



# A joined-up approach to sustainable packaging

Our series of web seminars covers every key topic you need to know about. Taking place from March 15 to 25.



# Mechanical recycling of polyamides in multilayer film structures

Webinar on March 18 with  
Dr. Rolf-Egbert Gruetzner and Dr. Roland Bothor



# Your hosts for today



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# Welcome to our session!

## Before we start... Webex housekeeping

- Please **provide your full name**: Do not appear as a “Dial-in User”
- We'll put you all on **mute** 
- Ask a question **via the chat or Q&A function (to everyone)** or “raise a hand,” so we can unmute you 
- All questions will be answered **after** the session
- Please **turn off** your video
- We recommend to use **VoIP** audio connection (“**call using computer function**”)
- Please note that this session is going to be **recorded**   
(Q&A will not be published)

# Mechanical Recycling of PE/PA Multilayer Film Waste: Opportunities & Limits (Part 2)

**Dr. Rolf-Egbert Gruetzner, BASF SE**  
Webinar March 18<sup>th</sup>, 2021

*partially a joint project of*

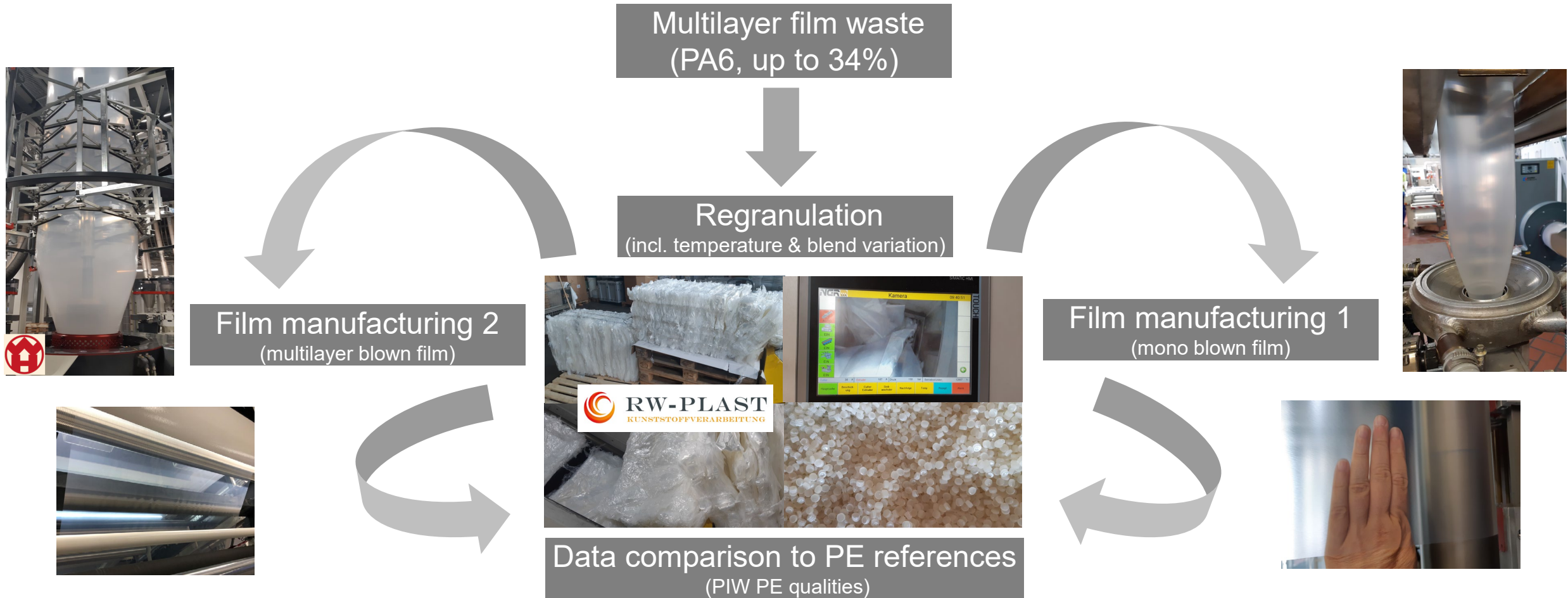
# Agenda

- Review of Part 1 “Mechanical recycling of PE/PA6 multilayer film waste”
- Project with Institute Cyclos-HTP (New results on PE/PA6 multilayer film waste)
- Is mechanical recycling of PE/CoPA multilayer film any different?
- How is the mechanical recycling of structures with both PA and EVOH?
- Outlook

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# What has been investigated in Phase 1 (PE/PA6 multilayer film waste)?





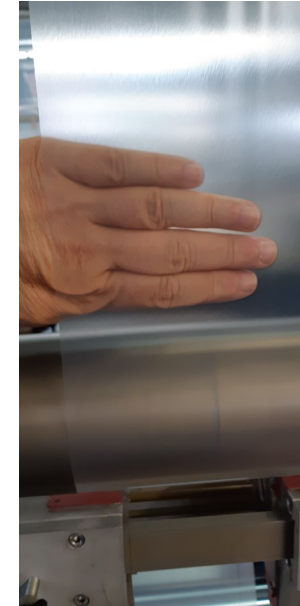
# PA concentrations < 10% are dispersible in a polyethylene stream w/o using compatibilizers



- PA/PE pellet mix ( PA6: 5-8%)
- NO compatibilizer
- Temperature range 215-240°C
- NO additional compounding
- NO additional drying



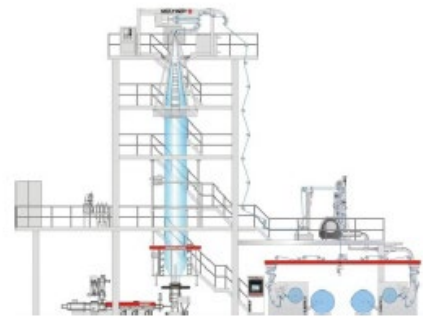
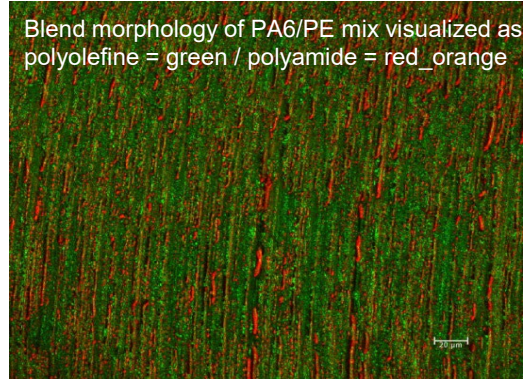
Direct processing  
of regranulate to 2<sup>nd</sup> blown film



Transparent films  
showing reasonable  
mechanical performance  
(mono-/ multilayer films)

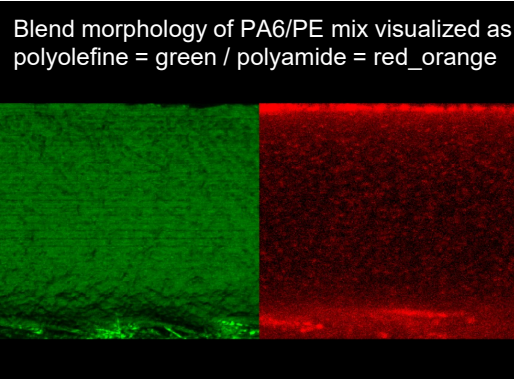
# Compatibilization offers additional options for utilizing PA/PE waste blends with PA concentrations > 10% in a polyethylene stream

PA/PE mix pur (pellet, 20% PA6)

