminated by dust of PET bottles)	<i>Entira™ Bond 12, Elvaloy® PTW</i>
PP-PE (case of bottles, flacons, tubes , food, ,cosmetics and household)	<i>«Entira™ EP 1753 and New compatibilization system,(patent pending)</i>
PE-PVC	<i>Entira™ Bond 12 + Fusabond A560</i>
PC-Polyesters	<i>Elvaloy® PTW</i>
PC-ABS	<i>Elvaloy® PTW + Elvaloy AC 3427</i>

- *Fusabond® M603 and Elvaloy® PTW do not have food approval*
- *Loading levels for compatibilization typically 2 – 7 w%*

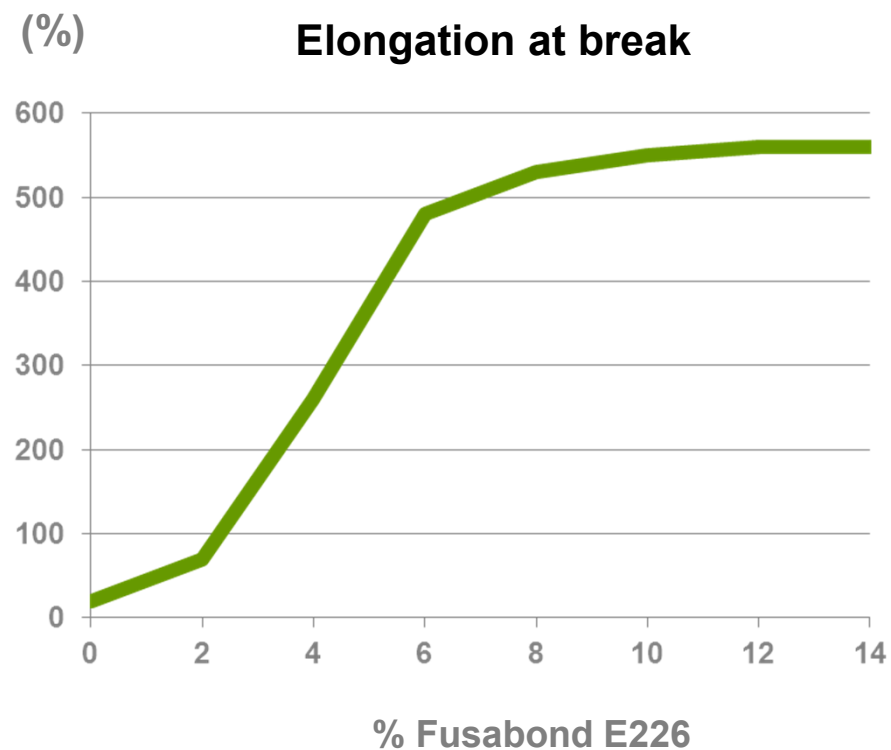
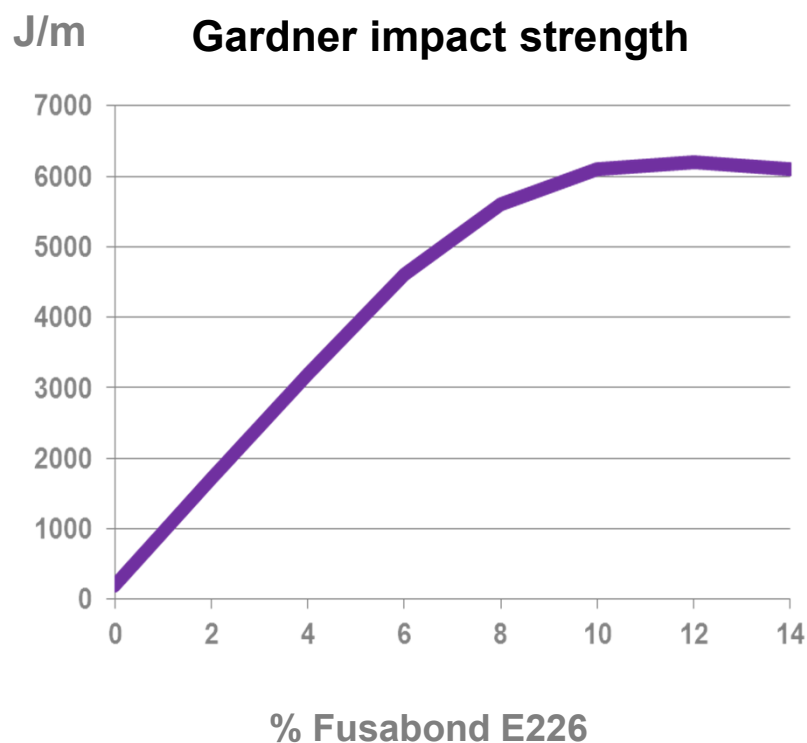
Ex: Post Consumer Recycling of PE-PA Multi Layer Container



