



Multifaceted Approaches to Improve Sustainability of Multilayer Packaging

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Overview

SK Group

Ecodesign

Mechanical recycling

Advanced recycling

Emulsions

SK Group Overview

Manufacturing and Business Footprint

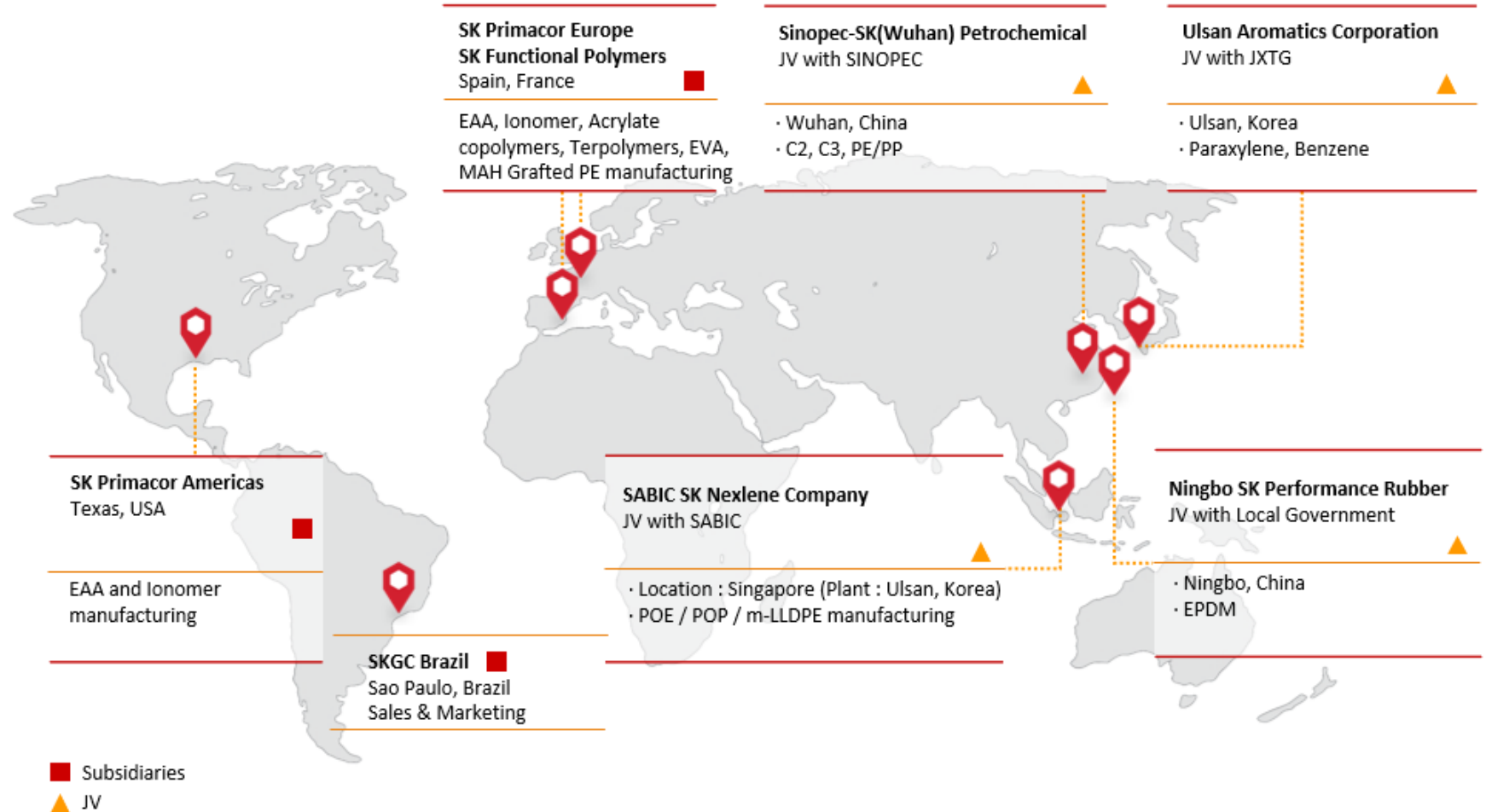
SK Group (SK):

- Multinational company.
- Annual revenue >\$100 billion.
- Headquartered in South Korea.
- SK is driving ahead in Green, New Tech Materials, Bioscience and Digitalization.
- SK has 12 divisions where SK innovation holds SK geo centric.

SK geo centric Capital

Investments:

- 1st EU Ionomer Manufacturing Plant – Spain – June 2022.
- New EAA Manufacturing Plant – China – 2025.



SK Geo Centric

Business Portfolio at Glance

Products

Basic Chemicals

❑ Olefins

- Ethylene ¹⁾ | Propylene ¹⁾

❑ Aromatics

- PX ²⁾ | BZ ²⁾ | SM

Polymers

❑ Polyethylene

- LLDPE | HDPE

❑ Polypropylene

- HCPP | HSPP | r-TPO

❑ Advanced Materials

- EAA | Ionomer | Terpolymer | EA | EVA
- POE | m-LLDPE | POP ³⁾

Performance Chemicals

- ❑ High purity normal heptane/hexane, 1,4-BDO, PDEB, De-aromatized solvents, Cyclopentane, etc.