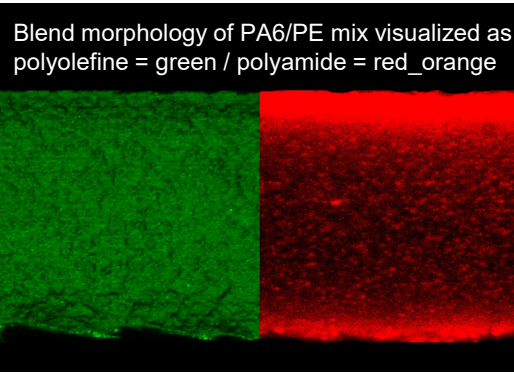


**Compatibilizer** added as **dry blend** during 2<sup>nd</sup> blown film process

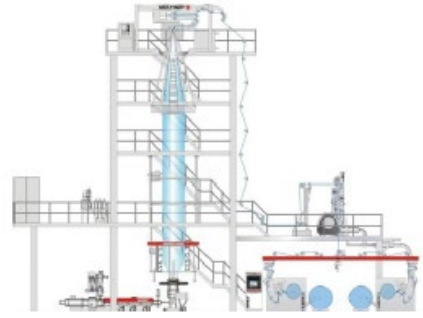
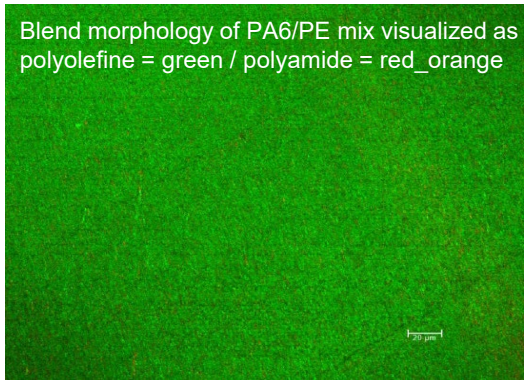
Monolayer PA/PE blown film



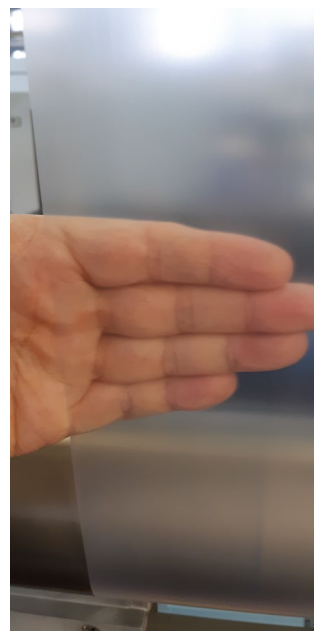
Monolayer PA/PE blown film



PA/PE mix, pre-compatibilized (pellet, 20% PA6)



**Direct processing of pre-compatibilized** PIR during 2<sup>nd</sup> blown film process



Transparent films showing reasonable mechanical performance (mono-/multilayer films)



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# Mechanical Recycling of PA6 in Multilayer PE Films

Recyclability Assessment according to CHI Standard

**BASF Webinar, March 18, 2021**

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Dr. Roland Bothor

**Institute cyclos-HTP GmbH**

Institute for Recyclability and Product Responsibility





1. Short introduction to the **cyclos-HTP institute (CHI)**
2. The **CHI Standard** for the assessment of recycling compatibility
3. Project targets and test program
4. Results of regranulation and production of recyclate blends
5. Results of Injection Moulding and Blown Film application tests
6. Summary and Outlook



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# Short introduction to the Institute cyclos-HTP (CHI)



The Institute cyclos-HTP with headquarter in Aachen was founded in May 2014 as a company for the **classification, evaluation and audit of recyclability for packaging and goods**, as well as **research and development** in this field.



supported by almost 30 years of experience in plant design and in auditing sorting and recycling plants (plastics, fibre-based packaging and metals)

**Established process knowledge**

**CHI-RA – approved test standard**

EU-wide audit standard for packaging of all material types, accepted by industry and in accordance with norms (EN 13430, ISO 14021)



**Science-based and practice-proven assessment**

We work with brand owners packaging manufacturers discounters and our partner DSD “Der Grüne Punkt” (The green dot).

we work independently and free of directions

**Independent**

**Publicly appointed and sworn experts**

as publicly appointed and sworn experts we carry out expertises for courts and public clients

CHI, was the first **expert organization** who has draft and implement a **fully transparent assessment procedure** for packaging - based on scientific principles and practical experience in recycling.



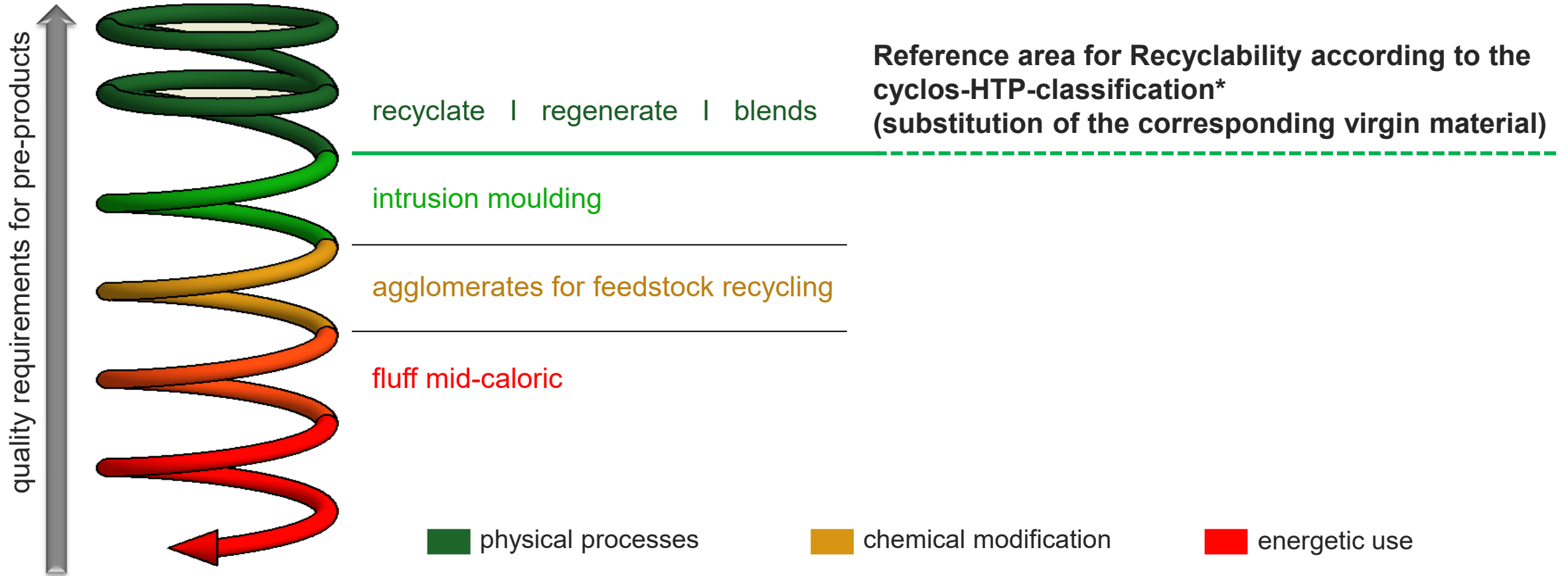
- Recyclability Assessments for packaging for distributing companies
  - individual certification/ group certification
  - Performing round about 1,500 recyclability assessments per year (brand owners, packaging manufacturers) for all material types plastic, fibre-based materials, metal and glass
- Workshops for packaging manufacturers, brand owners and traders
- Projects for D4R Packaging Optimizing (stand-up pouches **Mondi**, freezer bag **Frosta**)
- CHI as Testing Instance for different packaging manufacturers (testing of packaging before market introduction)
- Product Range Screening to determine the status quo of recyclability (for packaging manufacturers, brand owners and traders), taking international markets and actual developments into account
- Basic Research (Regularities of NIR sorting, development of analysis and simulation methods)
- IT Developments:
  - Recyclingkompass DSD '**Der Grüne Punkt**'
  - CHIRA (CHI Recyclability Assessment), completion mid of 2021





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## 1. Recycling...





## Assessment Basis

*Rate of substitution* of corresponding virgin material by recycled secondary raw material.