Virtuus Circle



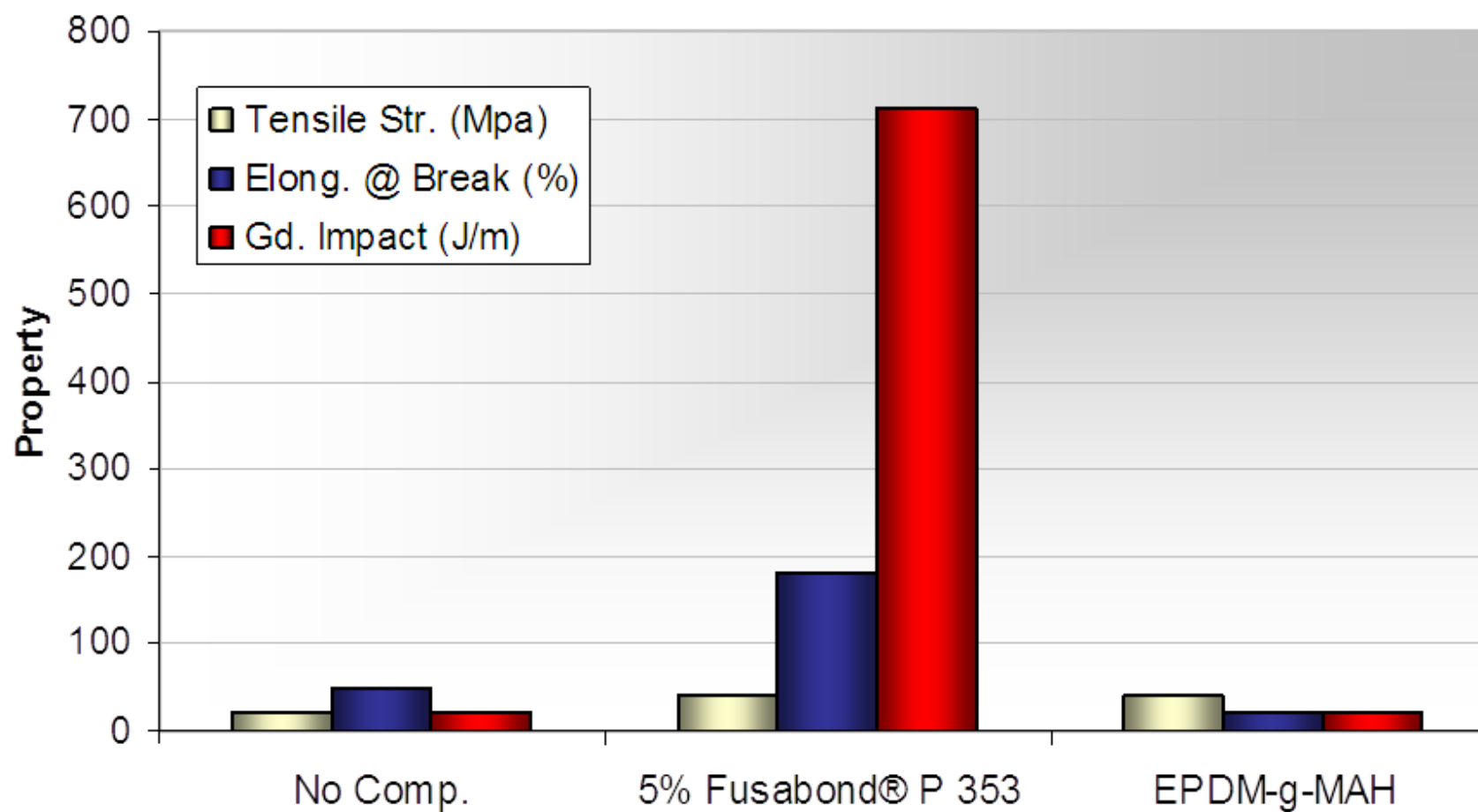
PE - PA Compatibilization (70 % PE + 30 % PA)