Trade Products

- **PRIMACOR™(EAA)**: Excellent adhesion for tie-layer and dispersion coating
- **IONIA™ (Ionomer)**: Superior sealability & excellent adhesion
- **SUPREME™ (POP)**: Superior sealability & toughness
- **SMART™ (m-LLDPE)**: Excellent toughness & processability
- **YUCLAIR™ (Z/N-LLDPE)**: Excellent toughness & stiffness
- **LOTRYL® (EA)**: Excellent adhesion & compatibility with other polymers
- **EVATANE® (EVA)**: Excellent filler acceptance, adhesion & elasticity
- **OREVAC® (MaH-G)**: Superior adhesive power and high reactivity
- **LOTADER® (Terpolymer)**: Excellent adhesion & high flexibility
- **XPLENE™ (HCPP)**: Excellent stiffness & impact strength balance
- **SOLUMER™ (POE)**: Excellent impact strength & processability
- **SUPRENE™ (EPDM)**: Excellent weather/heat/ozone resistance

1) Including production for internal consumption

2) Including SKIPC production

3) Produced in SSNC JV by Nexlene™ Tech

Bolded: Products Promoted in the Americas and Europe

* EAA(Ethylene Acrylic Acid), POE(Polyolefin Elastomer), POP(Polyolefin Plastomer), HCPP(High Crystallinity Polypropylene), HSPP(High Strength Polypropylene), r-TPO(reactor made thermoplastic polyolefin), PDEB(Para-diethylbenzene), EPDM(Ethylene Propylene Diene Monomer)

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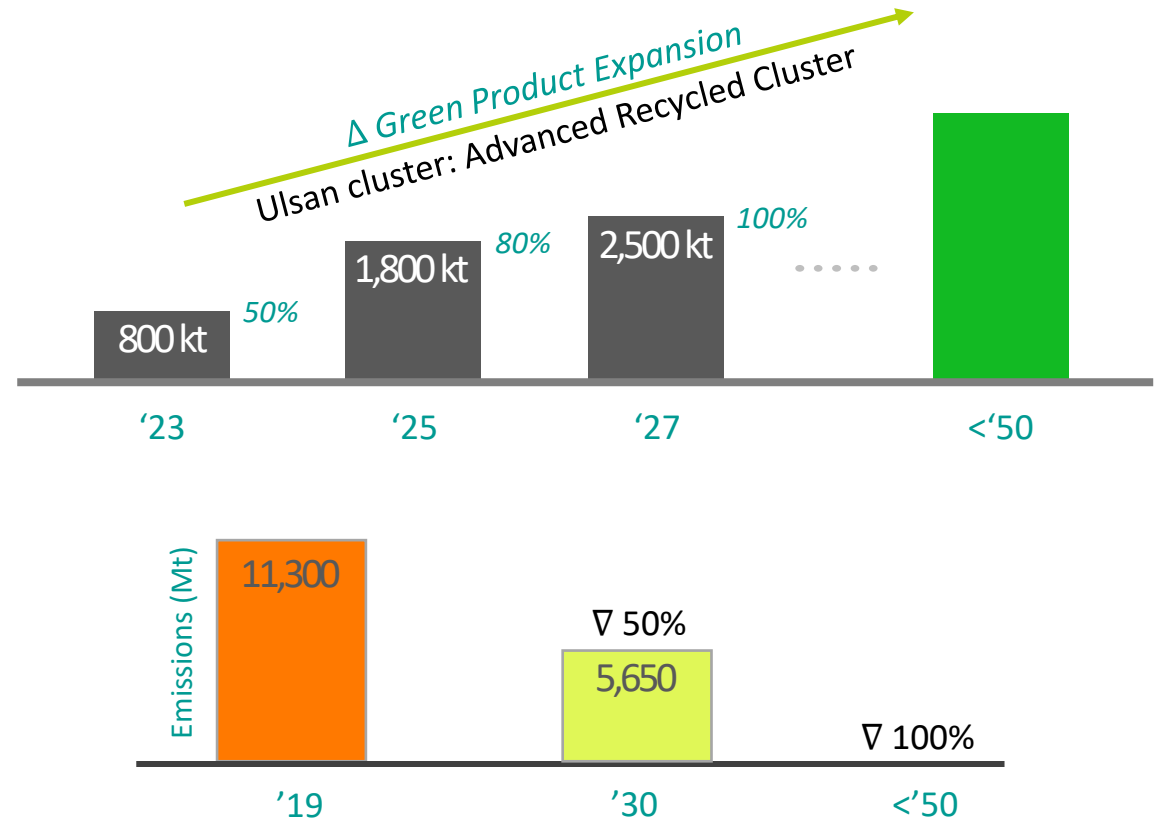
Green Product Portfolio

Expand Green Products Globally

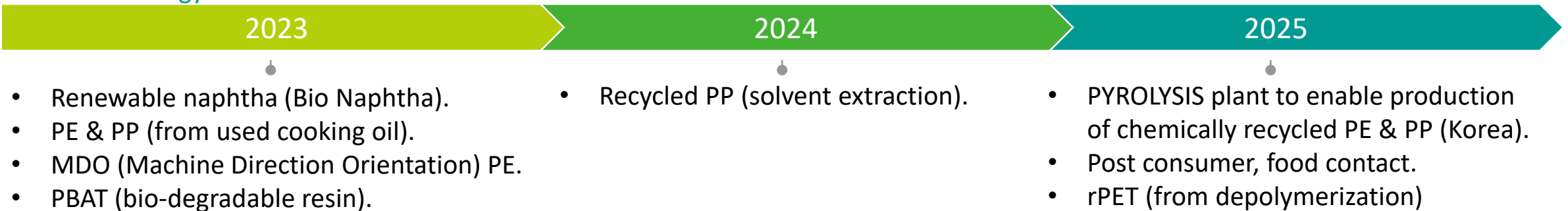
- Closed-Loop recycle eco-system with brand owners.
- Globally Plug & Play.
- Collaboration for:
 - Easy-recyclable,
 - Reduce weight - slim packaging,
 - Self-life extension, etc.

Carbon Zero:

- 50% emission reduction by 2030 (off 2019 baseline).
- Net-zero by '50.