## Recyclability ...

Individual *gradual* suitability of a packaging or product to *factually* substitute material-identical virgin material in the post-use phase; “factually”: collection and processing structures in industrial scale are available.\*



**Conformity** of Packaging Design with Functional Requirements of established Recycling Processes



**National differentiation** of Recyclability, as long as structures not harmonized

→ **Certificate of Recyclability**

→ *Conformity in the form of a Supplier Declaration acc. to DIN EN ISO 14021*



## Main Aspects and Definitions

### Reference Processes

Relevant processes in the corresponding Recycling Path incl. **Recyclate Applications**

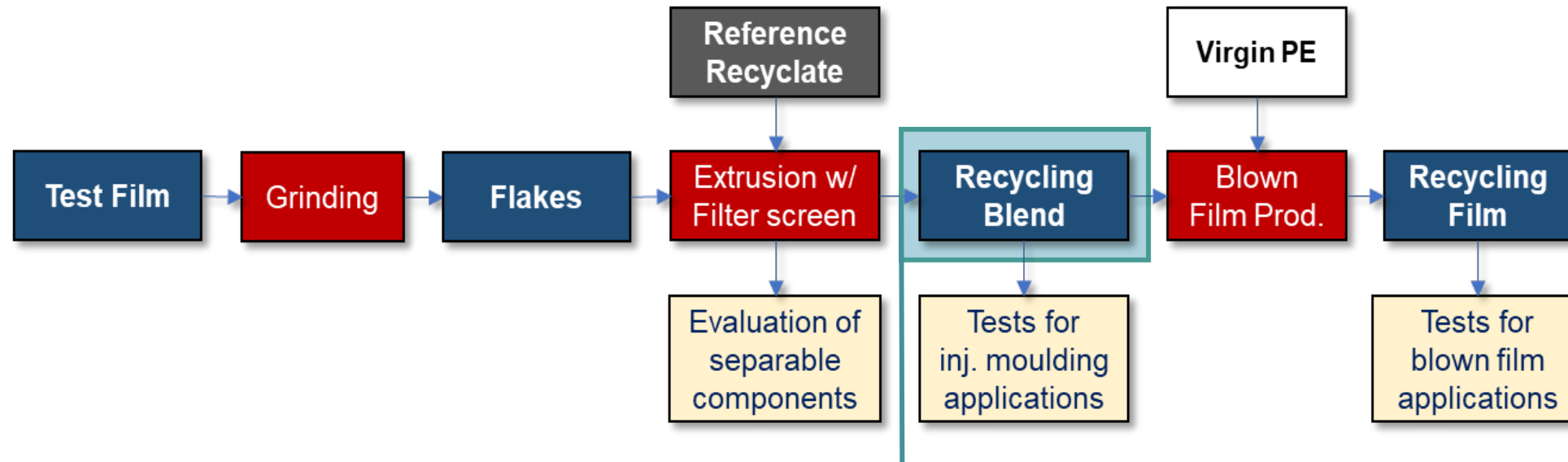
### Reference Material

Commercial PCR recyclate commonly used for the same reference applications in the recycling path

### Sample

Packaging/Material containing a component with an **unknown recycling compatibility**

## Recycling Application Compatibility Test for PE-based Flexible Packaging (CHI-C8-PEF-1)



### Assessment of Recycling Blends *against Reference material*:

- CHI5** “Realistic Scenario” for the concentration of a packaging material in the recycling stream = **5% Sample** + **95% Reference** → **Compatibility of Packaging or Material?**
- CHI30** “Worst Case Scenario” for the concentration of a packaging material in the recycling stream = **30% Sample** + **70% Reference** → **100% Recyclability of Packaging ?**
- REF** Commercial **PCR Recyclate** from the recycling stream



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Appendix 3 of the German ZSVR Minimum Standard provides the basis for determining incompatibilities.

**PA barriers are currently listed as “Incompatibility”** in the packaging group “Film and LDPE”.

For any **deviating determination** (PA not negatively affect recyclability), **individual evidence** must be provided.

- Effects of PA concentration, film structure and tie layer resins on recyclability are not considered
- Can the recycling compatibility of PA be improved with a compatibilizer agent incorporated as blend in PE?

## **Targets of this project:**

- Investigation of the effects of PA6 (most critical PA grade) on the relevant properties of recyclates in LDPE film recycling
  - PA6 is incorporated as **coextruded layer with tie layers** in a LLDPE/LDPE film
  - Additional tests of films with PA6 and a commercial **compatibilizer** blended in PE
- Tests of the reference applications for LDPE recyclates:
  - Blown films
  - Injection moulding

→ **Assessment of PA6 as “Recycling Compatible” or “Recyclable” in LDPE films (by demand with use of a compatibilizer)**



# Test Phase 1 – Production of Sample Blown Films – Raw materials



## Multilayer Blown Films produced at Windmüller & Hölscher

### 7 layer film structures:

**FB0** – PE / PE / PE / PE / PE / PE / PE (100 µm)

**FB1** – PE / Tie layer / **PA6** / Tie layer / **PA6** / Tie layer / PE

**FB2** – PE + **Comp** / Tie layer / **PA6** / Tie layer / **PA6** / Tie layer / PE + **Comp**

### “Recycling-critical” materials to be tested:

LDPE-based film with **30% PA6** and **15% tie layer resin** \*

LDPE-based film with **15% PA6** and **7.5% tie layer resin** \*

LDPE-based film with **30% PA6** and **15% tie layer resin** \* and **5% Compatibilizer** \*\*

\* *Maleic anhydride grafted PE (Standard grade for PA/PE coextrusion)*

\*\* *Maleic anhydride grafted PE (high MAH content)*





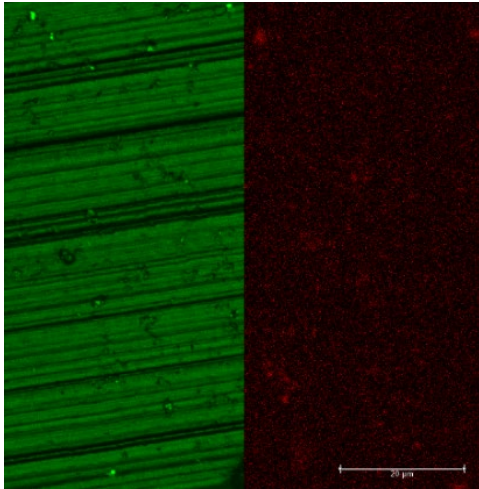


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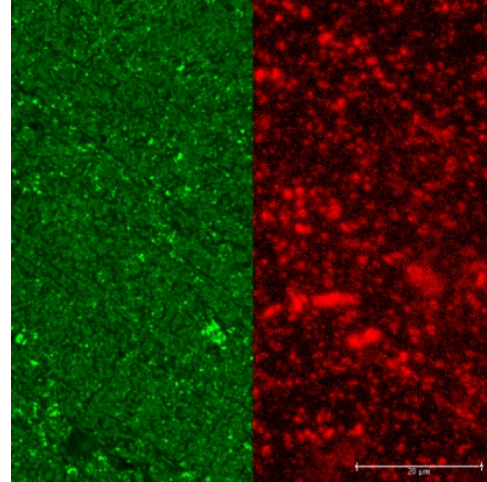
# Morphology of Regranulate pellets after Regranulation on a NGR line



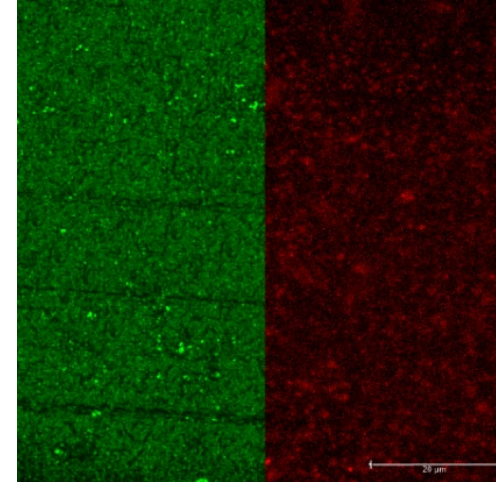
FB0: Regranulate,  
100% PE reference



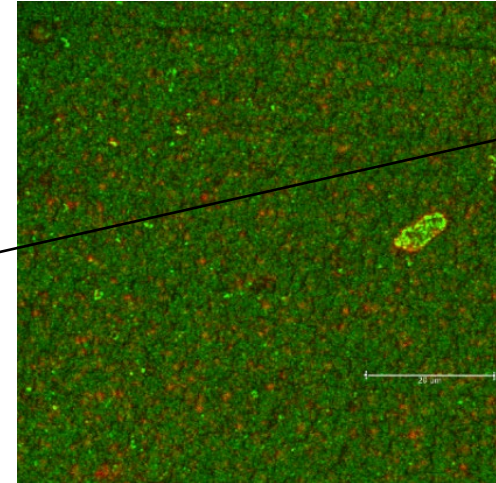
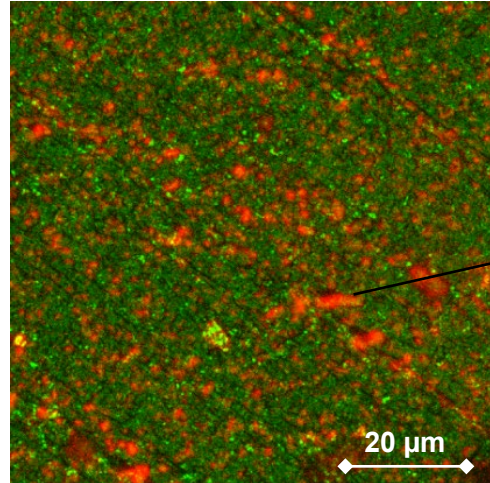
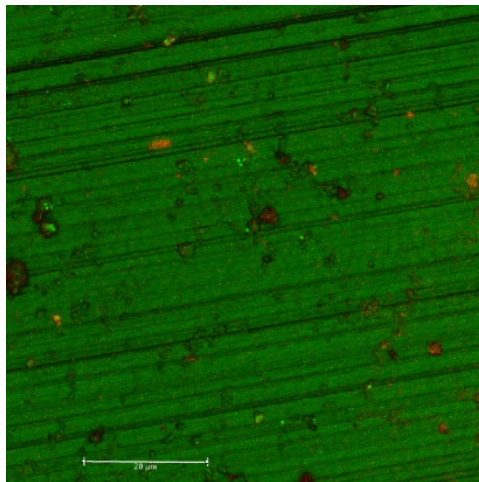
FB1: Regranulate w/  
**30% PA6**, 15% Tie