- Typical PE/PA blends used to make films, can be blended with PE. In case of re-use in PE/tie/PA/tie /PE films, recycled PE-PA blends can be used in PE layer or in a layer dedicated to 100 % recycled PE-PA.
- For cost /performance ratio, % of Fusabond is usually around 4-5%

PP - PA compatibilization

(50 % PP + 50 % PA6)

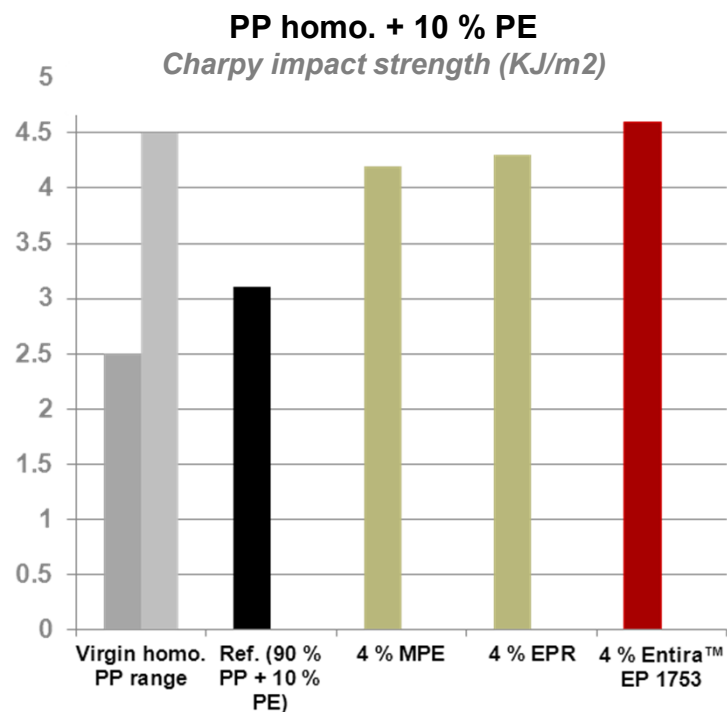
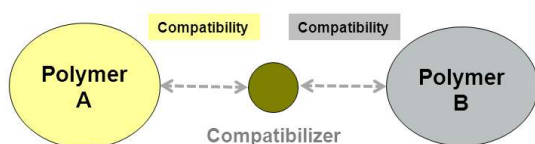


PP - PE Compatibilization (90 % PP + 10 % PE)

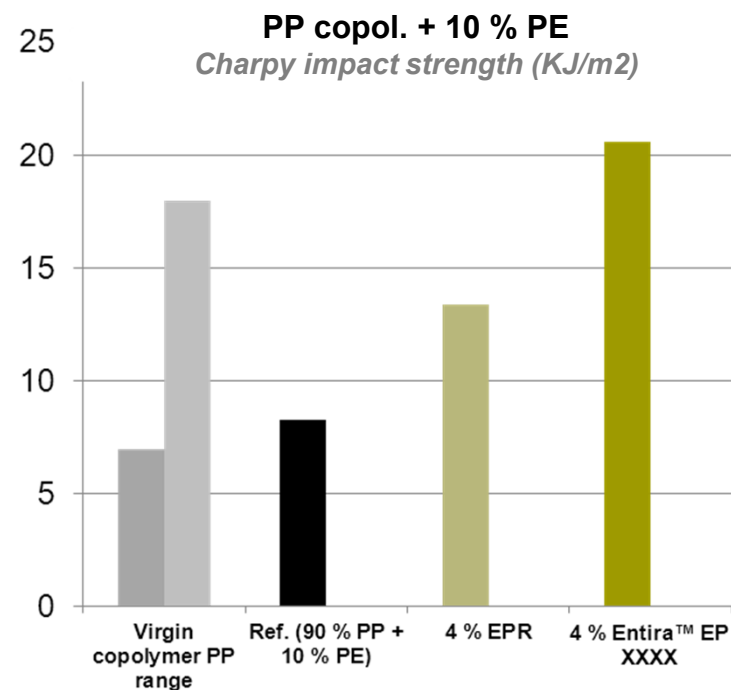
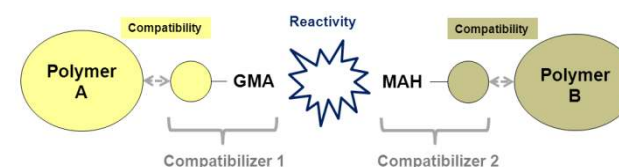
Due to their similar density, PP and PE are hard to sort out.

