



## 21st Century EVOH recycling study



*kuraray*

# 2013 Recycling study

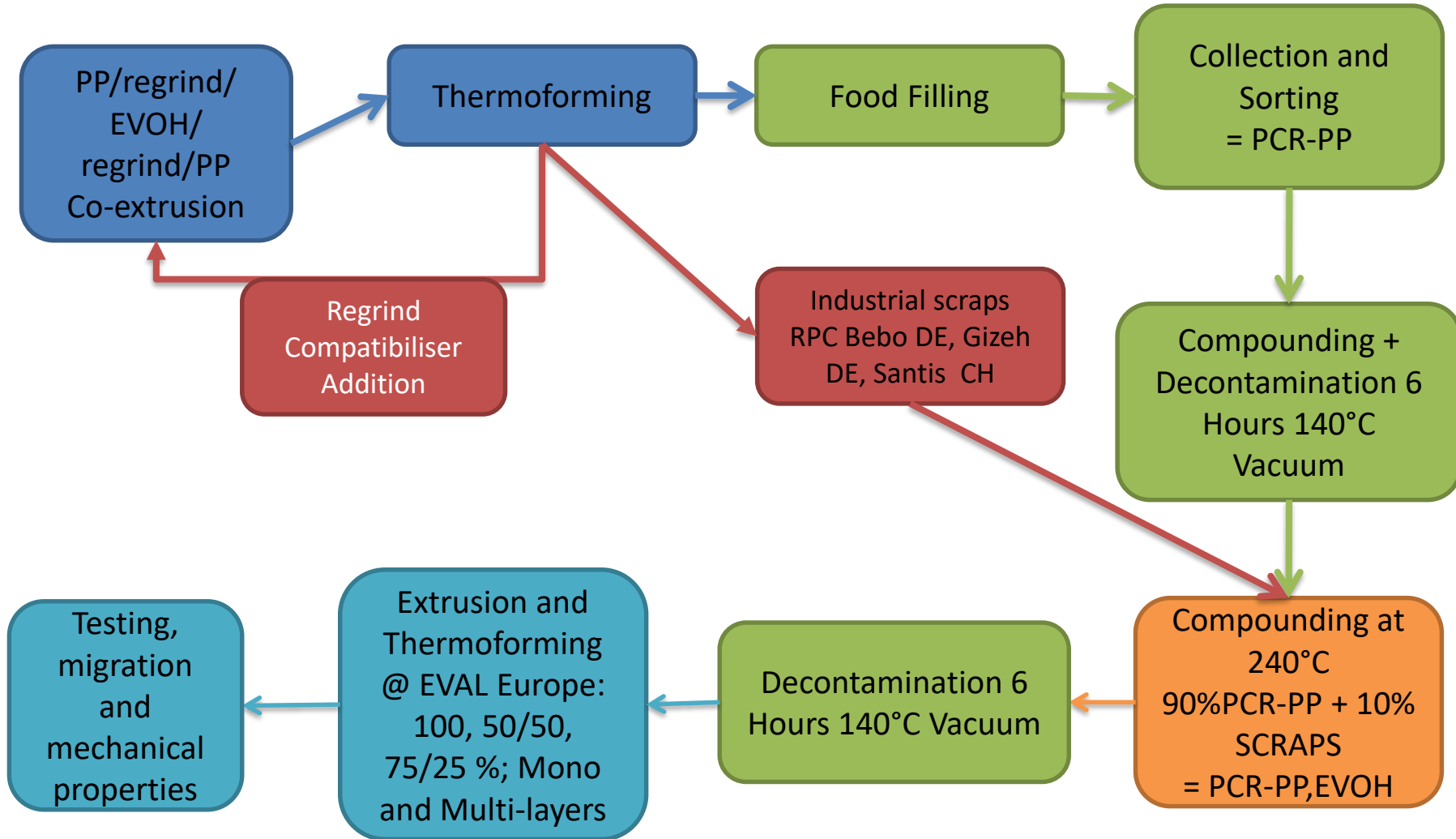


In cooperation with Nextek, [www.nextek.org](http://www.nextek.org)

- Nextek is a recognised consulting organisation in the field of recycling
- PP/EVOH/PP and HDPE/EVOH/HDPE recycling study on multilayer sheet and bottles was conducted
- First, Focus on PCR-PP\* processing and thermoforming using up-to-date recycle stream
  - Description of the Process
  - Performance
  - Analysis
  - Summary
- Next, Multilayer HDPE/EVOH Packaging influence in Processing and Performance of Recycled HDPE for blow moulded articles was studied

