



**21st Century EVOH recycling study**



***kuraray***

# 2013 Recycling study

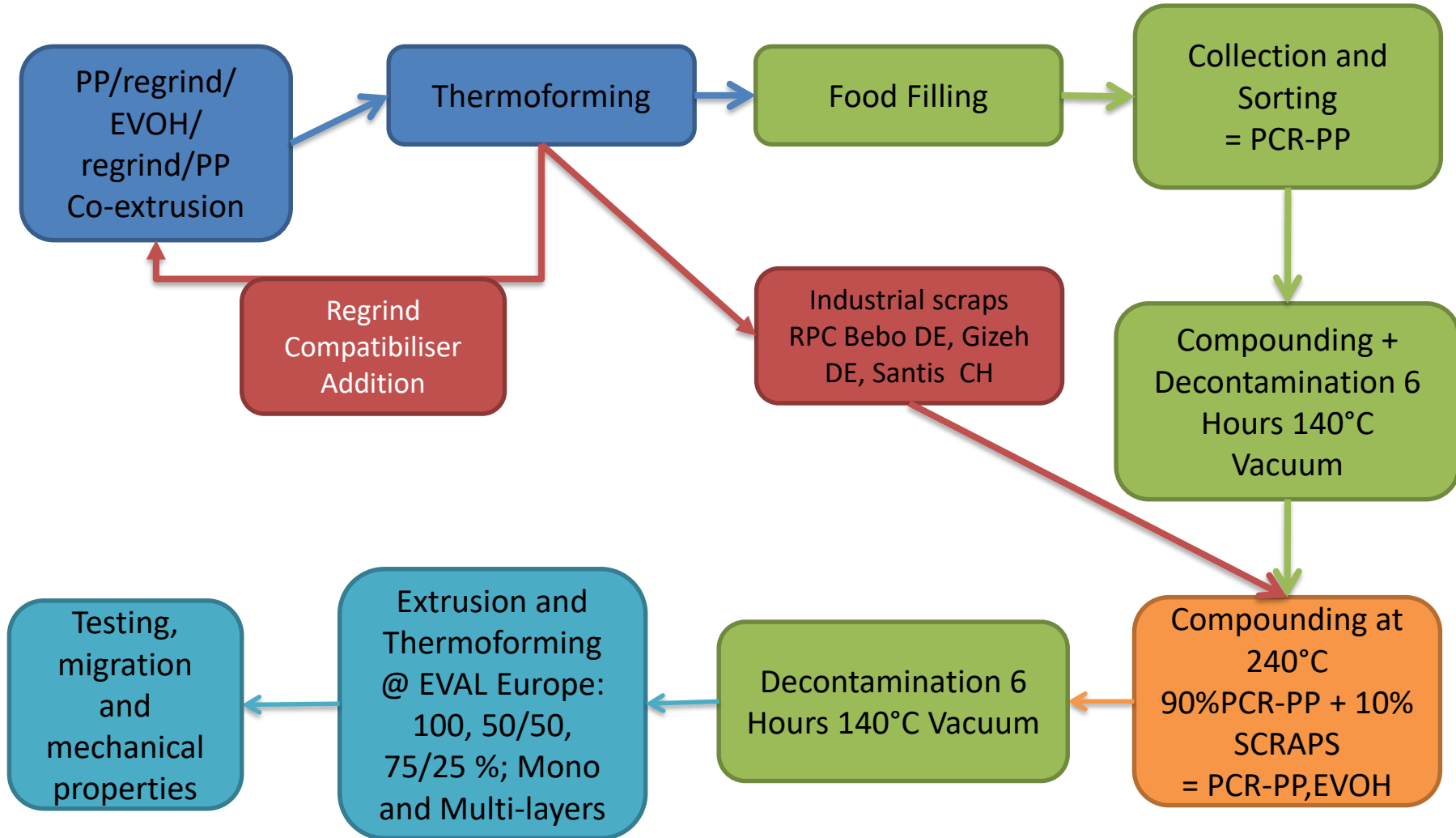


In cooperation with Nextek, [www.nextek.org](http://www.nextek.org)

- 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

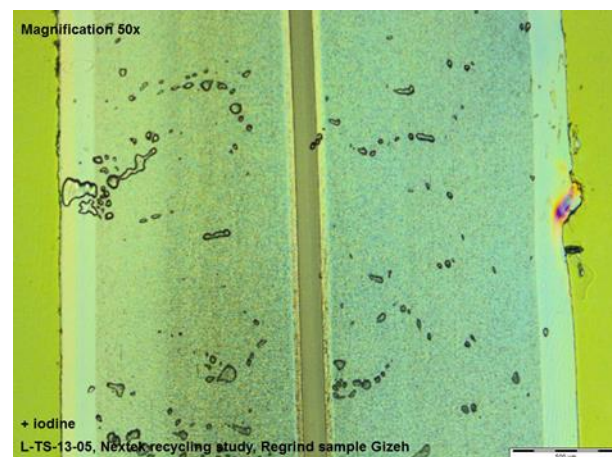
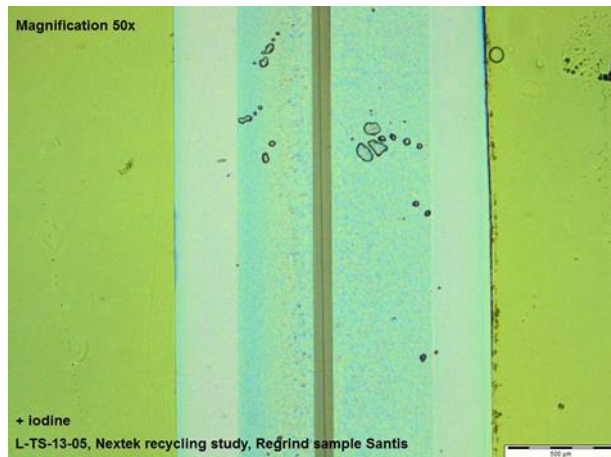
\* PCR = Post-Consumer Recycled