SKGC Technology Contributes to GREEN MATERIALS



Ecodesign – Reduce, Replace, Recycle - 3R

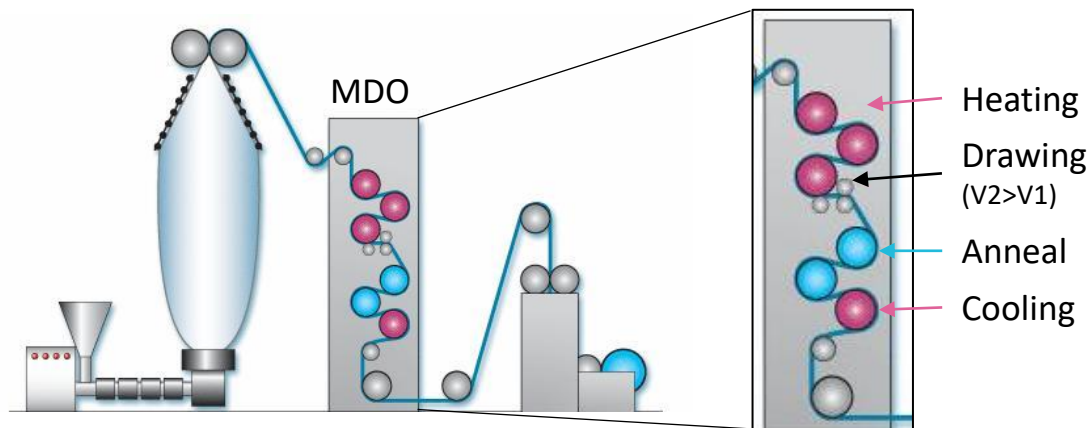
Monomaterial PE film Machine Direction Orientation (MDO)

❑ Monomaterial Packaging

- Product made with just one type of material i.e. full PE or PP.
- Easy to recycle.
- Ecodesign to mono-material packaging solutions i.e. using MDO.

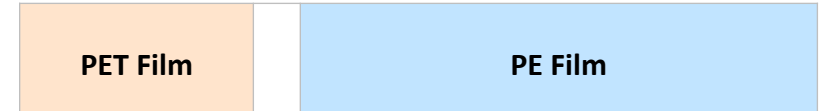
❑ Machine Direction Orientation

- Post extrusion process used to enhance film properties such as optics or even rigidity.
- The extruded film is stretched several times in machine direction module.



Concept

Non-recyclable **Multimaterial** Packaging



Redesign

Recyclable **Monomaterial** Packaging



General Advantages



Improved recyclability.



Reduce CO₂ footprint.



Custom down-gauging.

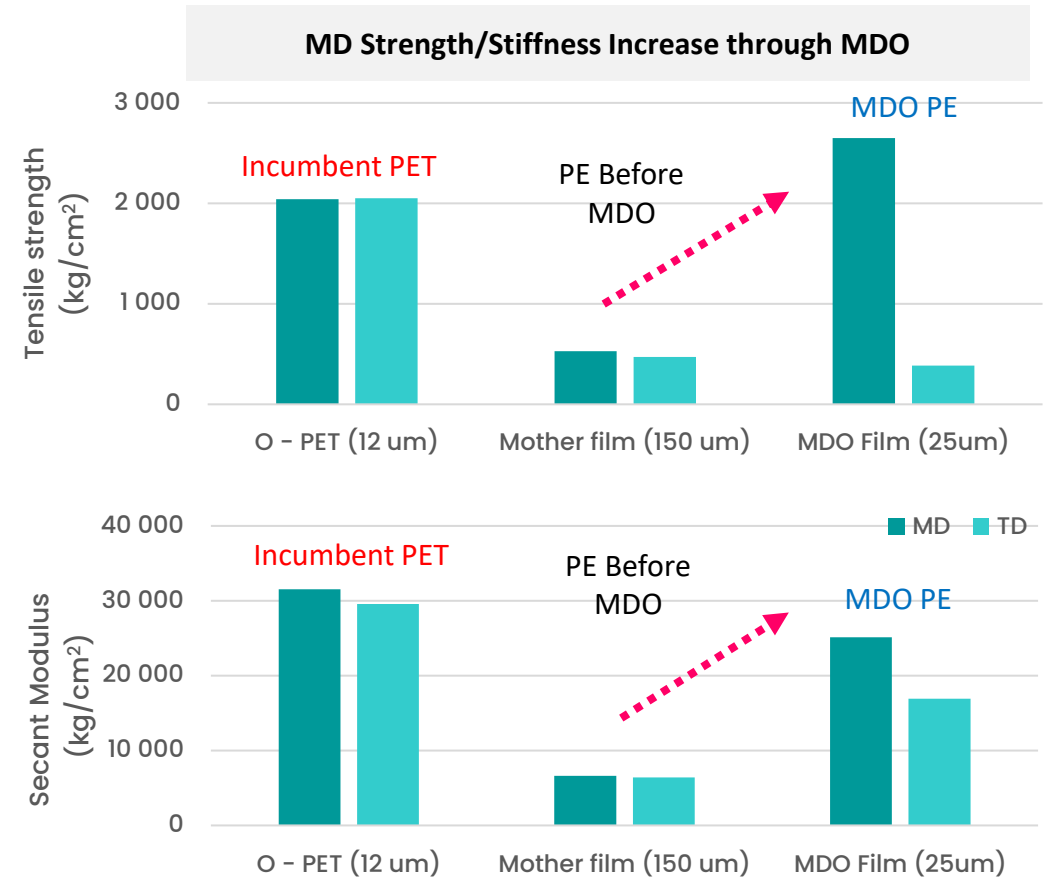
Ecodesign – Reduce, Replace, Recycle - 3R

Monomaterial PE film Machine Direction Orientation (MDO)

- SK Yuzex™ 8300 HDPE is selected for maximum stiffness, thermal stability, and minimizing die drool.
- After MDO stretching, Yuzex™ 8300 properties are closer to PET (stiff, clear, puncture resistant).

Yuzex™ 8300: Pilot scale data (for reference only)

Density (g/cm³)		0.963
Melt Index (g/10min)		0.7
Softening Point (Vicat °C)		124
Brittleness Temperature (°C)		< -80
Tensile Strength @ Yield (kg/cm²)	MD: x1	MD: 530; TD: 470
	MD: x5	MD: 2,650; TD: 390
	MD: x6	MD: 3,560 ; TD: 380
Elongation @ Break (%)	MD: x1	MD: 980; TD: 1000
	MD: x5	MD: 26; TD: 1
	MD: x6	MD: 16; TD: 1
2% Secant Modulus (kg/cm²)	MD: x1	MD: 6,620; TD: 6,390
	MD: x5	MD: 25,110; TD: 16,910
	MD: x6	MD: 31,430 ; TD: 17,160
Dart Impact Strength (g)	MD: x1	<66
	MD: x5	<66
	MD: x6	<66
Thickness (μm)		25 (max stretching is 10)



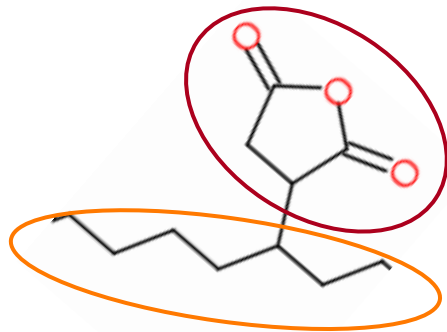
- MDO-PE films to replace PET laminated film
- Full PE packaging for a better recyclability.

