

# Strategie chimiche per la circolarità di adesivi poliuretanici per l'industria del legno

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31/03/2026

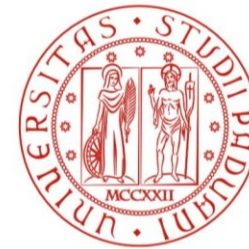
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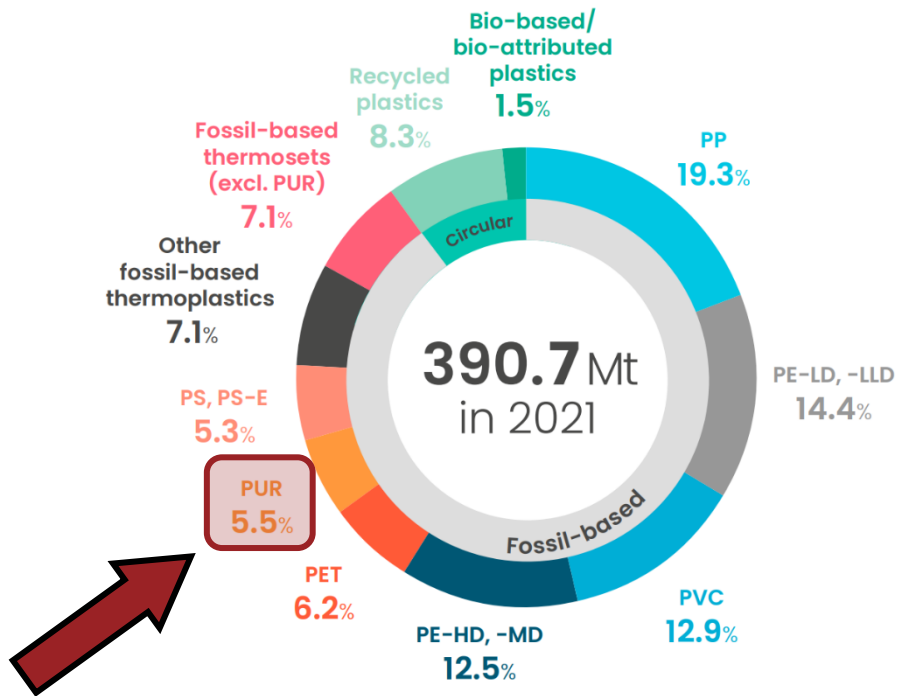
Dott. Stefano Romagnano  
Dott. Giacomo Del Bianco

Prof. Michele Modesti  
Dott. Alex Covassin  
Dott. Riccardo Donadini

# Soudal group







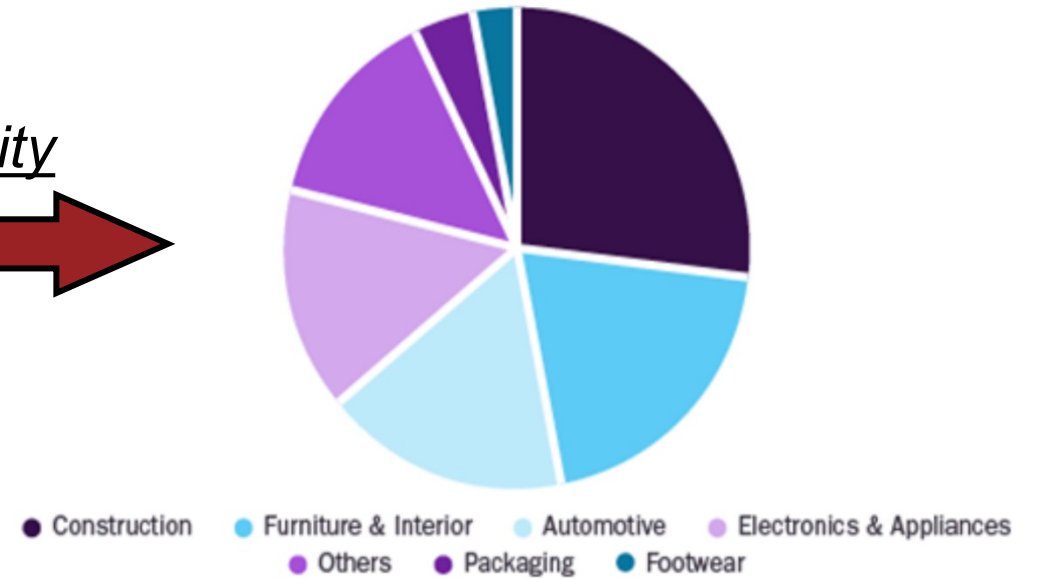
Sources: Conversio Market & Strategy GmbH and nova-Institute

PU high versatility



## Global Polyurethane Market

Share, by End-use, 2022 (%)