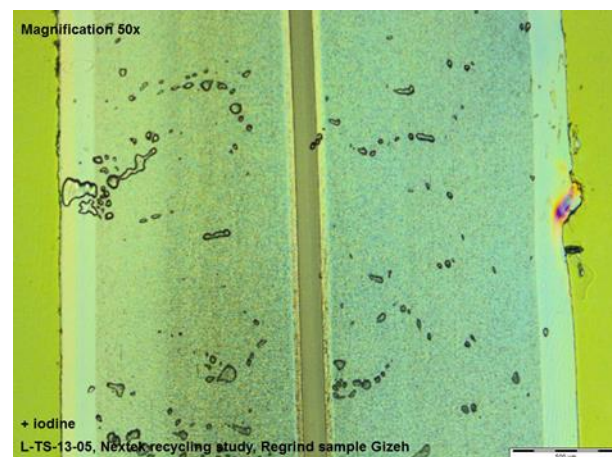
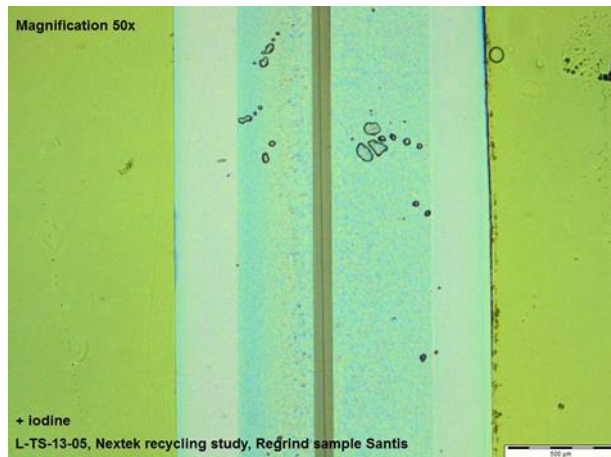
\* PCR = Post-Consumer Recycled

# Recycling Study Stream



# Industrial Scrap

## Analysis of multilayer PP/EVOH/PP sheet with 4 to 6% EVOH



Structure	(out) PP	Regrind	Adhesive	EVOH	Adhesive	Regrind	PP	TOTAL	
Thickness (μm)	287	326	36	82.8	33	442	282	1489	5.5%
Thickness (μm)	168	930	33	107.6	33	985	166	2423	4.5%
Thickness (μm)	491	668	47	125.0	44	717	419	2511	5.0%





DUALES SYSTEM HOLDING

# Collection and Sorting

Thanks to the cooperation of Systech Company

- [www.gruener-punkt.de](http://www.gruener-punkt.de)
- [www.systech-plastics.de](http://www.systech-plastics.de)
- **Observation:**
  - In the region of Germany studied, about **2% of plastic waste** is barrier packaging.
  - In these 2% barrier packaging:
    - 90% is for meat packaging
    - The remaining 10% is pâté, ready meals, cheese and fish salad



# Collection and Sorting

## MARKET APPLICATIONS AND PERCENTAGE OF EVOH IN RECYCLING STREAMS:

- An assessment was made by Nextek based on available market data and material audits to establish a typical and maximum percentage of HDPE barrier packaging in the market.
- Manual sorting bale audit at Viridor Arundel in the UK





# Sorting post-consumer waste

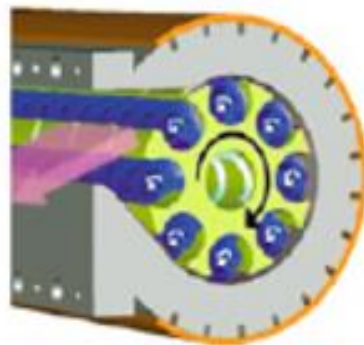
## Different forms of PP/EVOH waste



# Compounding and Decontamination

## PCR-PP and 90%PCR-PP + 10% industrial scrap (PCR-pp,evoh)

- PCR-PP was compounded and pelletised on a multi-screw extruder at 260°C and then decontaminated for 6 hours 145°C vacuum in batch reactor.
- Dry blend of 90%PCR-PP + 10% industrial scrap was then compounded on a twin screw extruder for about 3 minutes at 240°C
- PCR-pp,evoh blend was then decontaminated for 6 Hours at 130 - 140°C using vacuum batch reactor
- Melt index of the PCR-pp,evoh material suitable for sheet extrusion and thermoforming



Controlled time / temp / pressure is used during melt and solid phase to provide **complete decontamination of PCR-PP and highest quality**