Mechanical Recycling

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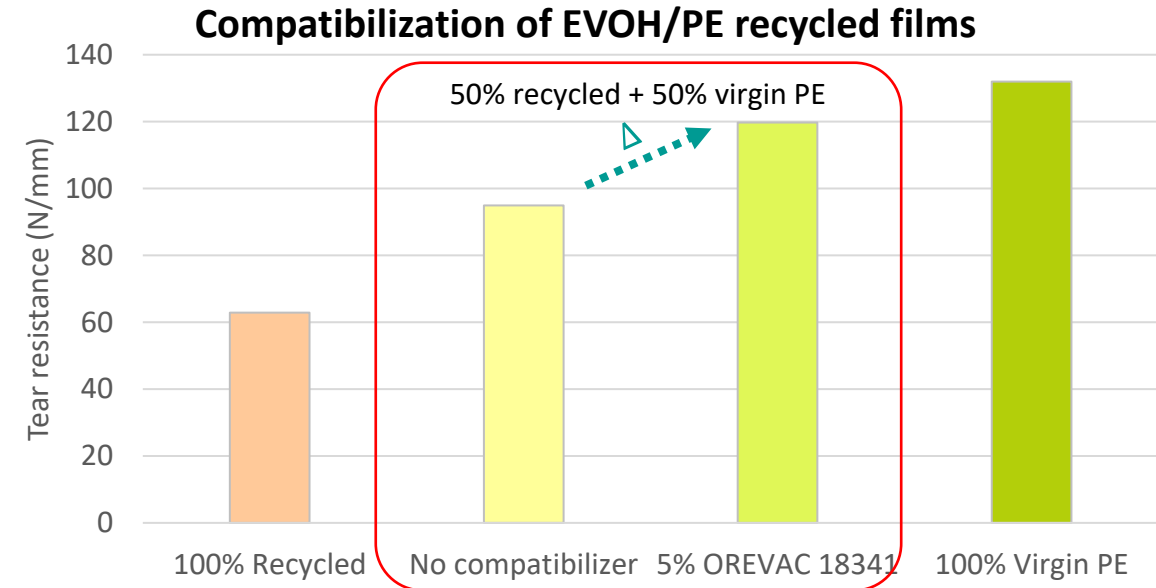
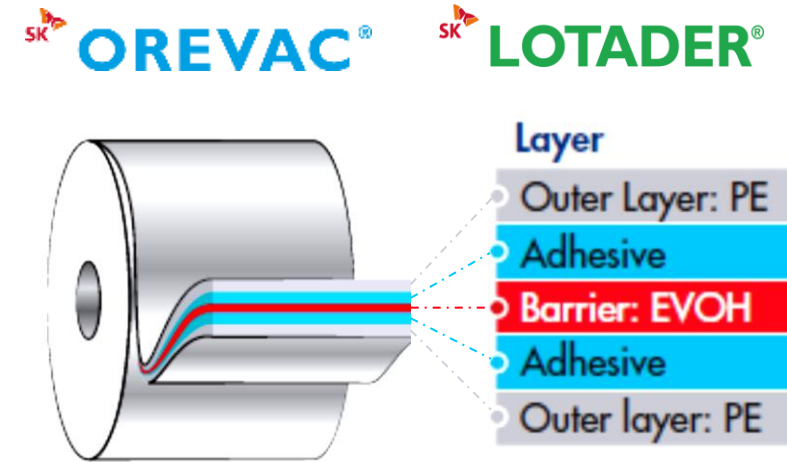
☐ Solutions for plastics recycling

- Upcycling post-consumer EVOH/PE waste.
 - Multilayer structures recycling
 - Based on polyolefins (LDPE, PP, HDPE) and engineering plastics (EVOH),
 - Widely used in flexible food packaging,
 - EVOH / PE waste blends immiscible,
 - Poor recyclability and processability (before compatibilizer).
- Orevac® enhance compatibilization of EVOH/PE blends:
 - Improved recyclability and processability



Reactivity with
PA or EVOH

Compatibility with pol
yolefins



Mechanical Recycling

SK Geo Centric

❑ Recycle Multilayer Materials

- Contain polyolefin layers and polar layer (EVOH, PA, etc) for barrier performance.
- Both layers cannot easily be separated and materials are not compatible.
- SKFP Compatibilizers Orevac® and Lotader® can be used to give a second life and avoid landfilling or incineration alternatives:
 - **Orevac® 18341** in agricultural protection flexible films,
 - **Lotader® 4210** in automotive fuel tanks or pipes.



 **OREVAC®**



- Recycling of barrier fumigation films,
- Compatibilization PE/EVOH multilayer.

 **LOTADER®**



- Fuel tanks made of PE/EVOH multilayers,
- PE bottle waste can be added.