Source: Grand View Research

# Transition from a linear to a circular economy model

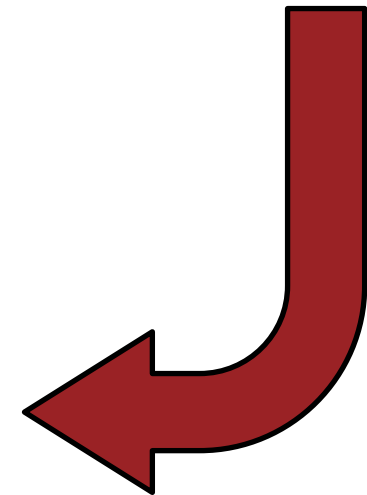
Raw  
materials

Product

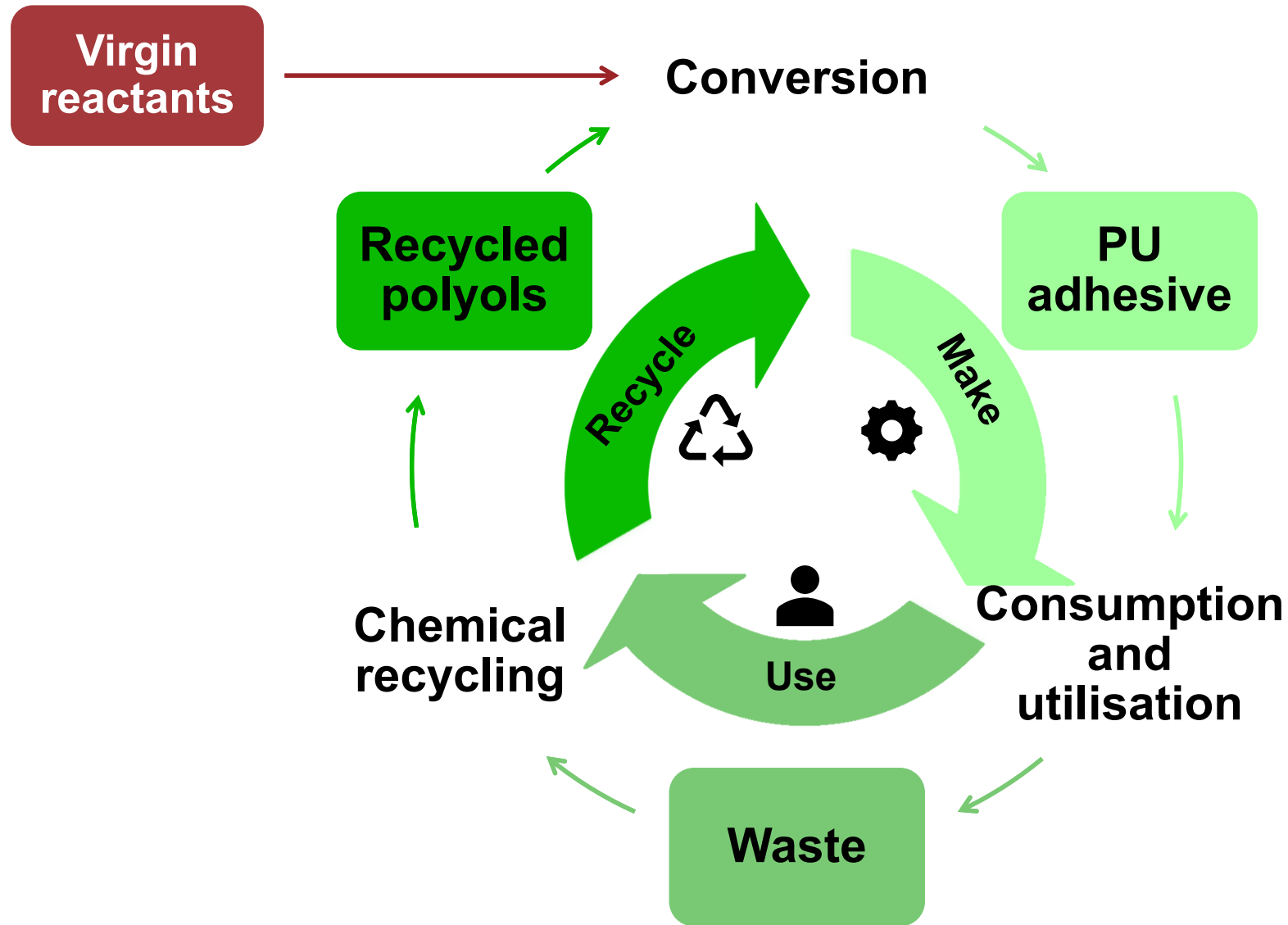
Utilisation

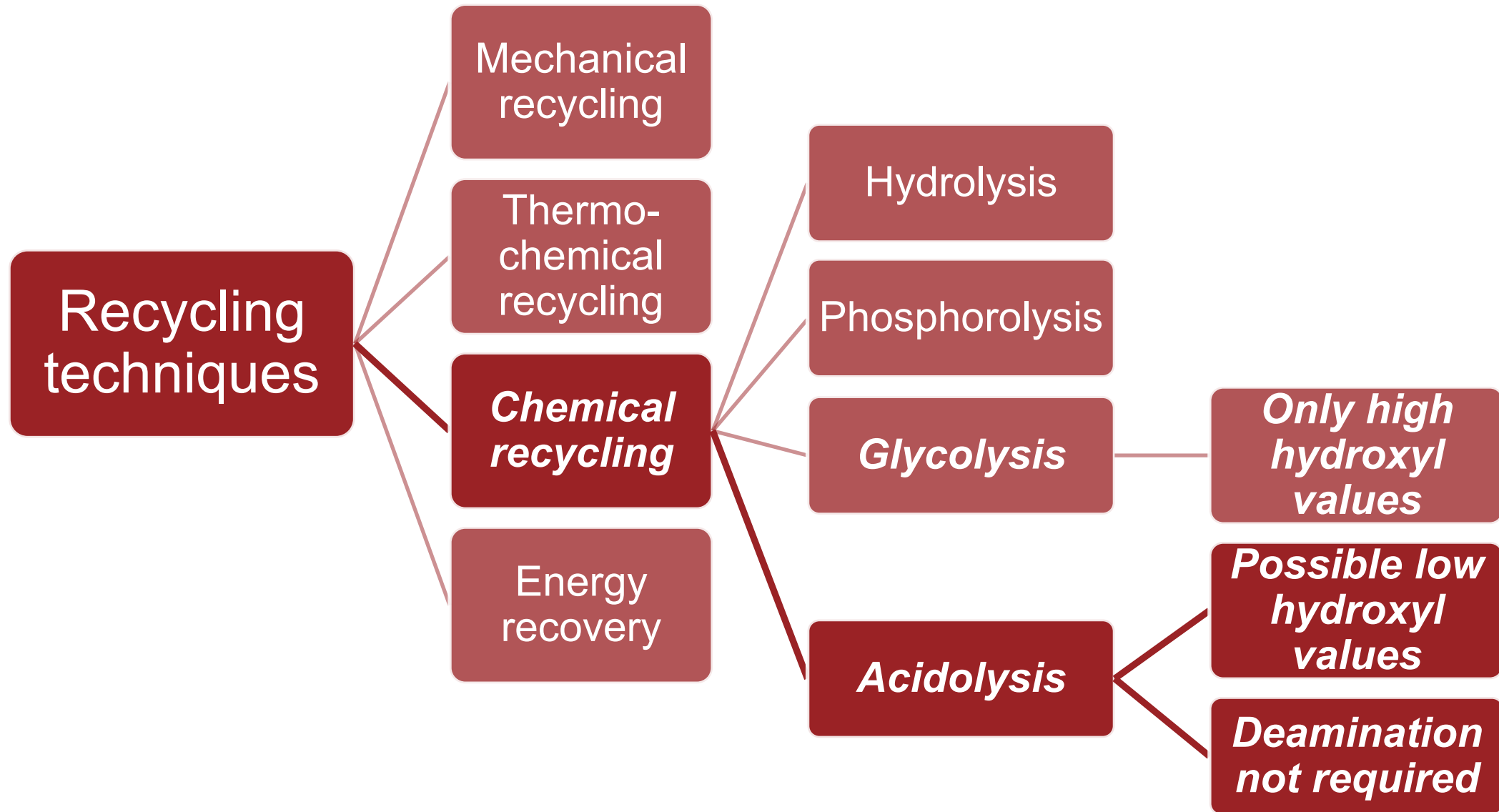
Waste

Landfill

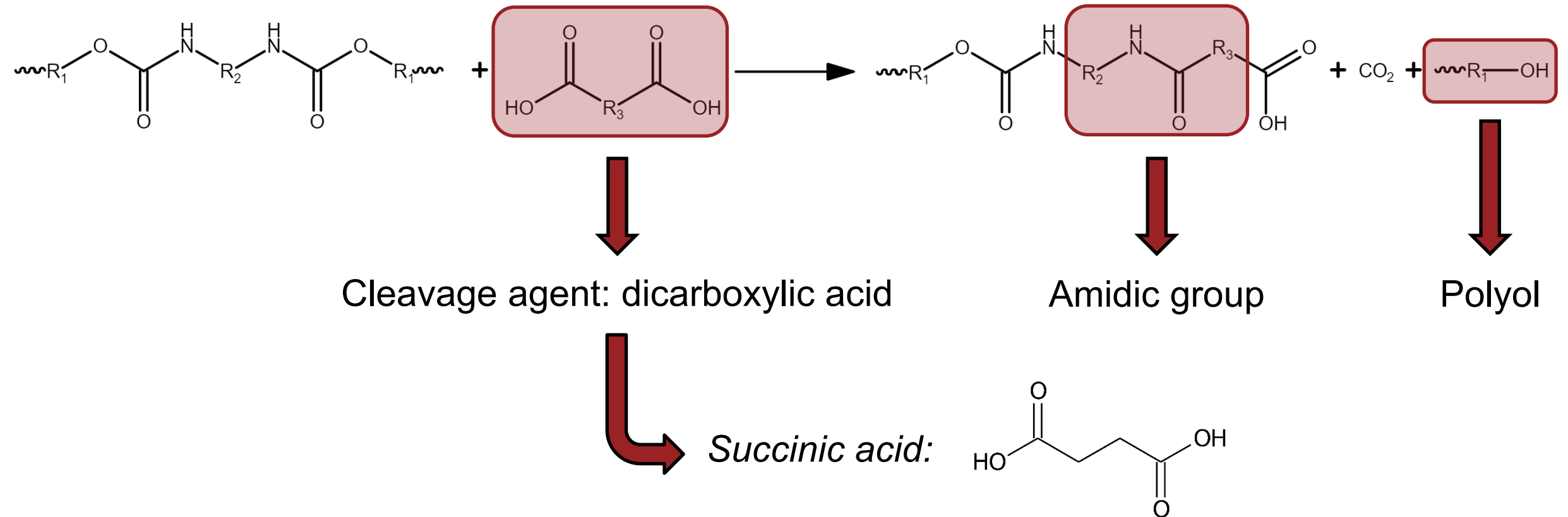