Contamination of PE in PP or PP in PE gives poor mechanical properties of blend.

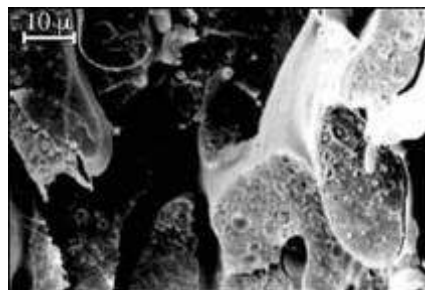
Reduction of interfacial tension



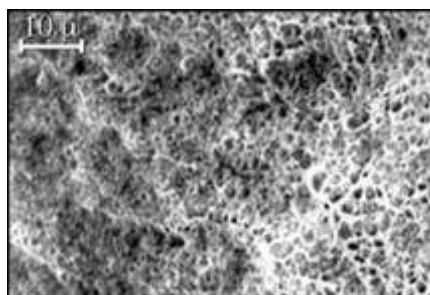
Double compatibilization system



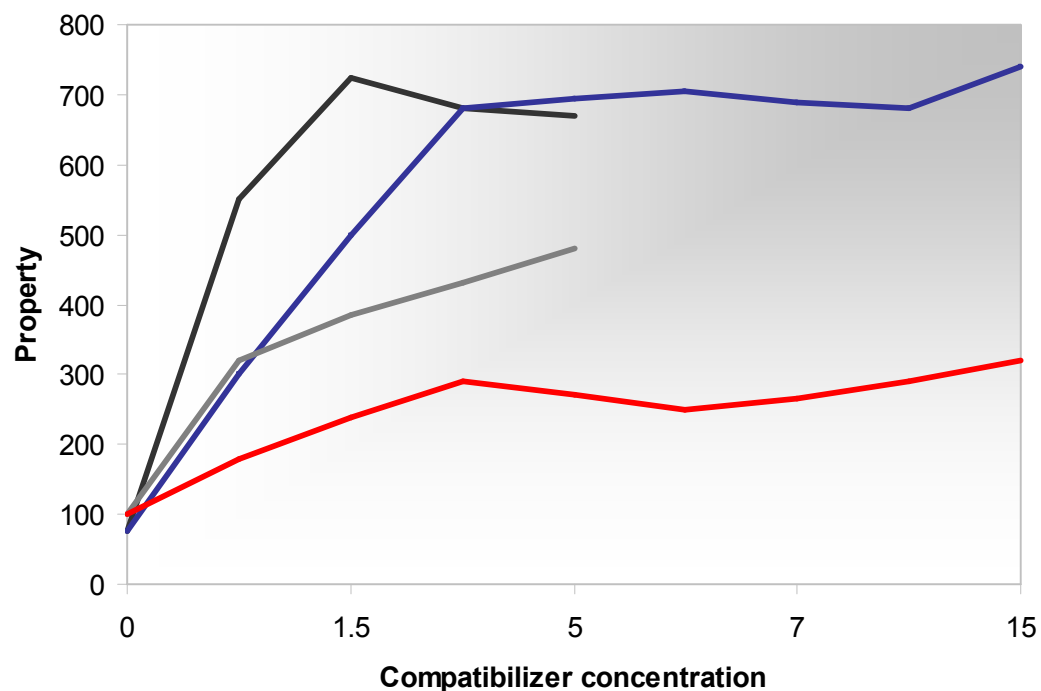
PE - PET compatibilization (75 % PE + 25 % PET)



Noncompatibilised Blend
PE-PET- poor dispersion



Addition of 5% Elvaloy®
PTW leads to fine
dispersion and superior
mechanical properties



Elongation at Break (%)