Mechanical Recycling

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#1 Recycling barrier films (PE/EVOH)

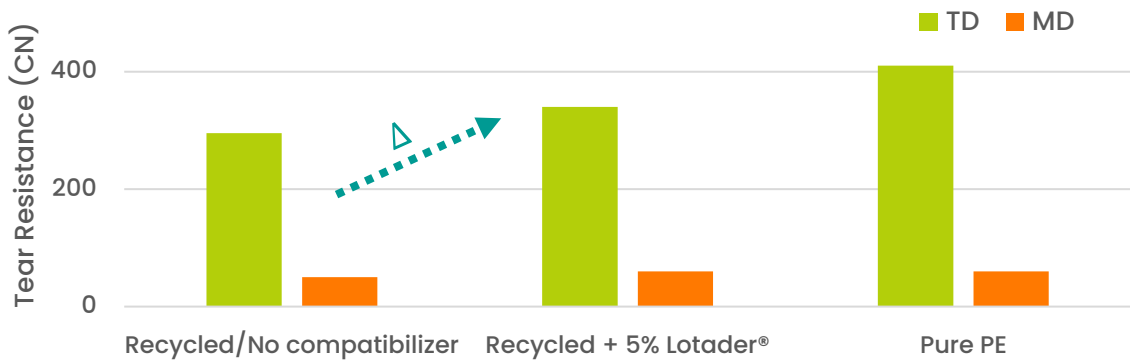
- Structure: PE/Tie layer/EVOH/Tie layer/PE.
 - i.e. PE: 89%, EVOH 10%, Orevac® 1%.

✓ **Mechanical recycling results:**

- Lotader® 4210 (at 5%) improves haze.

✓ **Tear strength:**

- Significant tear resistance improvement with addition of 5% Lotader®



#2 Recycling films (PE/PA)

- Structure: PE/Tie layer/PA/Tie layer/PE.
 - i.e. PE: 69%, PA 29%, Orevac® 2%.
- The high PA content makes the films more difficult to recycle than the EVOH-based films.

✓ **Mechanical recycling results:**

- Recycled PA film could not be processed without compatibilizer.
- 5% compatibilizer enables its processing into a new film.
- Increase tear resistance by >100% in the machine direction.

	Tear Strength (CN)	
Lotader	0%	5%
Recycled PE/PA film	16	39

#1Typical compatibilizer loading recommendations for PE/EVOH films: from 2 to 5% depending on the EVOH content.

#2For PA-based barrier films, it is recommended to compound it with virgin PE. Lotader® 4210 added at 0.75% in the recycled/virgin blend enables to retrieve many of the original properties of virgin PE.

Advanced recycling

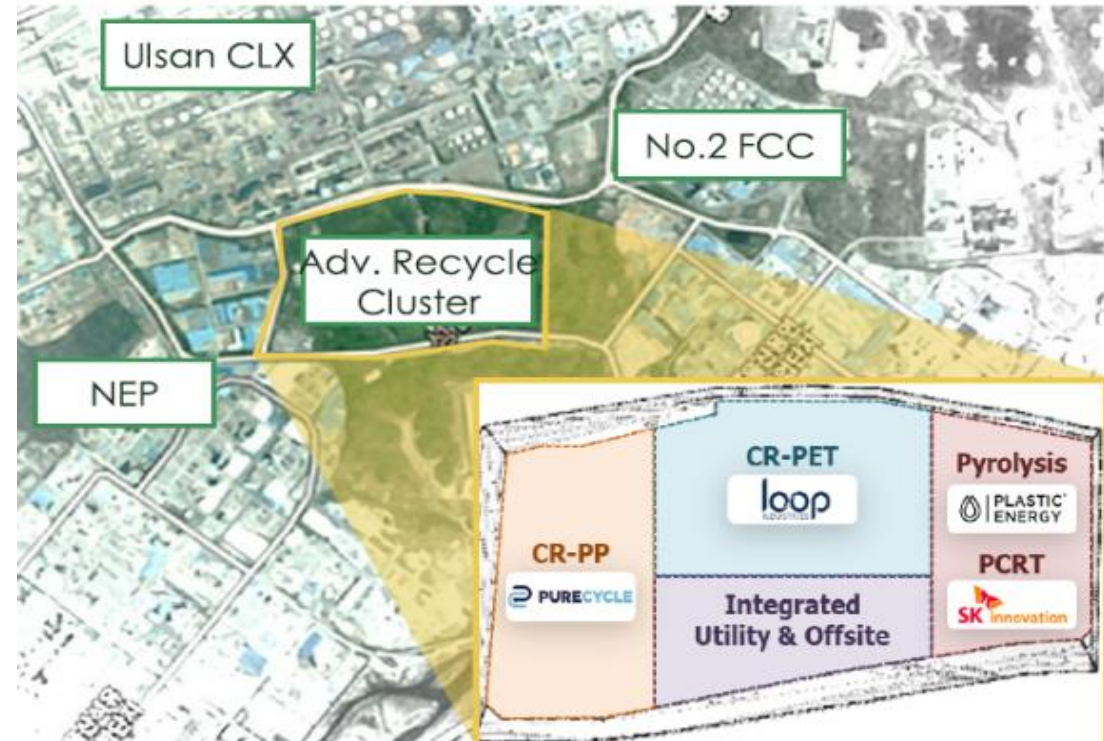
When mechanical recycling is not enough

❑ Advanced recycling

- Emerging solution to overcome traditional mechanical recycling when falls short.
- Provide a more sustainable approach to waste management.
- Can produce higher-quality recycled materials, (i.e. FDA approve).
- Achieving circular economy goals.

❑ Advanced Recycle Cluster, Ulsan, Korea

- Site area: 215,000m²,
- Capacity: ~250Ktons/year of waste plastics,
- Investment: 1.1 billions euros.
- Starting in Korea and moving to EU & US.
- SK to operate with three key advanced recycling technologies:
 - Ultra-Pure Recycled Polypropylene (PP) extraction,
 - Polyethylene Terephthalate (PET) Depolymerization,
 - **Pyrolysis and Post-treatment.**