# Transition from a linear to a circular economy model





## Acidolysis reaction

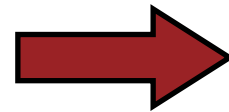


Initial experimental  
campaign

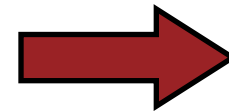
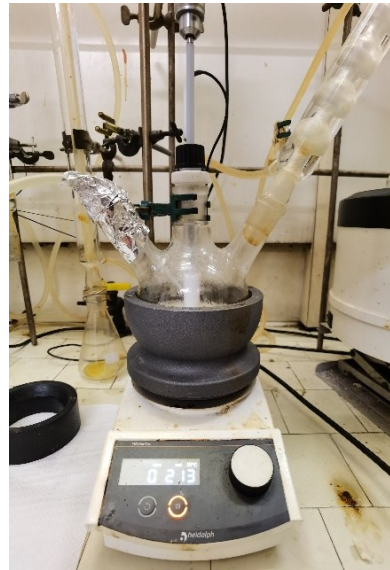


Design of Experiment (DoE)

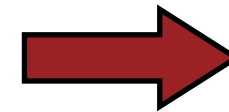
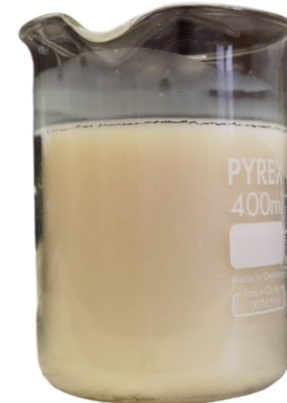
*PU adhesive scraps*