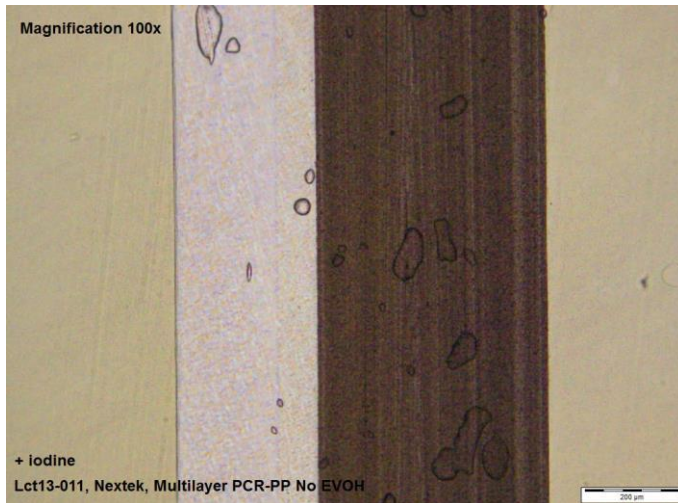
# Coextrusion and Thermoforming

EVAl Europe Technical Centre in Antwerp

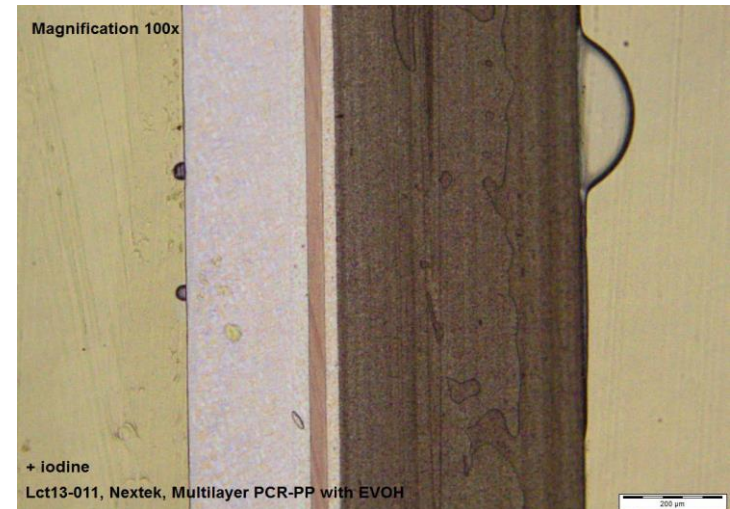


# PCR-PP,EVOH/EVOH thermoforming samples

Multilayer sheet PCR-pp,evoh(25)/PP and PCR-pp,evoh(25)/EVOH/PP



Structure	Virgin PP	Adhesive	25% PCR-PP/EVOH (white)	Total
Thickness (μm)	222	86	479	787



Structure	Virgin PP	Adhesive	EVOH	Adhesive	25% PCR-PP/EVOH (white)	Total
Thickness (μm)	208	37	30.4	29	490	794

# PCR-PP, EVOH thermoforming samples

0.5/1 and 1/1 samples were produced with monolayer sheet

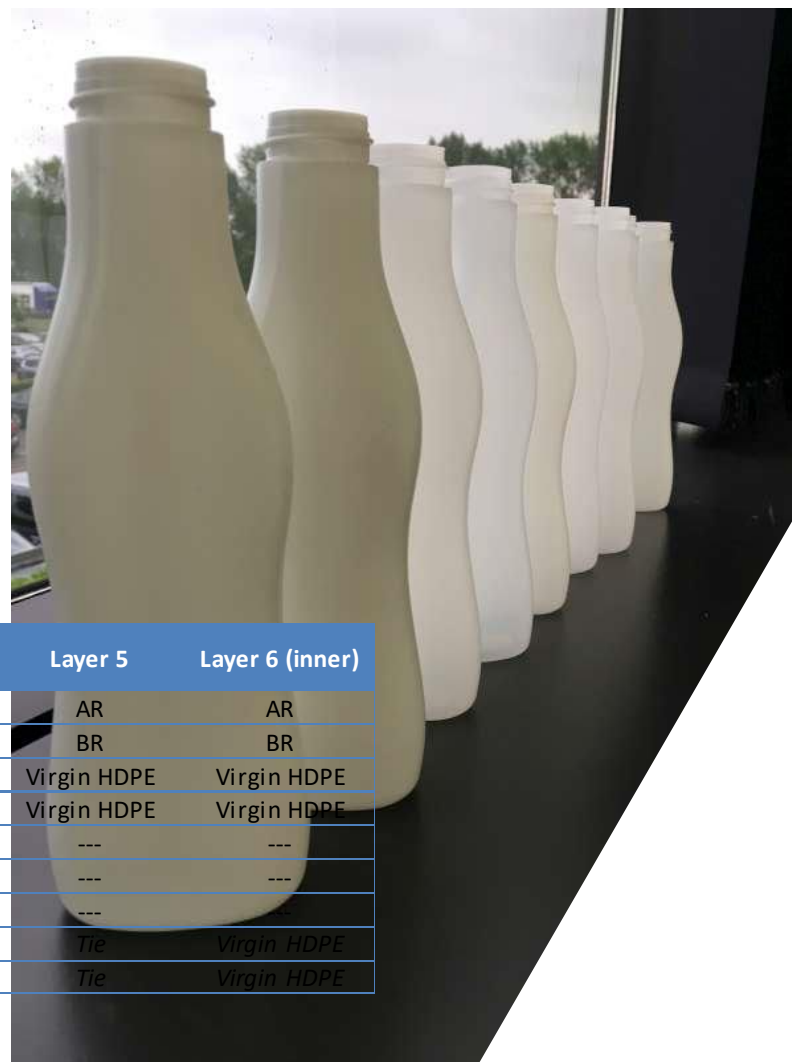
- Nice trays could be produced without issue