 **PURECYCLE**

 **PLASTIC ENERGY**

 **SK innovation**

 **loop INDUSTRIES**

**Solvent
Extraction**

Depolymerization



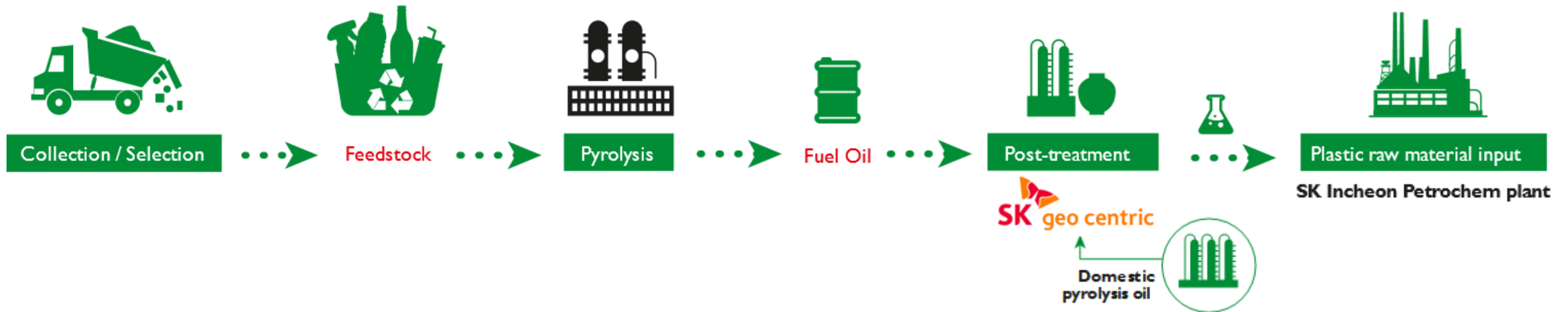
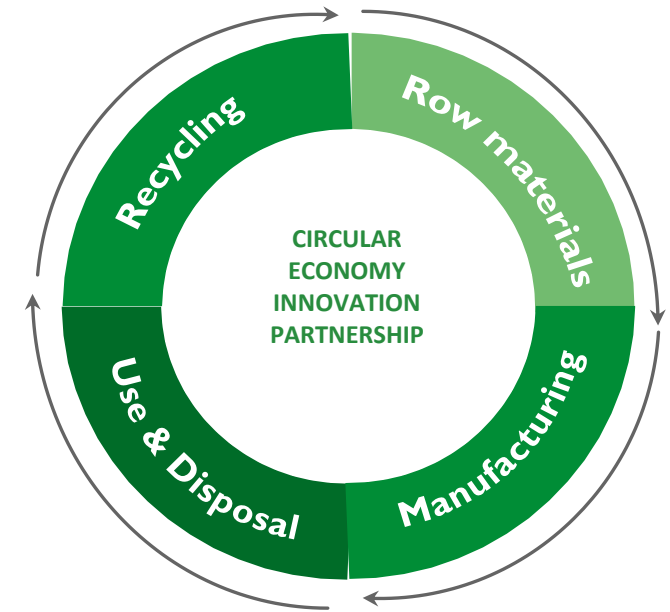
Advanced Recycling Cluster

Advanced recycling

Advanced Recycle Cluster (ARC)

Pyrolysis technology

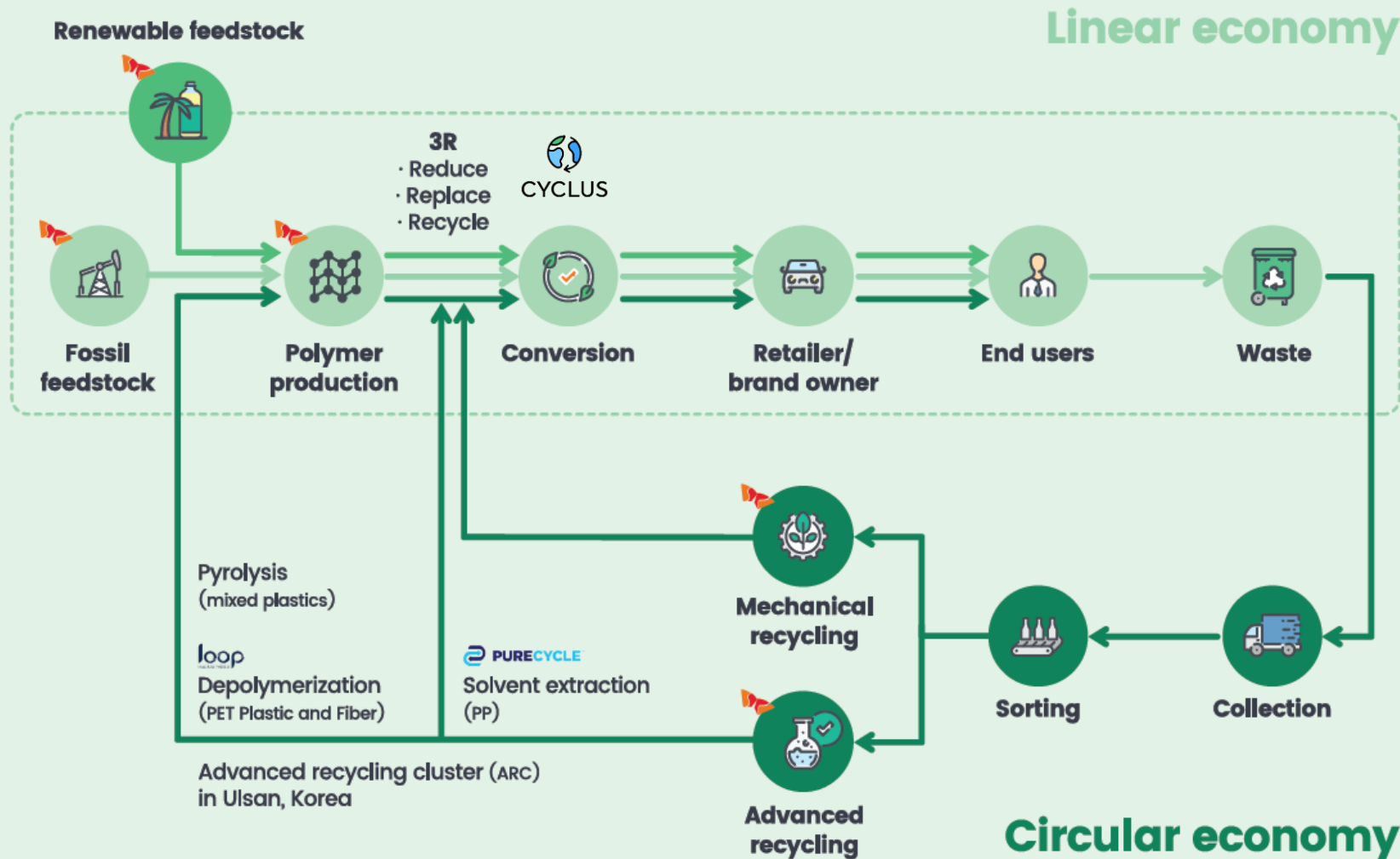
- To start in 2025 with a capacity of 100.000 MT/y.
- Recycle waste plastic and convert them into virgin plastics.
- Greenhouse gases reduction and builds a virtuous cycle of plastics.
- Korea government supporting collection material.