Acidolysis



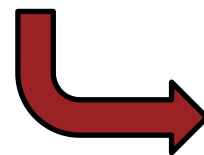
*Recycled polyol  
blend*



New PU  
adhesive



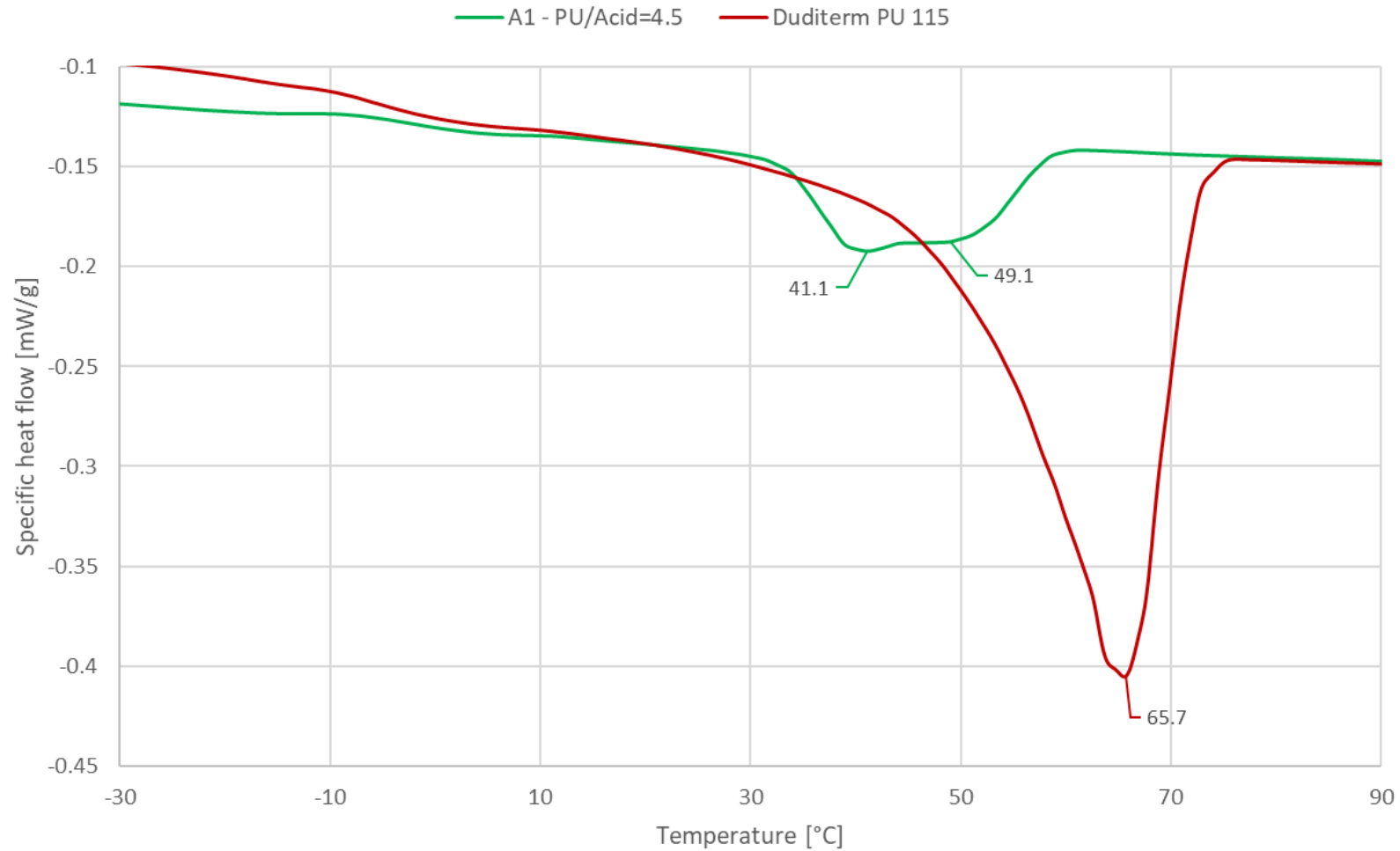
Duditerm PU 115 and 127/5



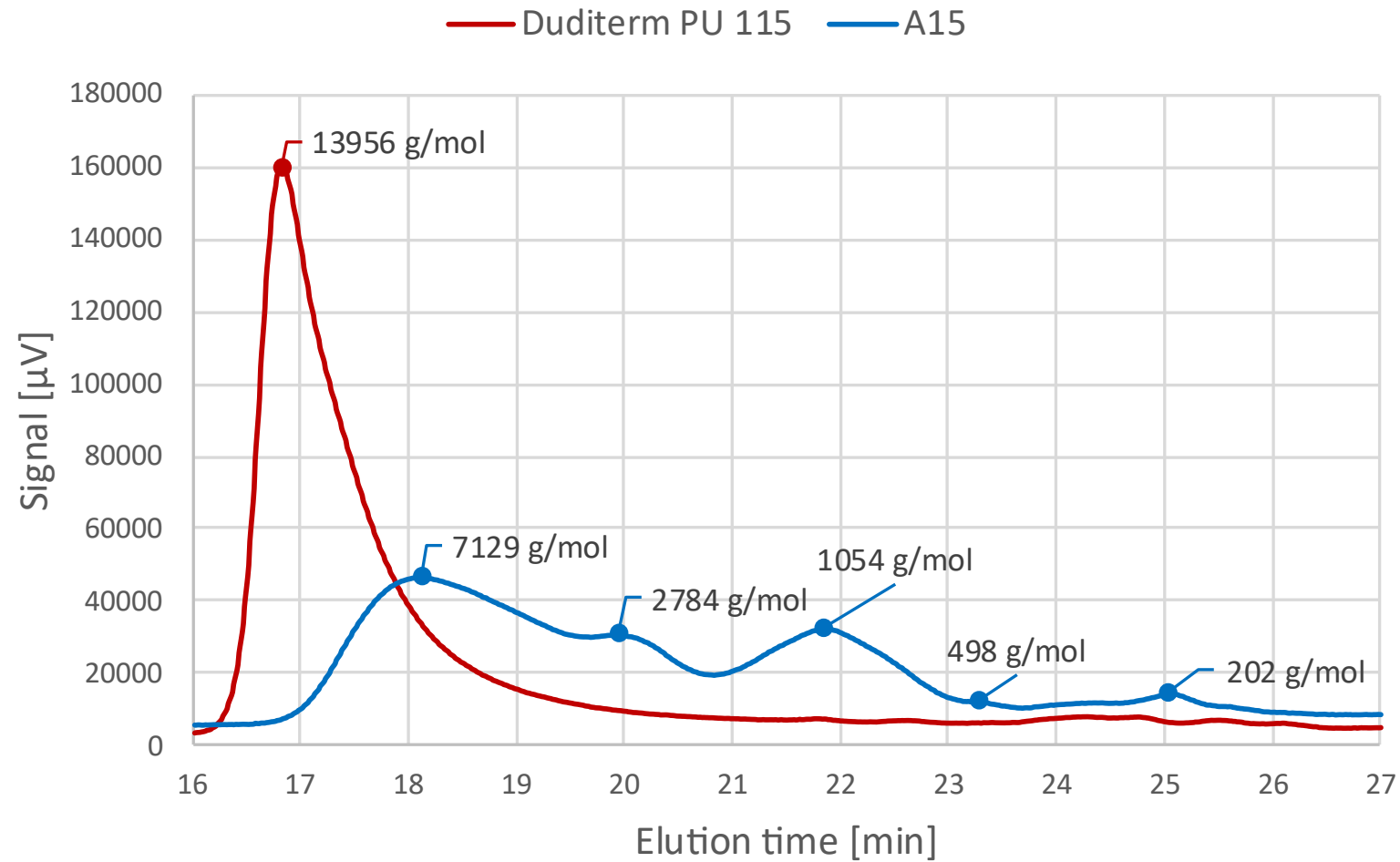
**Objectives:**

- MDA < 1000 ppm;
- $AV < 2 \frac{\text{mgKOH}}{\text{g}_{\text{sample}}}$
- HV within 30 – 45  $\frac{\text{mgKOH}}{\text{g}_{\text{sample}}}$