# The Bottles

## Co-EBM HDPE/EVOH



trial	Layer 1 (outer)	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6 (inner)
1	AR	AR	AR	AR	AR	AR
2	BR	BR	BR	BR	BR	BR
3	Virgin HDPE	Virgin HDPE	BR	BR	Virgin HDPE	Virgin HDPE
4	Virgin HDPE	Virgin HDPE	AR	AR	Virgin HDPE	Virgin HDPE
5	AR	AR	Tie	EVOH F101B	---	---
6	BR	BR	Tie	EVOH F101B	---	---
7	Virgin HDPE	Virgin HDPE	Tie	EVOH F101B	---	---
8	Virgin HDPE	BR	Tie	EVOH F101B	Tie	Virgin HDPE
9	Virgin HDPE	AR	Tie	EVOH F101B	Tie	Virgin HDPE

AR = Recycled HDPE + ± 0.25% EVOH

BR = Virgin HDPE + ± 0.25%EVOH

# Performance of the samples (I)

## Overall Migration tests conducted at SMITHERS PIRA

- Overall migration, by filling, into simulants iso-octane; exposure conditions 24 hours at 40°C as detailed in EU Regulation No 10/2011.

### PCR-pp,evoh(100) monolayer

Method	EN-1186-14 Migration into Iso-octane mg/dm <sup>2</sup>
Replicates	
1	42.4
2	40.1
3	42.9
<b>Mean result</b>	<b>41.8</b>
<b>Limit</b>	<b>#40.0</b>
<b>Tolerance</b>	<b>#*1.2</b>

### PCR-pp,evoh(25)/PP

Method	EN 1186-15 Migration into Iso-octane (rapid extraction) mg/dm <sup>2</sup>
Replicates	
1	8.8
2	10.9
3	9.9
4	10.1
<b>Mean result</b>	<b>9.9</b>
<b>Limit</b>	<b>10.0</b>