SK Geo Centric

The Unique & Exceptional Green Product Business Model

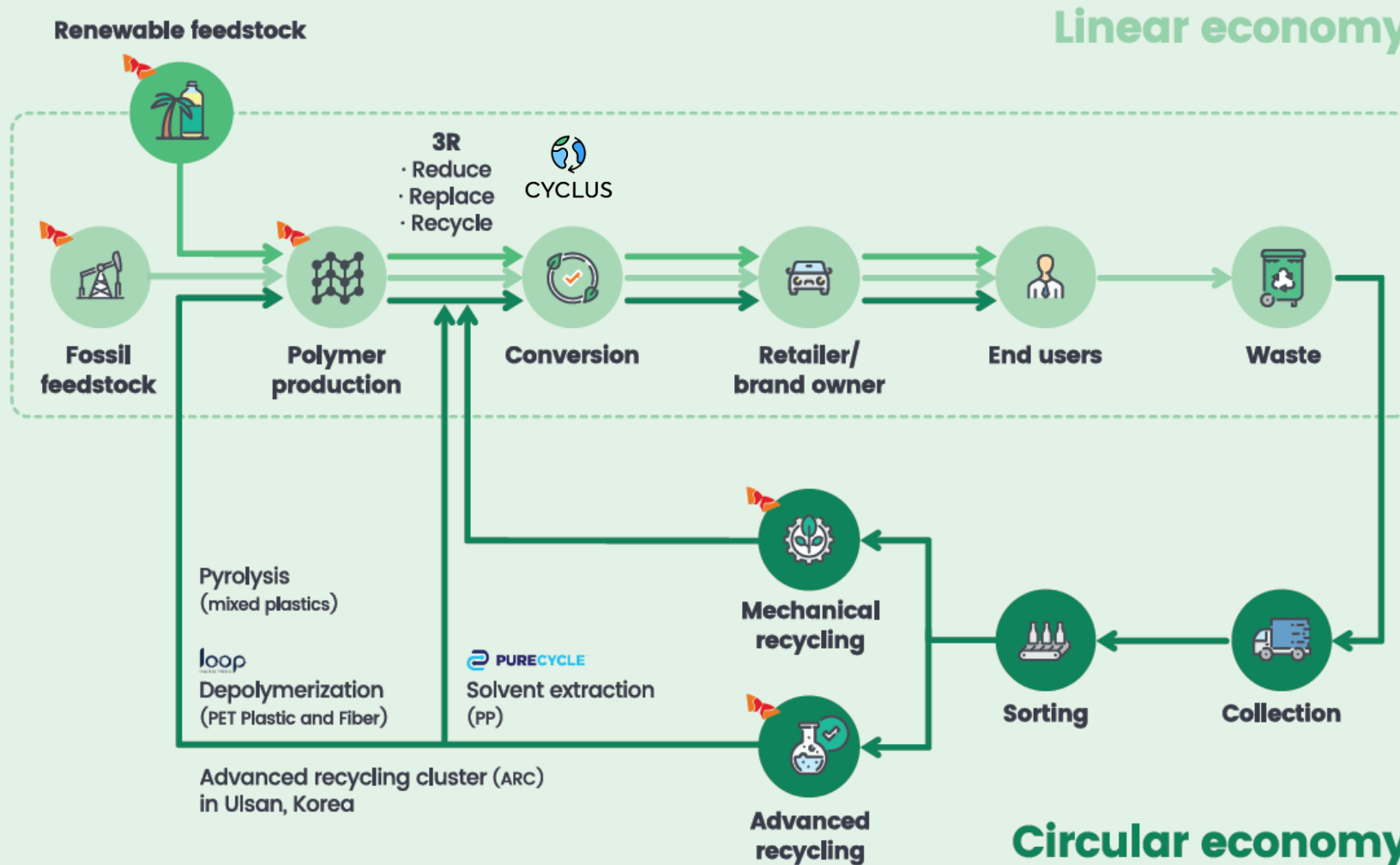
Is there any other way to reduce plastic in packaging?



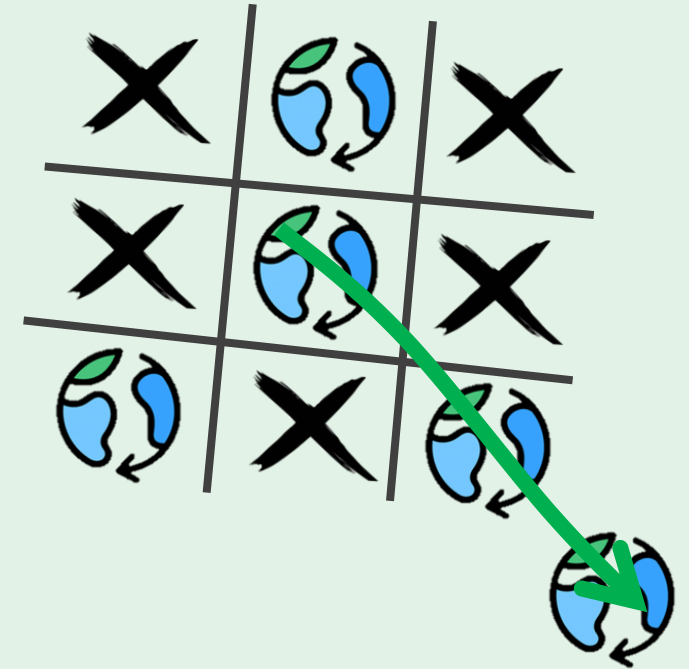
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The Unique & Exceptional Green Product Business Model

Is there any other way to reduce plastic in packaging?