FB2: Regranulate w/  
**30% PA6**, 15% Tie,  
**5% Compatibilizer**



Pre-compatibilization generates a **more homogeneous morphology** in comparison with 30% PA6 without compatibilizer



Reflection/Fluorescence microscopy (CLSM) pictures with kind permission by Dr. R.-E. Gruetzner, BASF SE 02/2020



<i>Composition of Recyclate Samples</i>				
<i>CHI std.</i>	<i>PA6</i>	<i>Tie layer</i>	<i>Comp</i>	<i>Recy*</i>
REF	0.0%	0.0%	0.0%	100%
CHI5	1.5%	0.8%	0.0%	95%
CHI5	1.5%	0.8%	0.3%	95%
CHI30	5.0%	2.5%	0.0%	70%
CHI30	5.0%	2.5%	0.8%	70%
CHI30	10.0%	5.0%	0.0%	70%
CHI30	10.0%	5.0%	1.7%	70%

\* RECY - *Reference Recyclate*: LDPE-based PCR Recyclate

### Extrusion parameters:

- Extruder set temperature (Head) = 210°C
- Melt pressure = 50 – 60 bar
- Vacuum degassing after 6 of 8 zones
- Melt pump

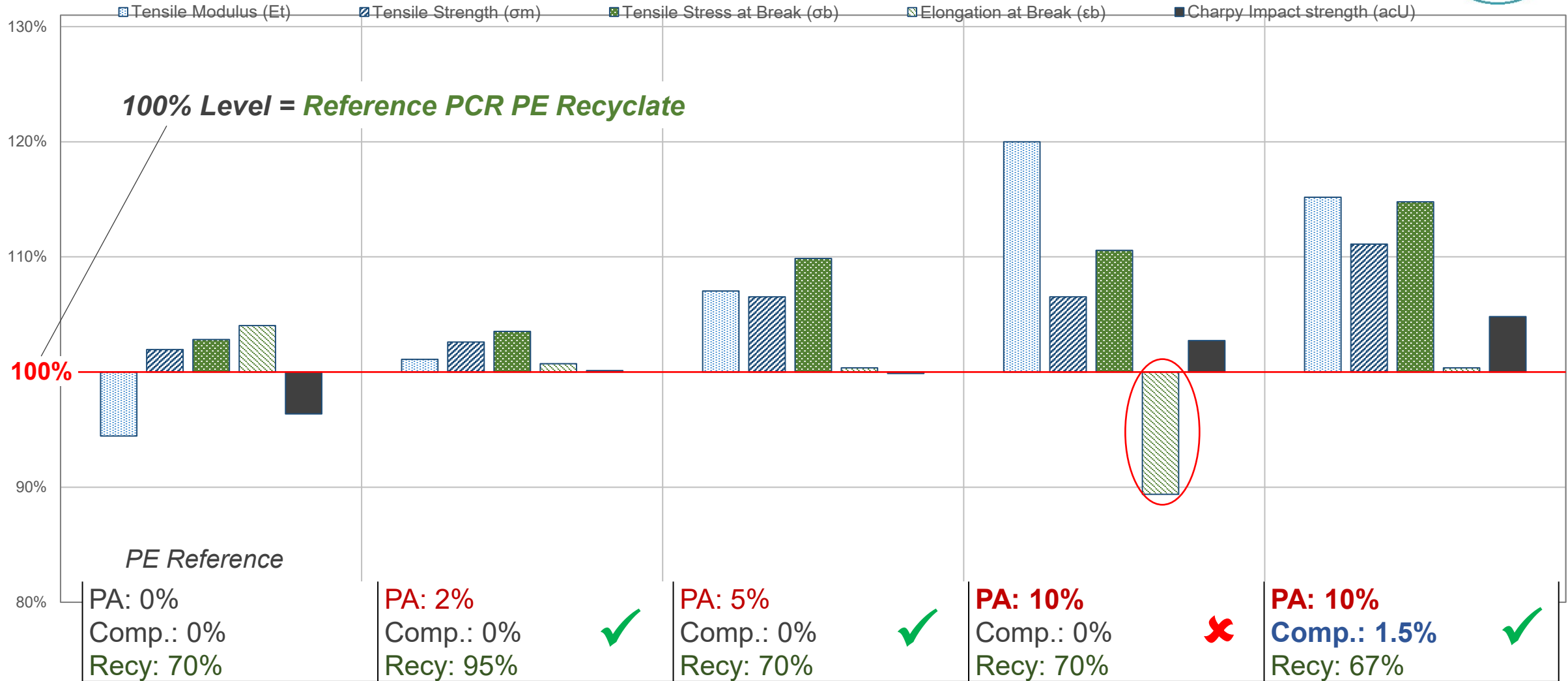


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# Injection Moulding Application - Mechanical Tests



## Injection Moulding Application of Recyclate Blends



# Application Test for Blown Films (Examples)



- Recyclate materials not dried !
- 50% virgin LD/LLDPE added for each film (Standard in industry)