# 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

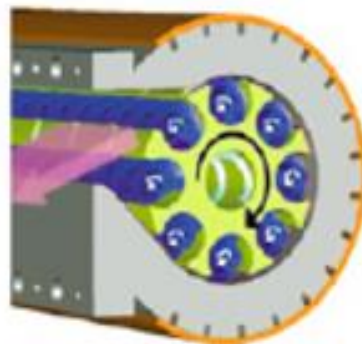
## Different forms of PP/EVOH waste



# 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**



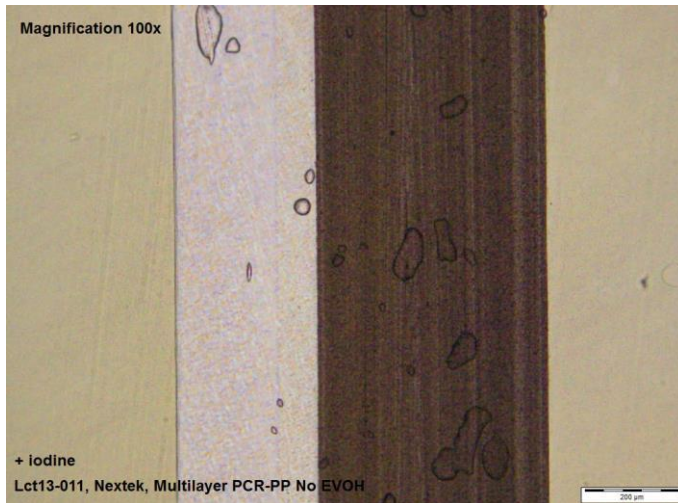
# Coextrusion and Thermoforming

EVAL Europe Technical Centre in Antwerp

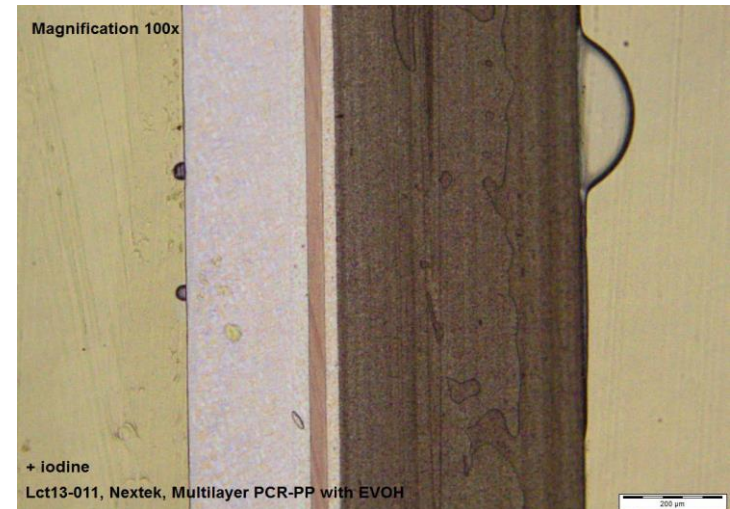


# PCR-PP,EVOH/EVOH thermoforming samples

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