Thinking Outside
The Box

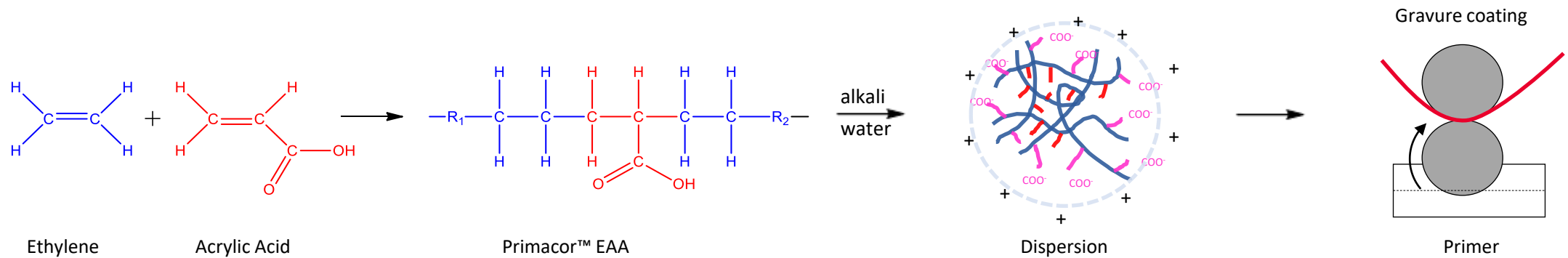


Primacor™ EAA Ethylene Acrylic Acid

Emulsions and Dispersions for Multilayer Paper Packaging

What is it a Primacor™?

- Random ethylene acrylic acid (EAA) copolymer produced by free radical copolymerization in a high-pressure process.
- Designed for high demanding performance sealants and adhesive applications (i.e. tie layers).



Thinking Outside The Box



- Possibility to make thinner coating layer (<5um).
 - Downgauging,
 - Solvent free,
 - Allow paper recycling.
- Formulations for grease, water, and other barrier performance.
- PFAS-free, BPA-free solution.



Primacor™ EAA Ethylene Acrylic Acid

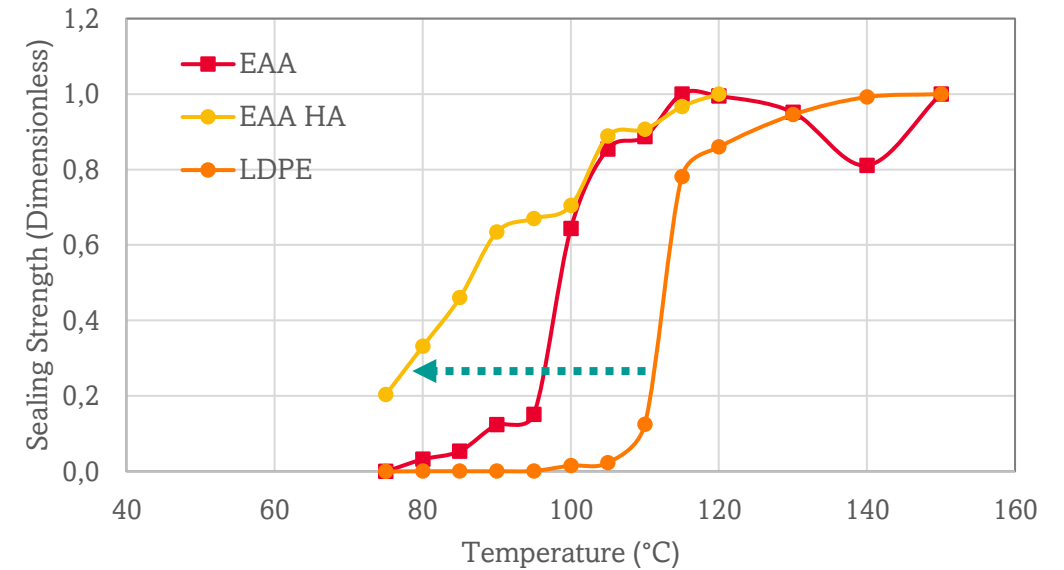
Emulsions and Dispersions

□ Primacor™ EAA 5980I

	Coating Thickness (μm)	Dry mass	Wet mass	Wet-Dry mass	Cobb (g/m ²)
No coating (Paper cup without coating)	0	3.50	4.22	0.77	77
Commercially available paper cup (PE Coated)	20	4.20	4.22	0.02	2
Primacor™ 5980I coated cups	5-10	3.76	3.77	0.01	1

*90°C water for 10minutes.

Heat Sealing Strength & Initiation Temperature



□ Compared to conventional resins, Primacor 5980I presents:

- Good water barrier,
- Lower initiation temperature for heat sealing,
- Good heat sealing strength.

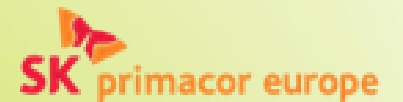
Conclusions

Closing Holistic/Agnostic approach to sustainability

- ✓ *SK geo centric* presented different working recycling methodologies solutions *to improve sustainability*.
- ✓ *Downgauging and Ecodesign* solutions to improve recyclability and sustainability like making a full monomaterial packaging by using *Yuzex™ 8300*.
- ✓ *Mechanical Recycling* reuse material for second life uses like the compatibilizers like *Lotader® 4210 & Orevac® 18341*.
- ✓ *Advanced Recycling* to recycle materials like *PET to rPET* which is *FDA approved*.
- ✓ Advanced Recycle Cluster (*ARC*) in Ulsan is the unique and revolutionary developed site where all existing and *novel recycling activities* are *working in synergy*.
- ✓ *ARC* is *supported by Korean government* for collecting plastics.
- ✓ *ARC* is being already expanded *in EU & US*.
- ✓ *Primacor™ 5980I high acid* is suitable for *emulsions and dispersions* for *multilayer paper packaging*.

SK geo centric have a dream for GREEN: to become the global #1 recycling company

Thank you!



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