**5% PA, no Comp, 215°C**



**15% PA, 215°C**



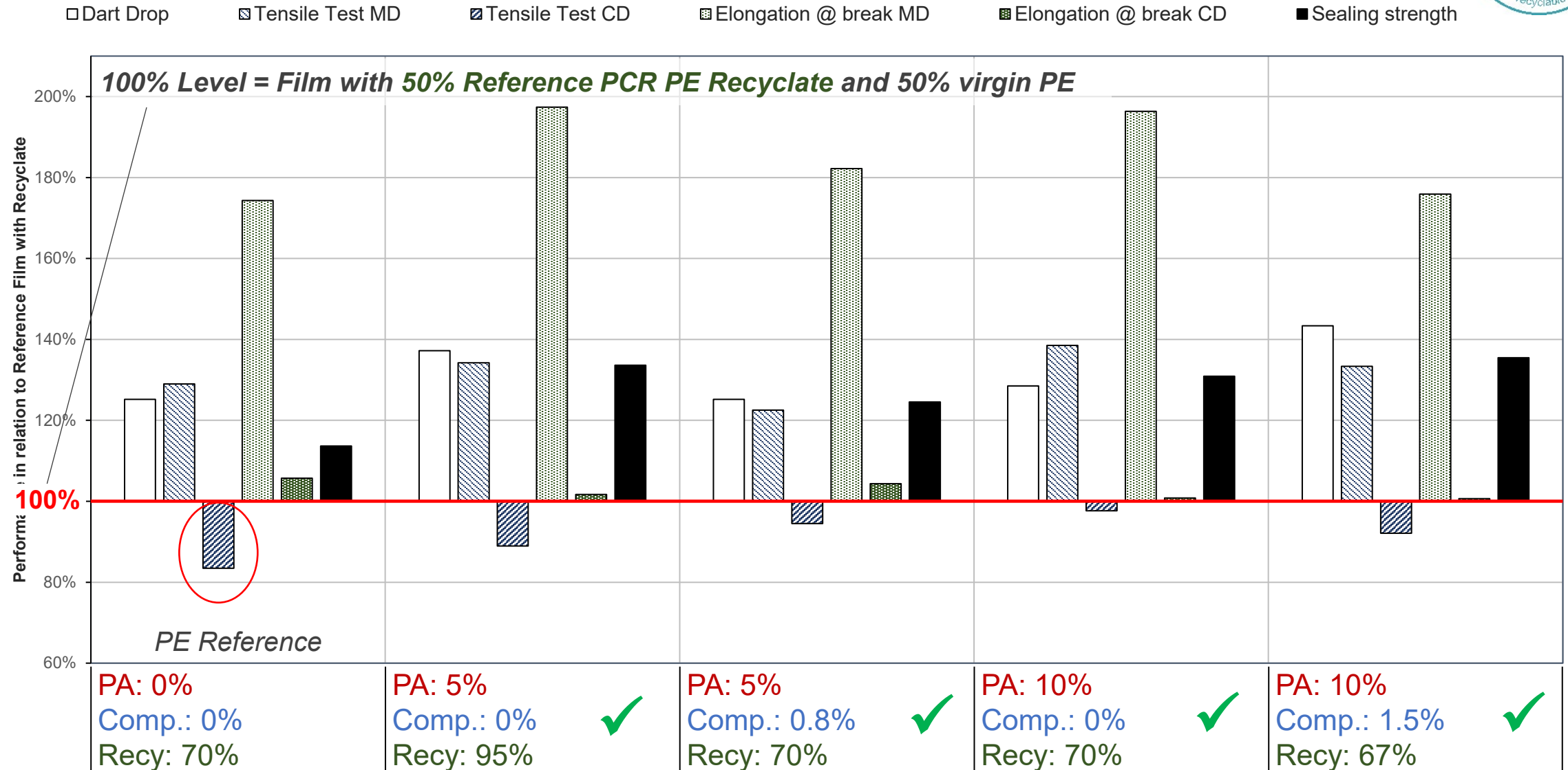
**15% PA, 2.5% Comp.**



# Blown Film Application Tests – Mechanical and Sealing Properties



Blown Films made of 50% Recyclates and 50% virgin PE - Mechanical and Sealing properties





1. Films sealed with seam width of 2 - 4 mm
2. Filled with 1.3 L of water (with 16 cm seam length and 20 cm fill height)
3. Test duration: min. 10 minutes
4. Count the number of drops per minute due to leakages in the seam
5. Test is passed with < 2 drops per minute

**All Sample Films  
passed the test ✓**







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**Individual evidence for the deviating determination of Polyamide 6**  
based on test results **according to CHI standard test method CHI-C8-PEF-1:**

**Polyamide 6 (PA6) is “Recycling Compatible for PE Film Recycling”**  
**in recyclates for injection moulding and blown film applications:**

- in combination with a **MAH-grafted PE\*** as **tie layer resin** in a ratio of  $\geq 0.5$  g per g PA;
- tested with  $\leq 30\%$  by weight of PA6 in coextruded polyethylene films, based on LDPE and LLDPE
  - no compatibilizing agent necessary for the recycling compatibility


**Packaging films \*\* with a PA6 barrier are “Fully Recyclable”:**

- in combination with a **MAH-grafted PE\*** as **tie layer resin** in a ratio of  $\geq 0.5$  g per g PA;
- the film structure must contain a **Compatibilizer** like “Dow Fusabond E226” (or comparable) in a ratio  $\geq 0.15$  g per g PA
- tested with  $\leq 30\%$  by weight of PA6 in coextruded polyethylene films, based on LDPE and LLDPE,

\* Maleic anhydride content suitable for PA/PE coextrusion

\*\* Structures without printing inks or other components that affect recyclability



Status	Categorization of PA6 according to CHI standard 	CHI Assessment of a Packaging structure Example: PE film with 10% PA6 + ≥ 5% Tie layer	Material (PA6) according to ZSVR Minimum Standard
Current	<b>CAT 3</b> <i>(PA in any structure)</i>	<b>Not recyclable (0%)</b>	<b>Contaminant / Incompatible</b> <i>(“PA layers”)</i>
Future (Based on results)	<b>CAT 2</b> <i>(PA6 layers with tie layer)</i>	<b>Recyclable (≤ 90%) **</b> <i>(no Compatibilizer)</i>	<b>Recycling compatible</b> <i>(“PA6 layers with tie layer”) *</i>
	<b>Valuable material</b> <i>(PA6 layers with tie layer and <b>Compatibilizer</b>)</i>	<b>Fully Recyclable (≤ 100%) **</b> <i>(Structure with <b>Compatibilizer</b>)</i>	

\* Application started for the next Minimum Standard 2021; final wording not yet agreed

\*\* Structure without printing inks or other components that affect recyclability



# Thank you for your Attention !



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# What has been done in phase 2 (Implementation of CoPolyamides)?

- Original films: PE/ CoPA Multilayer films with 20% Copolyamides
- Regranulation (S Gran 95, NGR, Austria)



- Morphologies of regranulates analyzed
- Monolayer blown films (40 $\mu$ m) made from regranulates blends in semi-tech scale; dilution series with and w/o compatibilizer (during blown film process)
- Visual & morphological evaluation; analysis of mechanical properties of monolayer films

# Film structures (100µm total)

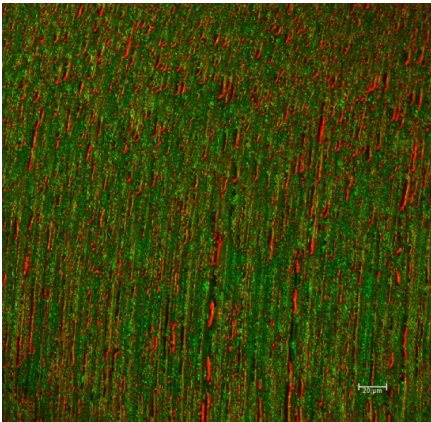
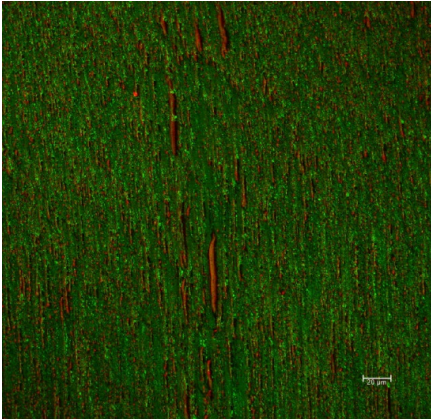
- PE Reference: PE/PE/PE/PE/PE/PE/PE/PE/PE/PE/PE
- Trial C: C40L/tie/PE/PE/PE/PE/PE/PE/PE/PE/PE (20% Ultramid<sup>®</sup> C40L<sup>\*\*</sup>)
- Trial F: F38/tie/PE/PE/PE/PE/PE/PE/PE/PE/PE (20% Ultramid<sup>®</sup> F38<sup>\*\*\*</sup>)

\*\* Ultramid<sup>®</sup> C40L = high viscosity (RV= 4,0), lubricated PA 6/6.6, Tm: 189°C

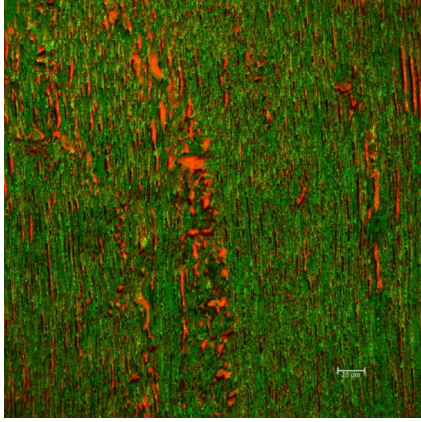
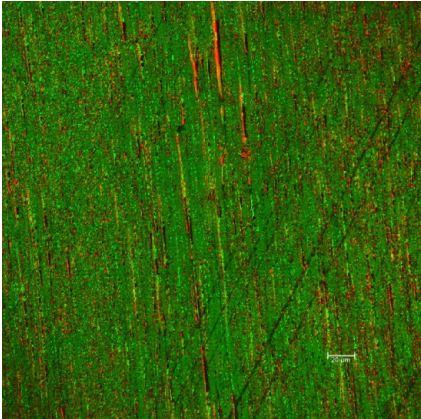
\*\*\* Ultramid<sup>®</sup> F38 = high viscosity (RV = 3,8), non- additivated special CoPA, Tm: 199°C