# Initial set of experiments



# Initial set of experiments



Design of Experiment →

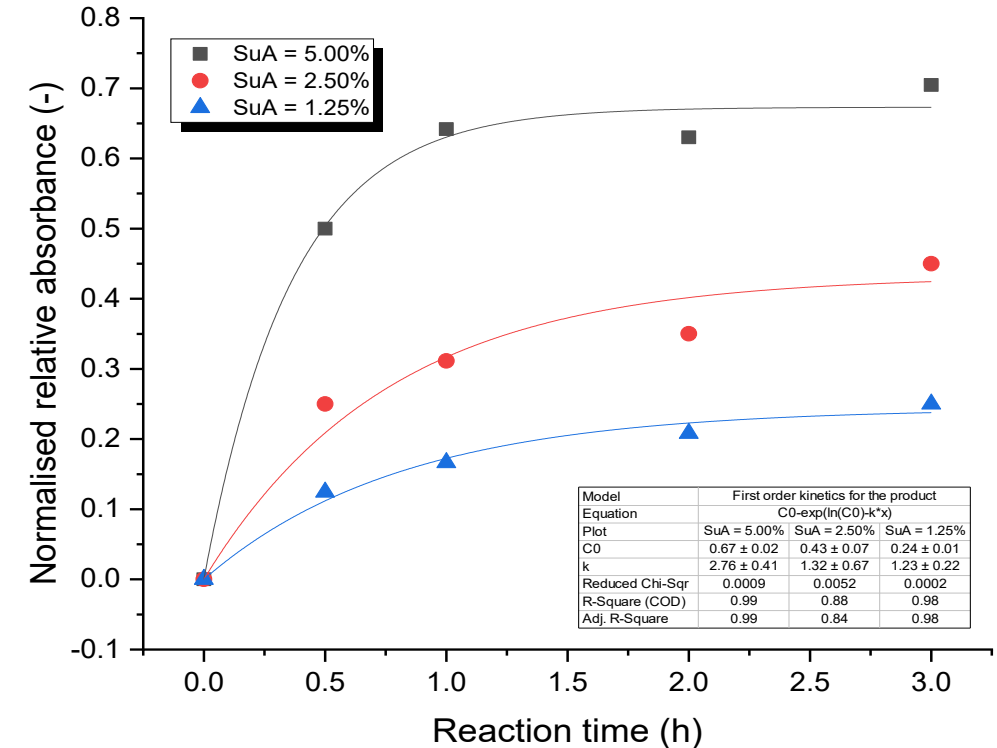
{ Optimal acidolysis reaction conditions  
Effects of the factors on the KPIs

DoE

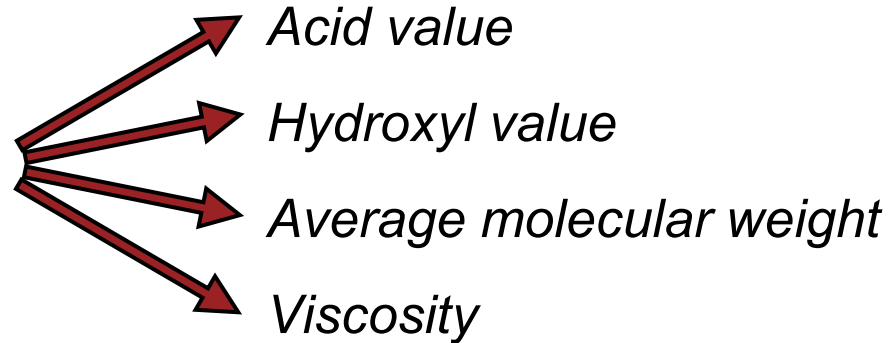
Fixed reaction time

3 investigated factors

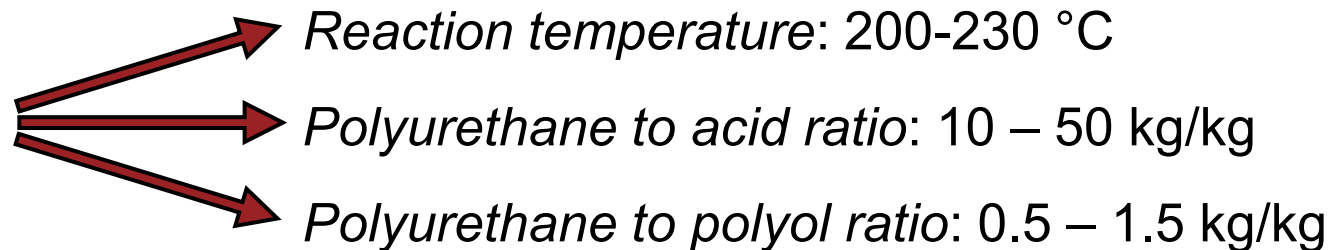
4 key performance indicators (KPIs)



**DoE key performance indicators (KPIs)**



**DoE investigated factors**



## Molecular weight

Factor	Coefficient
Intercept	4197
A	-160
B	480
C	599
B <sup>2</sup>	-348
C <sup>2</sup>	-130

## Viscosity

Factor	Coefficient
Intercept	+27
A	-1.5
B	+5.3
C	+15
AC	-1.3
BC	+3.5
B <sup>2</sup>	-1.6
C <sup>2</sup>	+1.1

## Acid value

Factor	Coefficient
Intercept	+2.0
A	-0.62
B	-1.8
C	+0.52
AB	+0.69
BC	-0.55
B <sup>2</sup>	+1.0

## Hydroxyl value

Factor	Coefficient
Intercept	+43
A	+1.6
C	-6.5

**A:** Reaction temperature

**B:** Polyurethane to acid mass ratio

**C:** Polyurethane to polyol mass ratio

## Optimal acidolysis operative conditions

(employed for both the PU scraps tested)

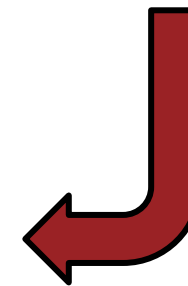
Temperature	→	220 °C
PU/Acid ratio	→	50 kg/kg
PU/Polyol ratio	→	1 kg/kg



## Recycled polyol properties

Acid value	→	1.28 mg <sub>KOH</sub> /g <sub>sample</sub>
Hydroxyl value	→	43.3 mg <sub>KOH</sub> /g <sub>sample</sub>
Molecular weight	→	4382 g/mol
Viscosity	→	745 mPa·s
MDA content	→	< 25 ppm