— Elvaloy® PTW
— Fusabond® E 226

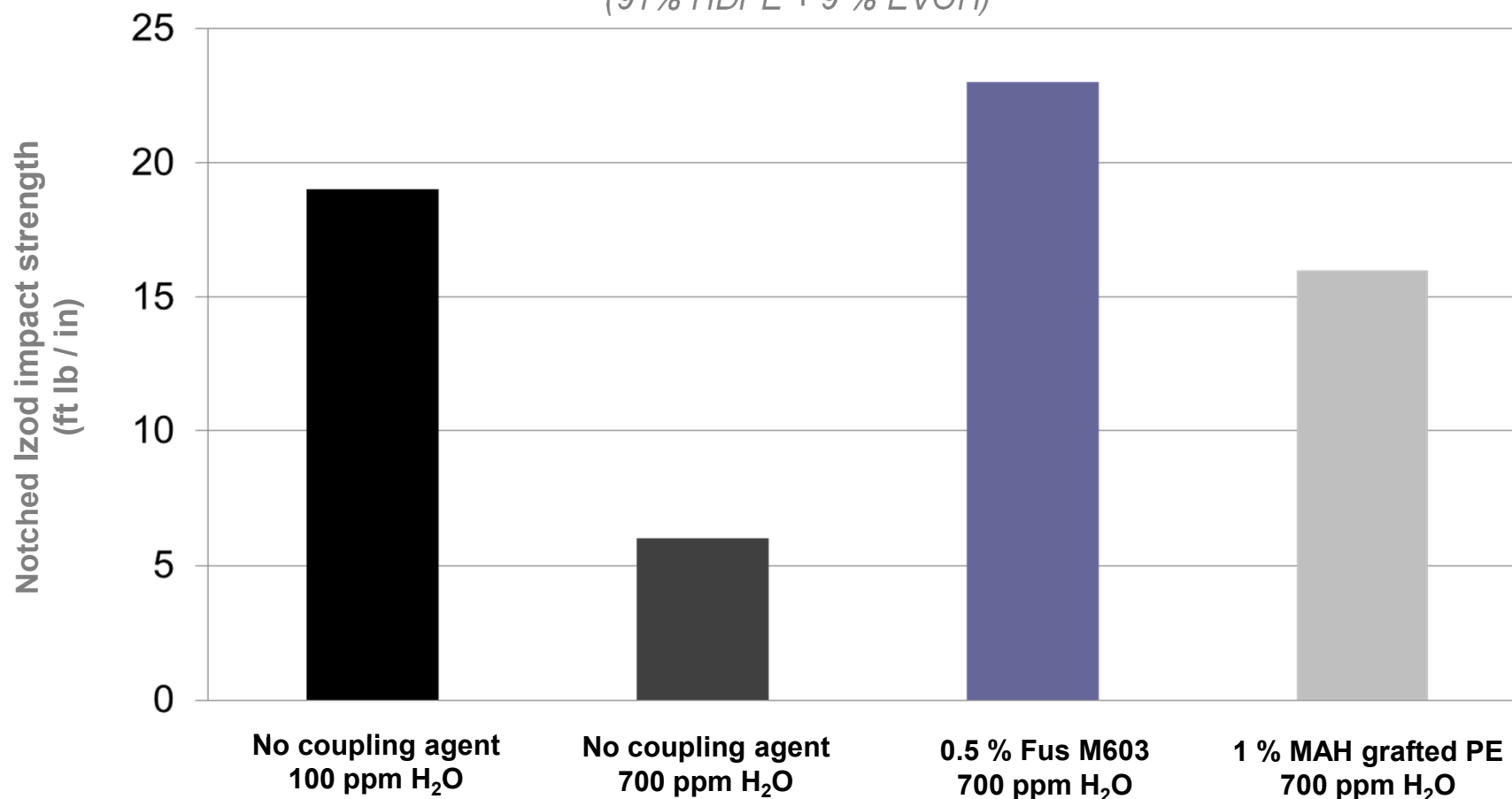
Gd Impact (10x J/m)

— Elvaloy® PTW
— Fusabond® E 226

PE - EVOH Compatibilization

- **Fusabond® E226** normally recommended
- **Fusabond® M603** recommended for moist HDPE-EVOH blend

(91% HDPE + 9 % EVOH)



* Moisture measured after extrusion compounding and immediately before molding test bars

Summary

**Due to the increasing amount of post consumer waste and
the need to use superior quality recyclates,
Fusabond[®], Entira[™] Bond, Entira[™] EP and Elvaloy[®] are effective compatibilising
agents to upgrading the recycling of various polymer compositions,
mixed and/or contaminated**

Thank You for Your Attention.

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