# Morphologies I - Comparison of regranulates

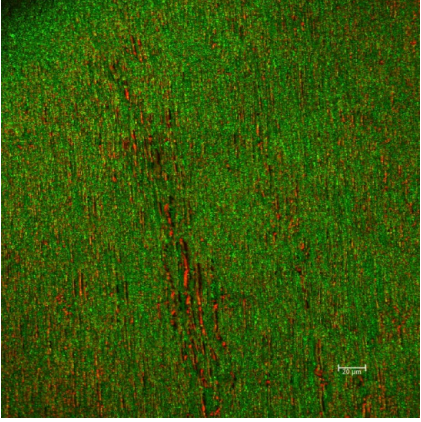
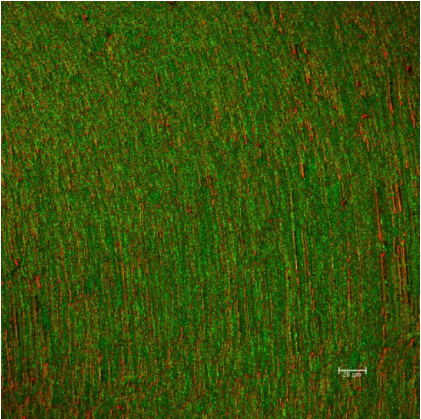
**Regranulate A\* (B40LN)**



**Regranulate C\* (C40L)**



**Regranulate F\* (F38)**



\* 20% of different polyamides in all regranulates, no compatibilizer



# Recipe overview I – Dilution series (w/o compatibilizer)

Trials	Reg A*(%/%PA6)	Reg C**(%/%C40L)	Reg F***(%/%F38)	Reg PE****(%)
1.0	-	-	-	100
1.1	100 / <b>20</b>	-	-	-
3.1	50 / <b>10</b>	-	-	50
3.2	37,5 / <b>7,5</b>	-	-	62,5
3.3	25 / <b>5</b>	-	-	75
2.5	-	100 / <b>20</b>	-	-
3.8	-	50 / <b>10</b>	-	50
3.9	-	37,5 / <b>7,5</b>	-	62,5
3.10	-	25 / <b>5</b>	-	75
2.2	-	-	100 / <b>20</b>	-
3.4	-	-	75 / <b>15</b>	25
3.5	-	-	50 / <b>10</b>	50
3.6	-	-	37,5 / <b>7,5</b>	62,5
3.7	-	-	25 / <b>5</b>	75

\*           **20% B40LN**  
 \*\*          **20% C40L**  
 \*\*\*        **20% F38**  
 \*\*\*\*       **Referenz PE Reg**

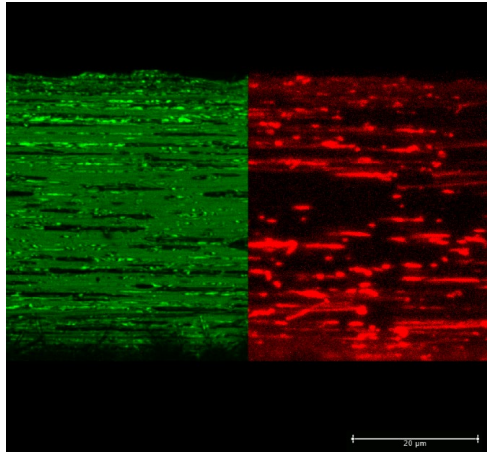
**All blends mixed on blown film machine as s&p directly!!**

Processing information (for CoPA):

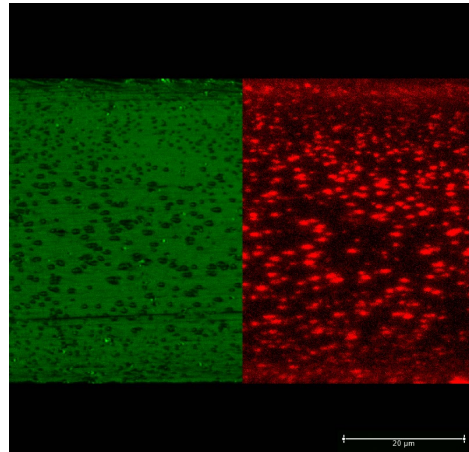
- Weber 30 air cooled blown film,
- 30mm screw diameter, L/D = 25
- 50mm die diameter
- 40 µm total thickness
- Temperature profile:  
     200°C/210°C/220°C/220°C
- Melt temperature 215-220°C

For PA6 trials 20°C higher set-up

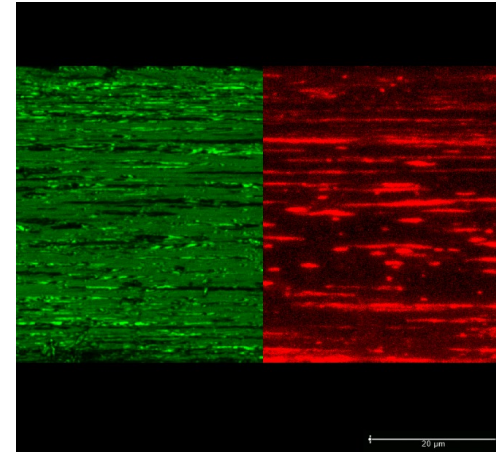
# Morphologies II – Monolayer films (Dilution w/o compatibilizer)



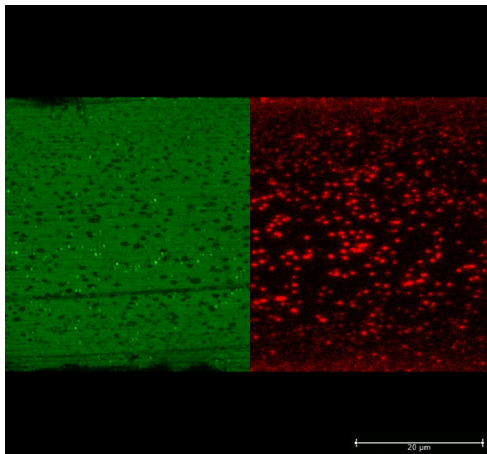
7,5% B40LN (# 3.2)



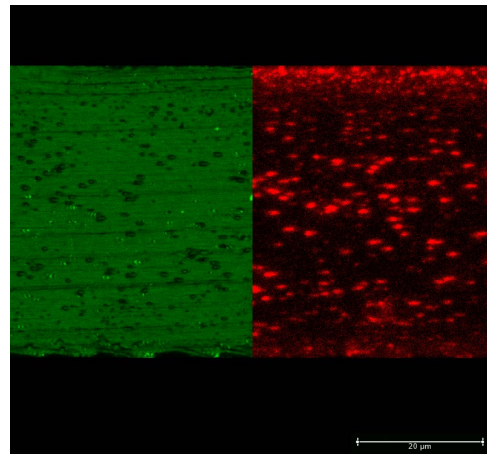
10% C40L (# 3.8)



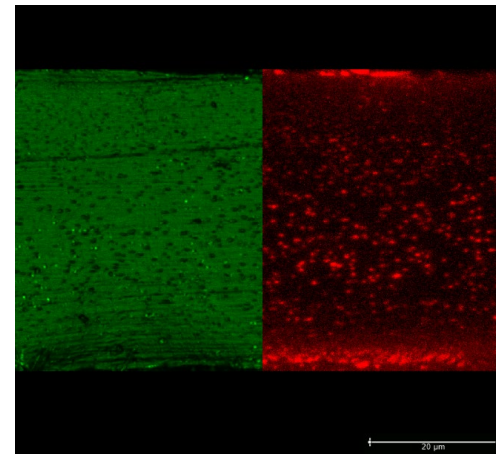
10% F38 (# 3.5)



5% B40LN (# 3.3)