Used for new adhesives synthesis



Duditerm PU 127/5 → Adhesive for edge bonding



Duditerm PU 115 → Adhesive for wrapping

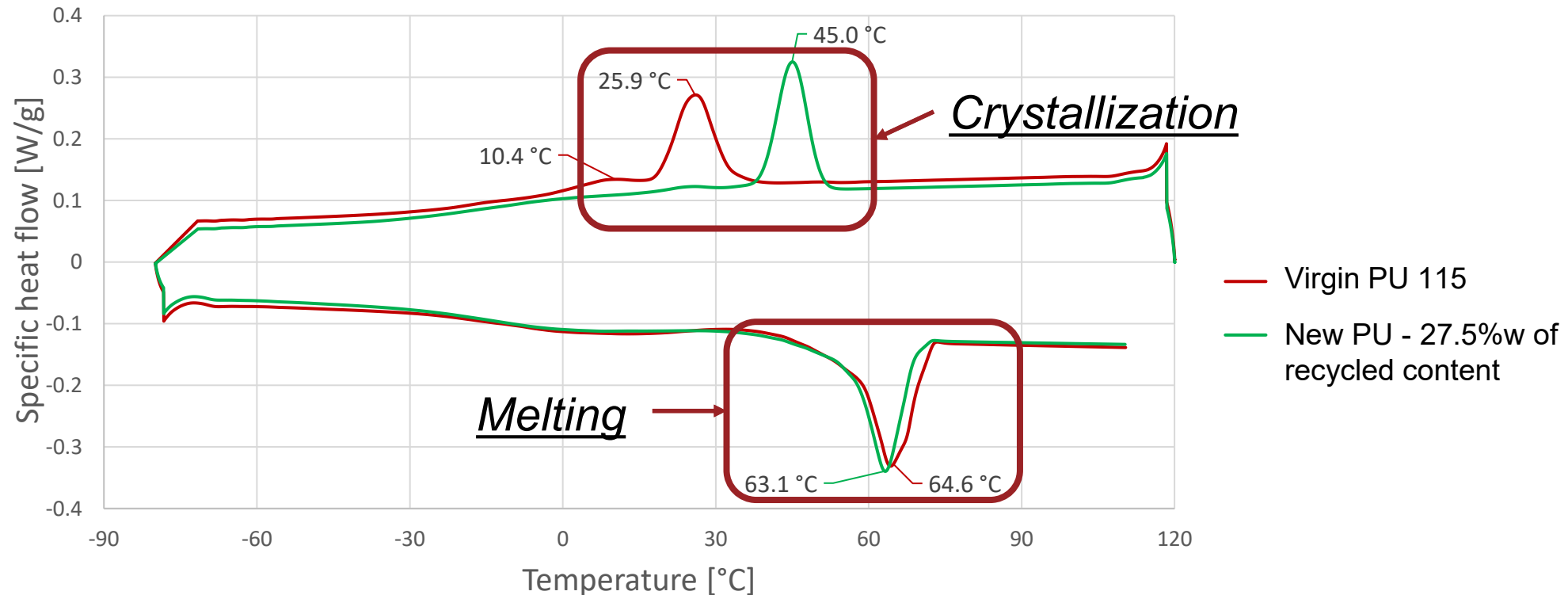


*New adhesives produced using different amounts of recycled polyols*



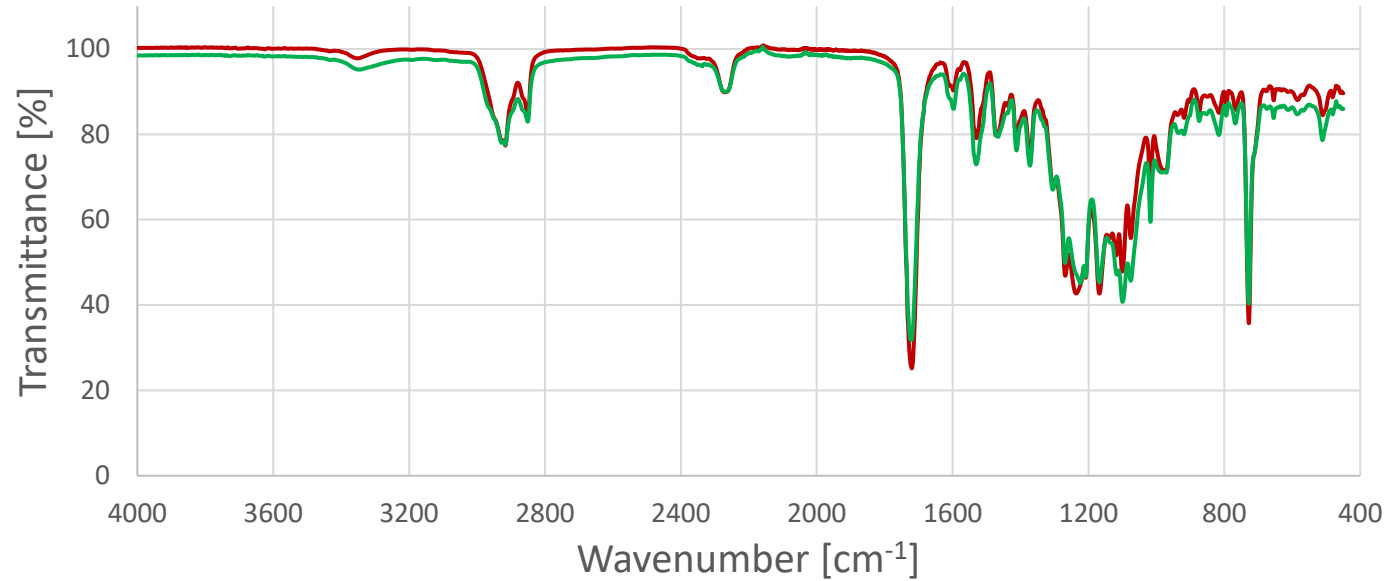
- PU 115 recycled: from 10%w to 40%w of recycled polyols
- PU 127/5 recycled: from 16% W to 40%w of recycled polyols