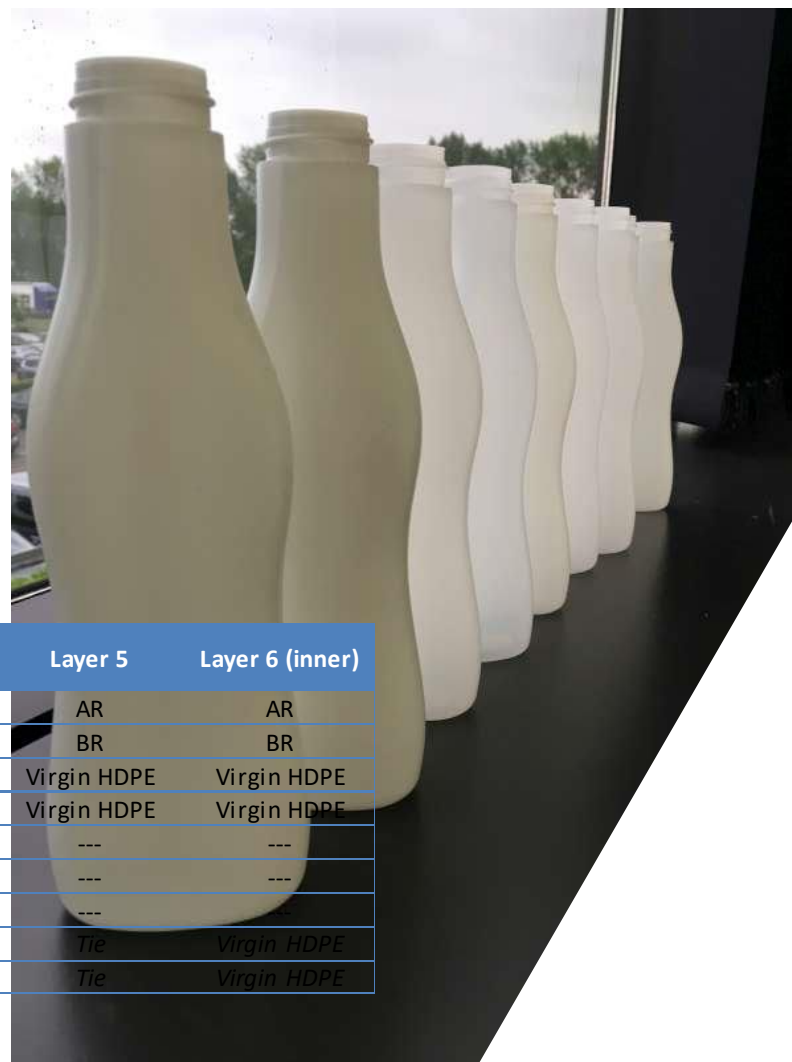
0.5/1 and 1/1 samples were produced with monolayer sheet

- 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

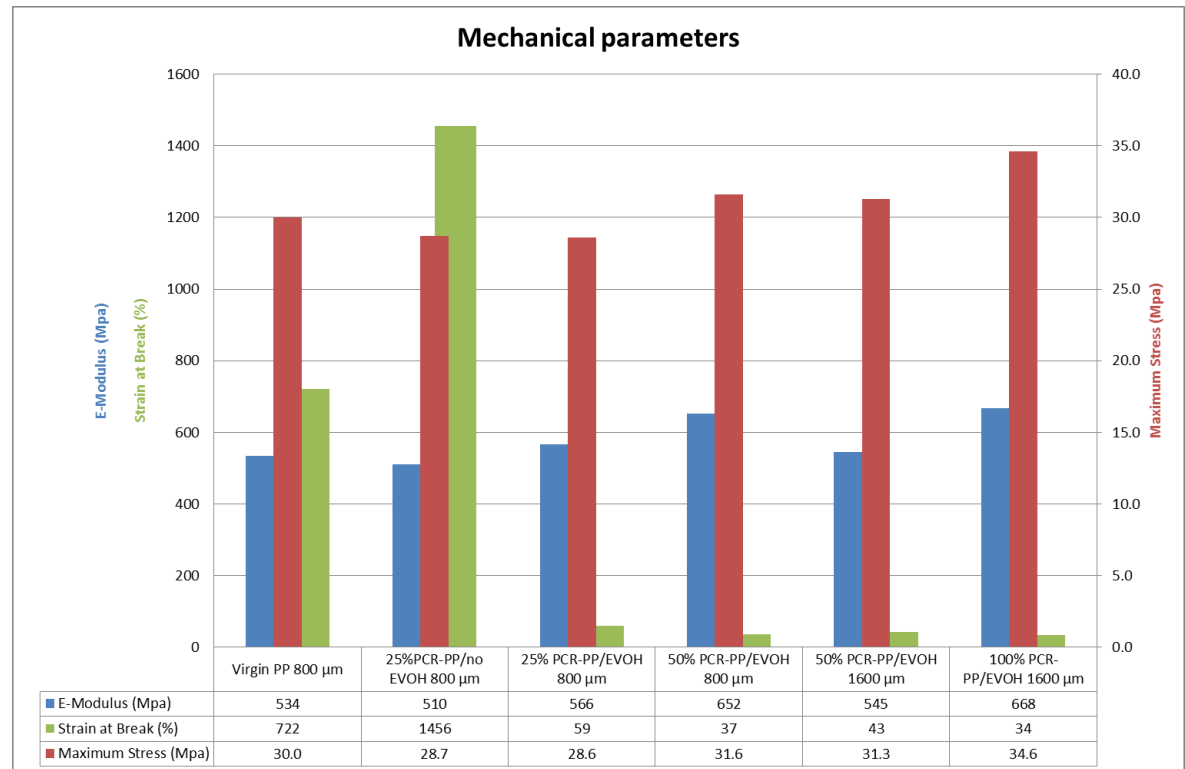
Method	EN 1186-15 Migration into Iso-octane (rapid extraction) mg/dm <sup>2</sup>
Replicates	
1	4.8
2	4.9
3	6.5
4	3.9
<b>Mean result</b>	<b>5.0</b>
<b>Limit</b>	<b>10.0</b>

- 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