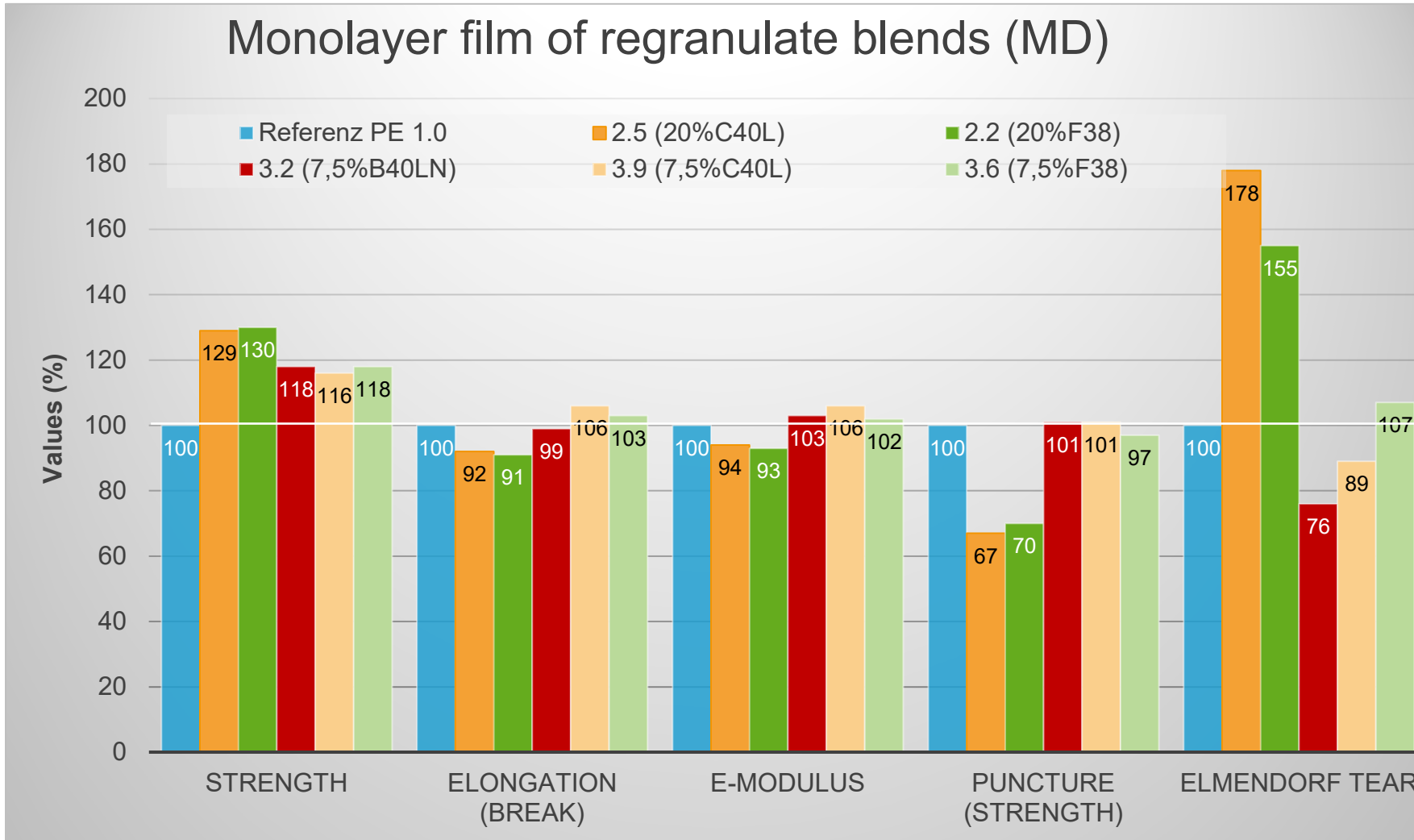


5% C40L (# 3.10)



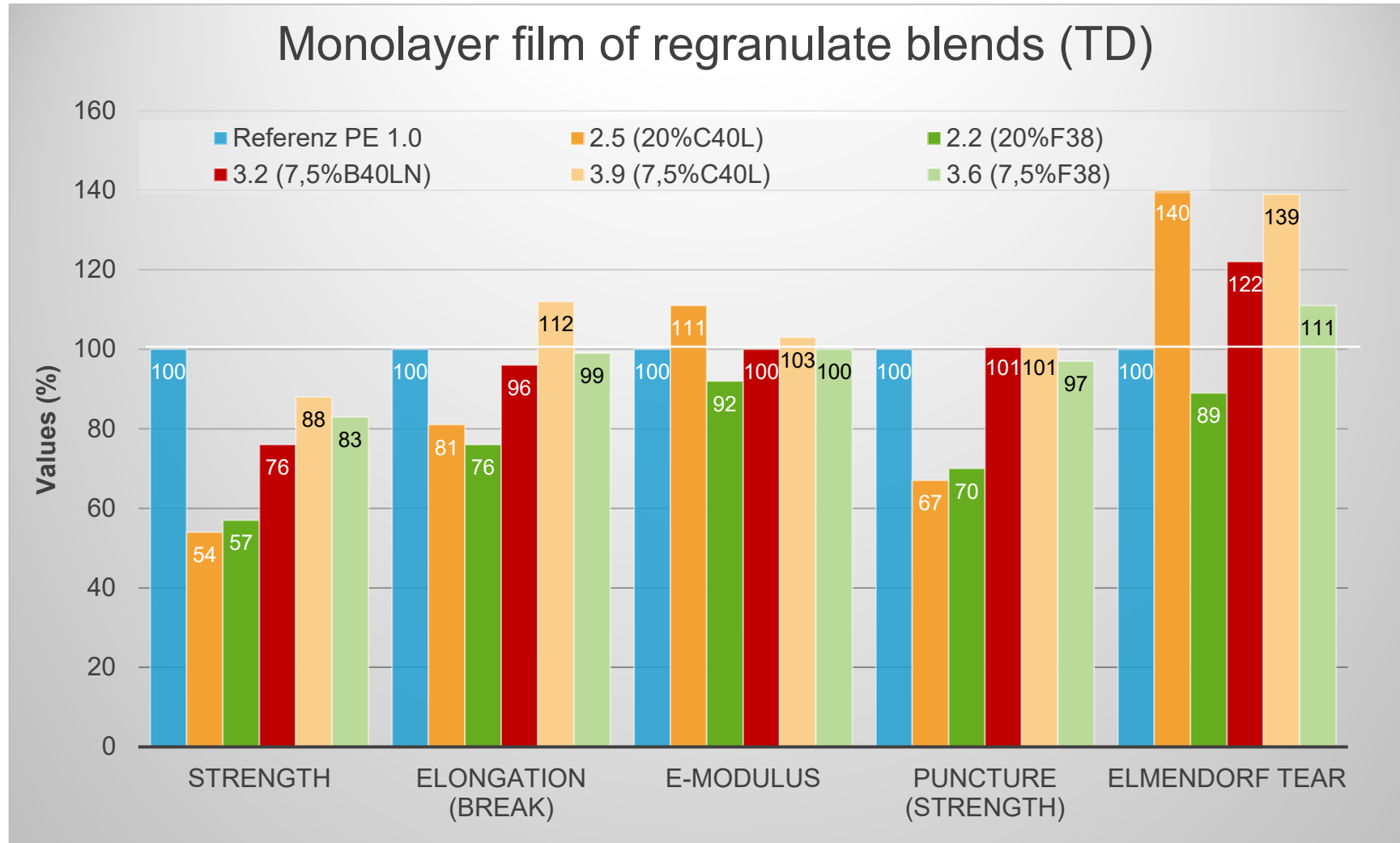
7,5% F38 (# 3.6)

# Comparison of mechanical properties in machine direction (MD) (Dilution w/o compatibilizer)



All components mixed as salt & pepper blends prior to blown film process directly!!

# Comparison of mechanical properties in transversal direction (TD) (Dilution w/o compatibilizer)



All components mixed as salt & pepper blends prior to blown film process directly!!

# Recipe overview II – Dilution series (with compatibilizer)

Trials	Reg A*(%/%PA6)	Reg C**(%/%C40L)	Reg F***(%/%F38)	Reg PE****(%)	Comp F# (%)
1.0	-	-	-	100	-
1.4	95 / <b>19</b>	-	-	-	5
4.2	50 / <b>10</b>	-	-	45	5
1.10	50 / <b>10</b>	-	-	47	3
4.3	37,5 / <b>7,5</b>	-	-	57,5	5
4.4	25 / <b>5</b>	-	-	70	5
4.10	-	97 / <b>19</b>	-	-	3
4.12	-	50 / <b>10</b>	-	47	3
4.13	-	37,5 / <b>7,5</b>	-	59,5	3
4.14	-	25 / <b>5</b>	-	72	3
2.7	-	-	98 / <b>20</b>	-	2
4.5	-	-	75 / <b>15</b>	23	2
4.6	-	-	50 / <b>10</b>	48	2
4.7	-	-	37,5 / <b>7,5</b>	60,5	2
4.8	-	-	25 / <b>5</b>	73	2

\* 20% B40LN  
 \*\* 20% C40L  
 \*\*\* 20% F38  
 \*\*\*\* Reference PE Reg  
 # Fusabond E226

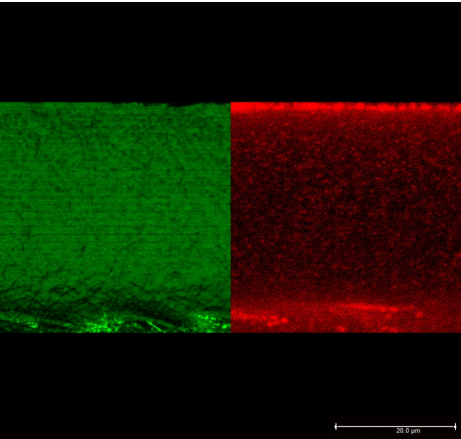
All blends mixed on blown film machine as s&p directly!!