**DSC**  
*analysis*



# Comparison between original recycled adhesives

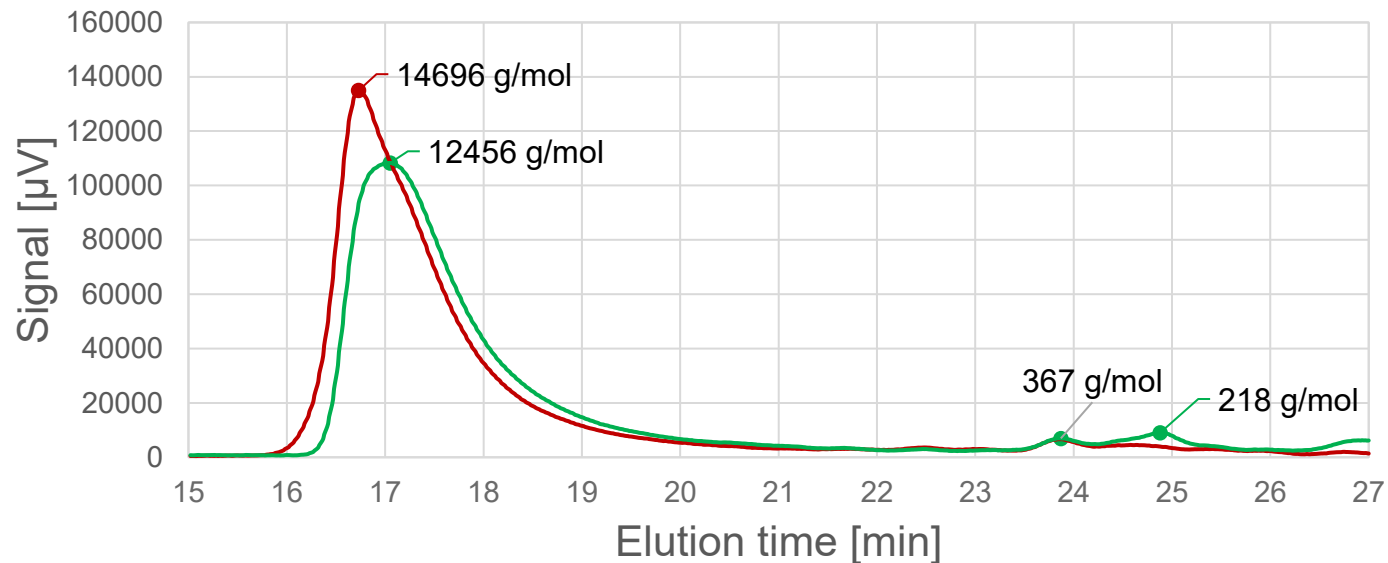
**FTIR**



— Virgin PU 115

— New PU 115 - 27.5%w of recycled content

**GPC**



— Virgin PU 127/5

— New PU 127/5 - 16.5%w of recycled content

# Comparison between original recycled adhesives

## *Peel tests*



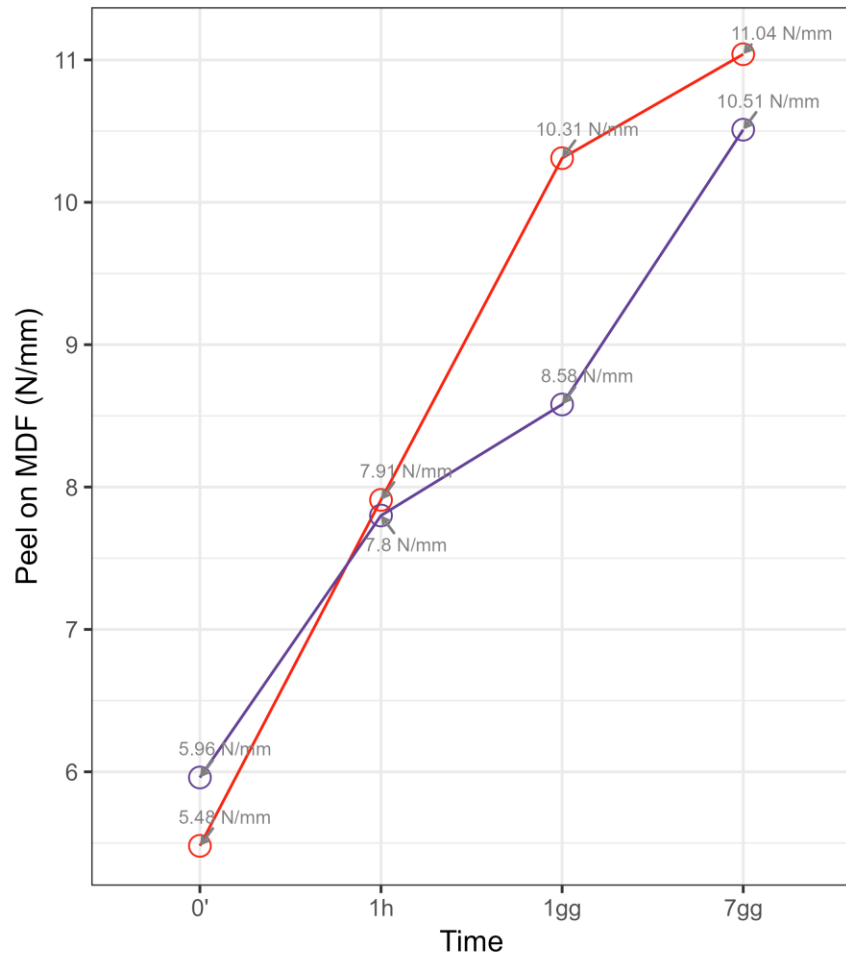
- Evaluation of the bond strength between panel and edge
- Crash effect, i.e. adhesive failure