### PCR-pp,evoh(25)/EVOH/PP

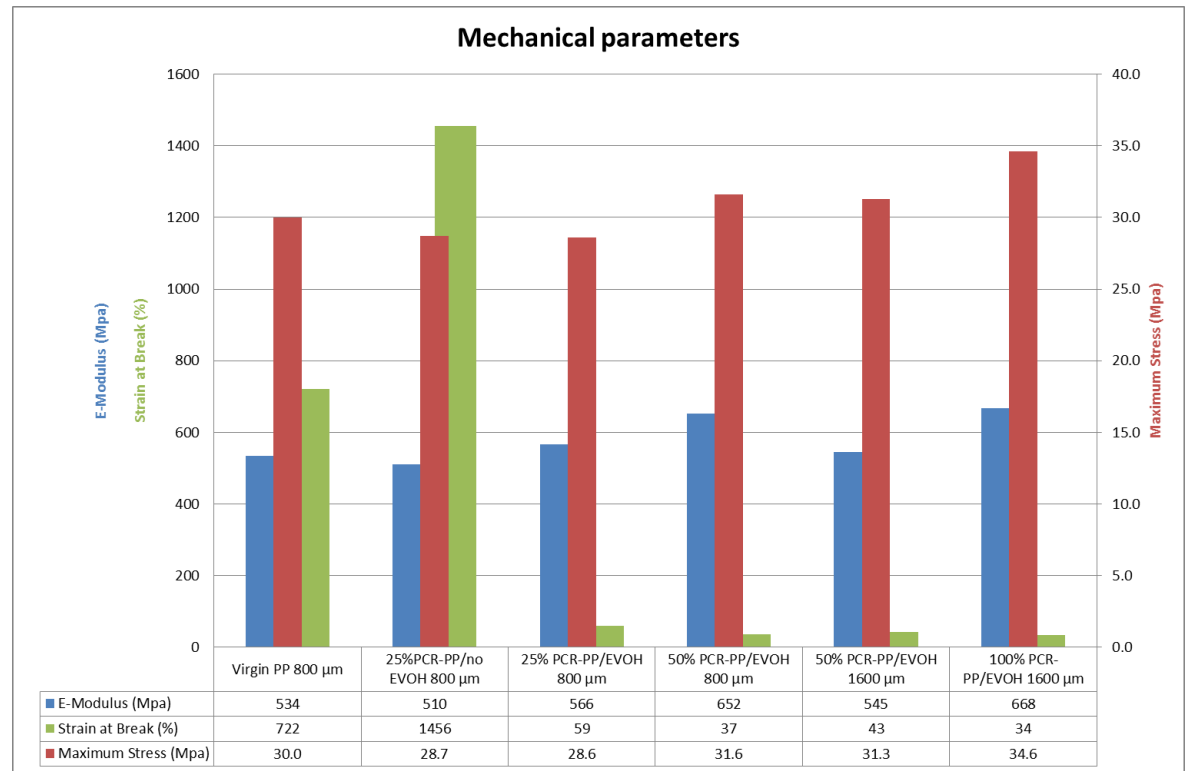
Method	EN 1186-15 Migration into Iso-octane (rapid extraction) mg/dm <sup>2</sup>
Replicates	
1	4.8
2	4.9
3	6.5
4	3.9
<b>Mean result</b>	<b>5.0</b>
<b>Limit</b>	<b>10.0</b>

- The samples are all OK for packaging food according to EU regulation 10/2011,
- EVOH provides efficient way to reduce Overall migration as functional barrier

# Performance of the samples (II)

## Mechanical properties of PCR-PP,EVOH with PCR-PP

- Notched Izod Impact strength of Injection moulded PCR-PP,EVOH(25) and PCR-PP pieces were determined; No difference observed (8 KJ/m<sup>2</sup>)
- Tensile test on 15mm wide strips cut out from the sheet (MD) was conducted. E-Modulus, Strain at Break and Maximum stress were determined.
- No difference with various loading PCR-pp,evoh in monolayer.





# Summary Recycling Study

## EVOH impact on the Performance of Recycled PP and HDPE

- The use of **EVOH** in **multi-layer barrier packaging** for long-time food preservation does not affect the recycling possibilities or opportunities
- It has now been demonstrated that:
  - **EVOH does not affect the recycling stream of PP and HDPE** (polypropylene)
  - It brings **new opportunities to recycle PCR-PP (or HDPE)** even in the food packaging applications
- Indeed, the use of **EVOH as functional barrier** certainly opens new doors to the plastic industry
- Recycling codes used to identify the material from which an item is made, to facilitate easier recycling or other reprocessing:

- #5 PP is applicable to PP/EVOH
- #2 HDPE is applicable to HDPE/EVOH





## Plantic™ Organic Recovery

# PLANTIC™

## PLANTIC™

- ✓ PLANTIC™ is a fully biodegradable renewable sheet suitable for thermoforming applications (e.g. for packing foods and goods with water activity of 35% to 70%).





# PLANTIC™

## PLANTIC™ CF (PLANTIC™ + BioPBS)

### Compost Certifications

Vincotte Certifications:

- PLANTIC™ mono layer



- BioPBS™



# Conclusion


**Kuraray, with its global presence, supports the circular economy with an advanced product portfolio:**

- EVAL™ EVOH resins and monolayer film, ready to be produced from renewable resources and which allows the production of multilayer structures fully recyclable with no impact on polyolefin recycling streams, independantly from the converting technologies  
→ Recycling Stream value chain
- PLANTIC™ CF films, Bio-sourced, Bio-Plastic, Bio-degradable and barrier film for advance packaging solutions  
→ Organic Waste value Chain
- Even more performant materials enabling downgauging, keeping efficiency for use, are being developed.

EVAL™ and PLANTIC™ for now and the future

# Thank You

*Special thanks to our partner Nextek (Edward Kosior , Kelvin Davies and Jonathan Mitchell) and to our EVAL Technical Centre colleagues in Antwerp*

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