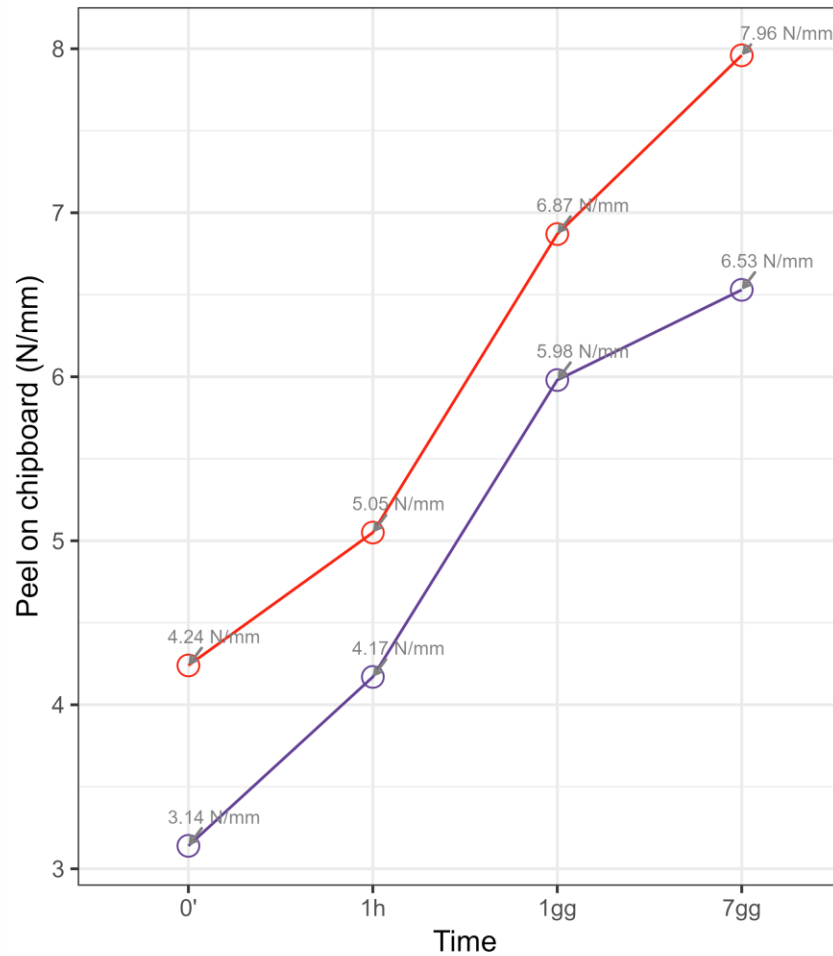
Crash

# Comparison between original recycled adhesives

Product: ○ 127/5 #3 ○ PU 127/5 STD



Product: ○ 127/5 #3 ○ PU 127/5 STD



**PU 127/5 STD**

«Crash» at 0' and 1h  
on chipboard ed MDF

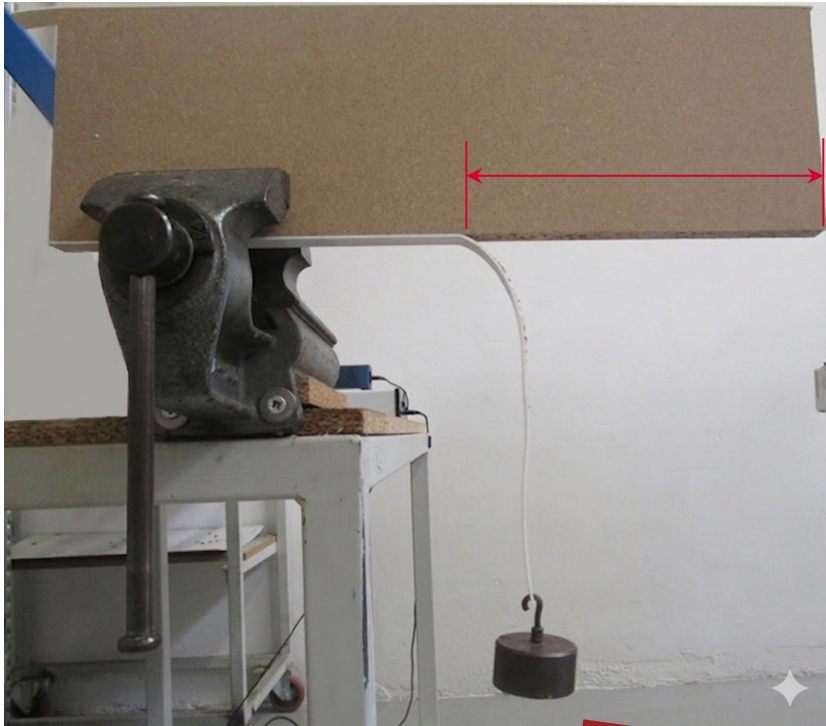
**PU 127/5 #3**

No «Crashing» phenomena

Pull speed: 250 mm/min

# Comparison between original recycled adhesives

## Application tests on recycled Duditerm 127/5

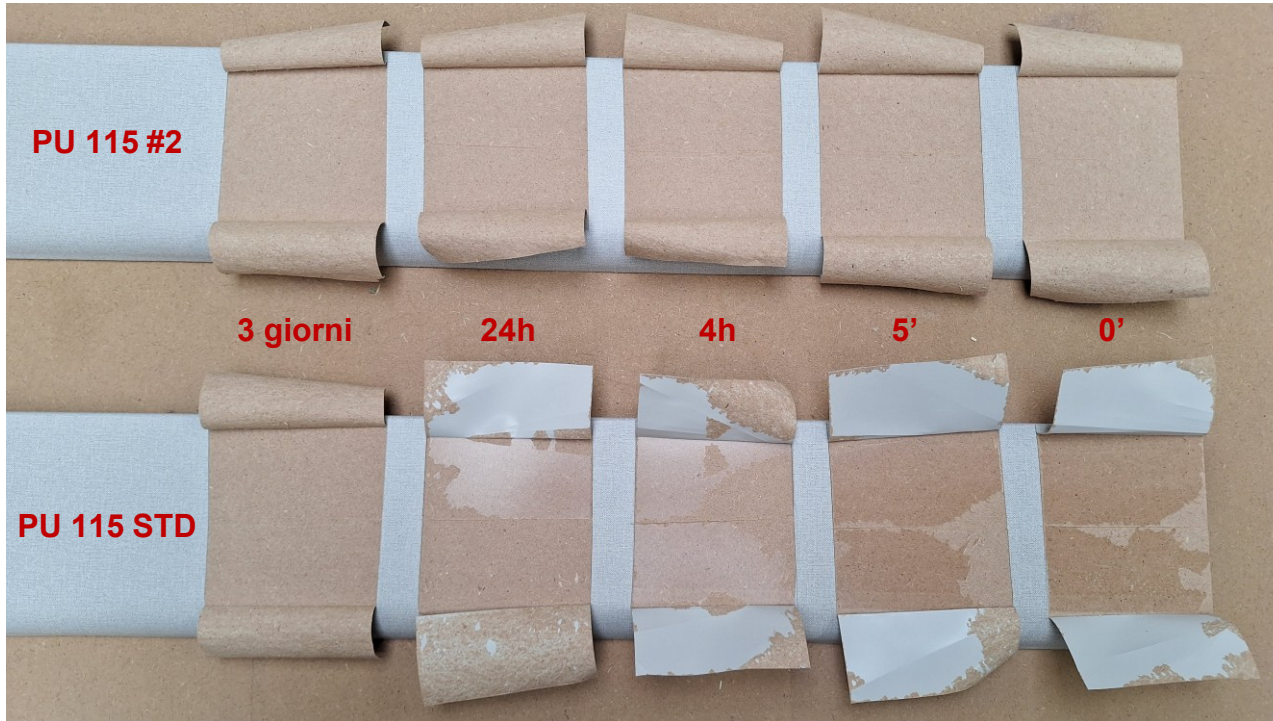


400 grams weight

Blend	Temperature	Weight Run @ 1 min [cm]	Weight Run @ 5 min [cm]
<b>127/5#3</b> 16,5% recycled	Environmental Temperature	1	1
	40 °C	28	34.5
<b>127/5#4</b> 29% recycled	Environmental Temperature	8.5	9
	40 °C	Falls @ 10 s	Falls @ 10 s
<b>127/5#5</b> 39% recycled	Environmental Temperature	18	24
	40 °C	Falls @ 30 s	Falls @ 30 s
<b>127/5 STD</b>	Environmental Temperature	< 1	< 1
	40 °C	6.2	8.1

# Comparison between original recycled adhesives

## Test su Duditerm PU 115 riciclato



Incollaggio su foglia di PP primerizzato

	PU 115 STD	PU 115 #2
Open time	2/3"	2/3"
Viscosity	~30000 mPa s	32500 mPa s
% recycled	0	27,50%

**Open Time:** It is the time within which the adhesive, after having been applied on the foil, will stick on the profile and result in a good bonding – UNI 111982

- The chemical recycling of PU adhesives can be effectively carried out through acidolysis, without the need for a deamination step;
- The recycled Duditerm PU 127/5 showed adhesion properties similar to those of the original adhesive, and was produced using **recycled polyols up to 16.5% by weight**;
- The **recycled Duditerm PU 115**, produced with a recycled **polyol content of 27.5%** by weight, showed chemical and adhesion properties very similar to the original material.

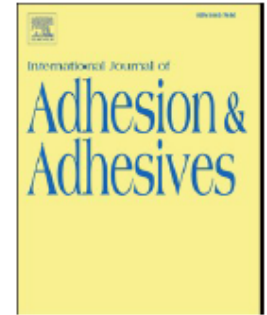
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## International Journal of Adhesion and Adhesives

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### Closing the loop of polyurethane adhesives: Acidolysis process optimization

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