Processing information (for CoPA):

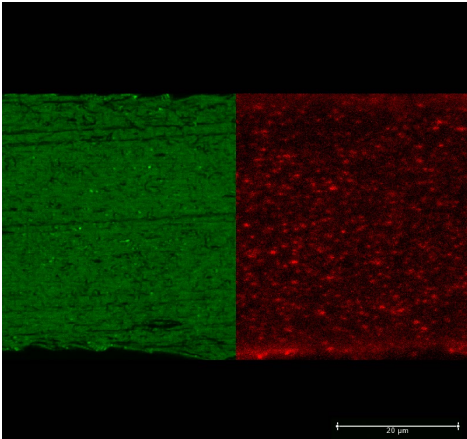
- Weber 30 air cooled blown film,
- 30mm screw diameter, L/D = 25
- 50mm die diameter
- 40 µm total thickness
- Temperature profile:  
200°C/210°C/220°C/220°C
- Melt temperature 215-220°C

For PA 6 trials 20°C higher set-up

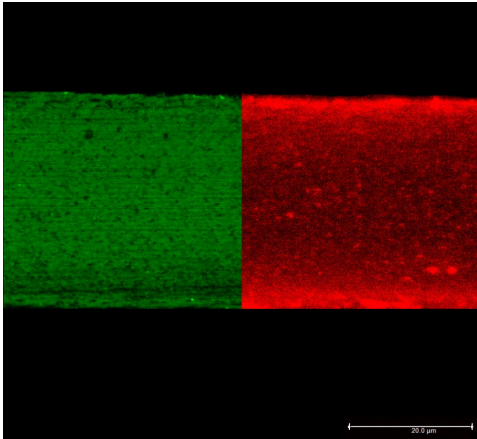
# Morphologies III - Monolayer films (Dilution with compatibilizer)



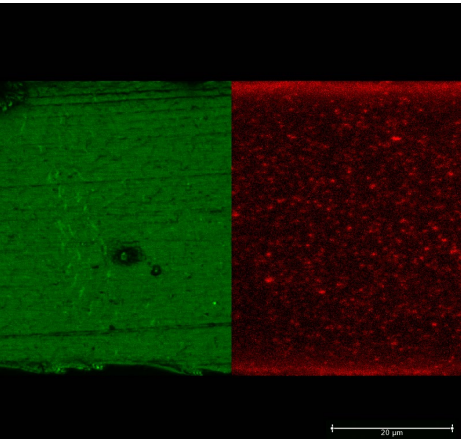
19% B40LN / 5%F (# 1.4)



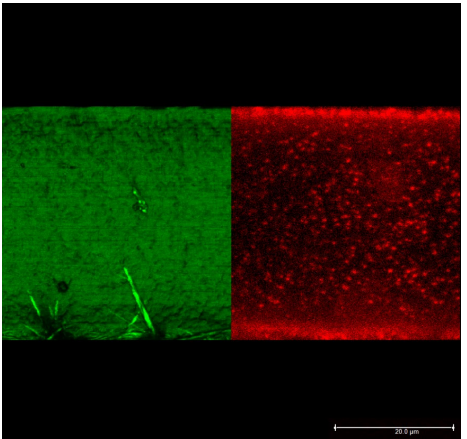
15% C40L / 3%F (# 4.11)



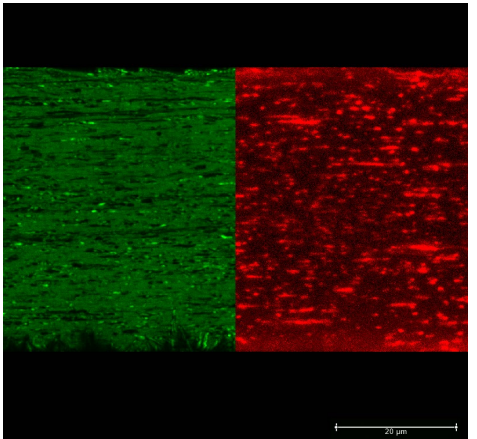
20% F38 / 2%F (# 2.7)



10% B40LN / 5%F (# 4.2)

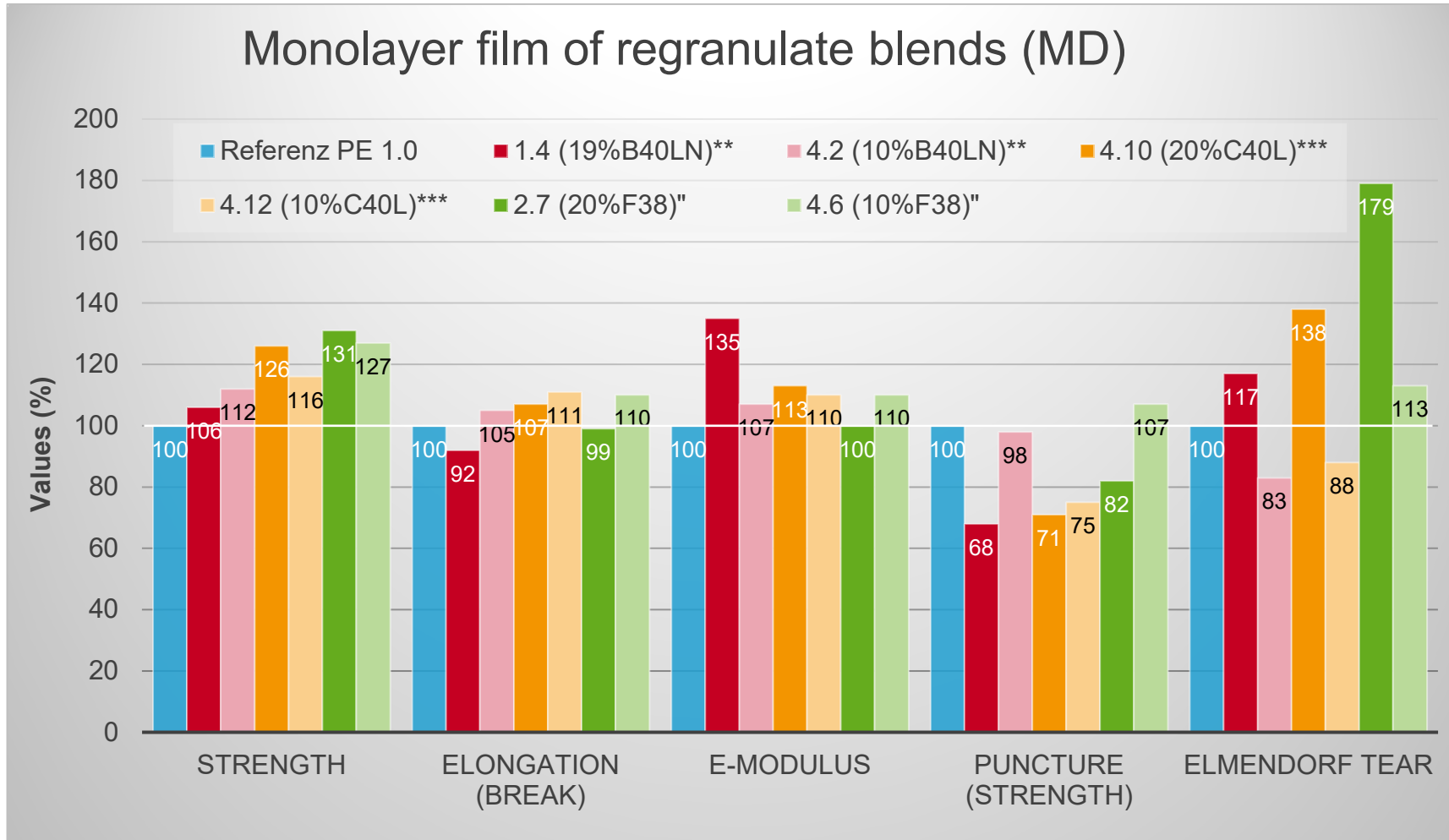


10% B40LN / 3%F (# 1.10)



15% F38 / 2%F (# 4.5)

# Comparison of mechanical properties in machine direction (MD) (Dilution with compatibilizer)

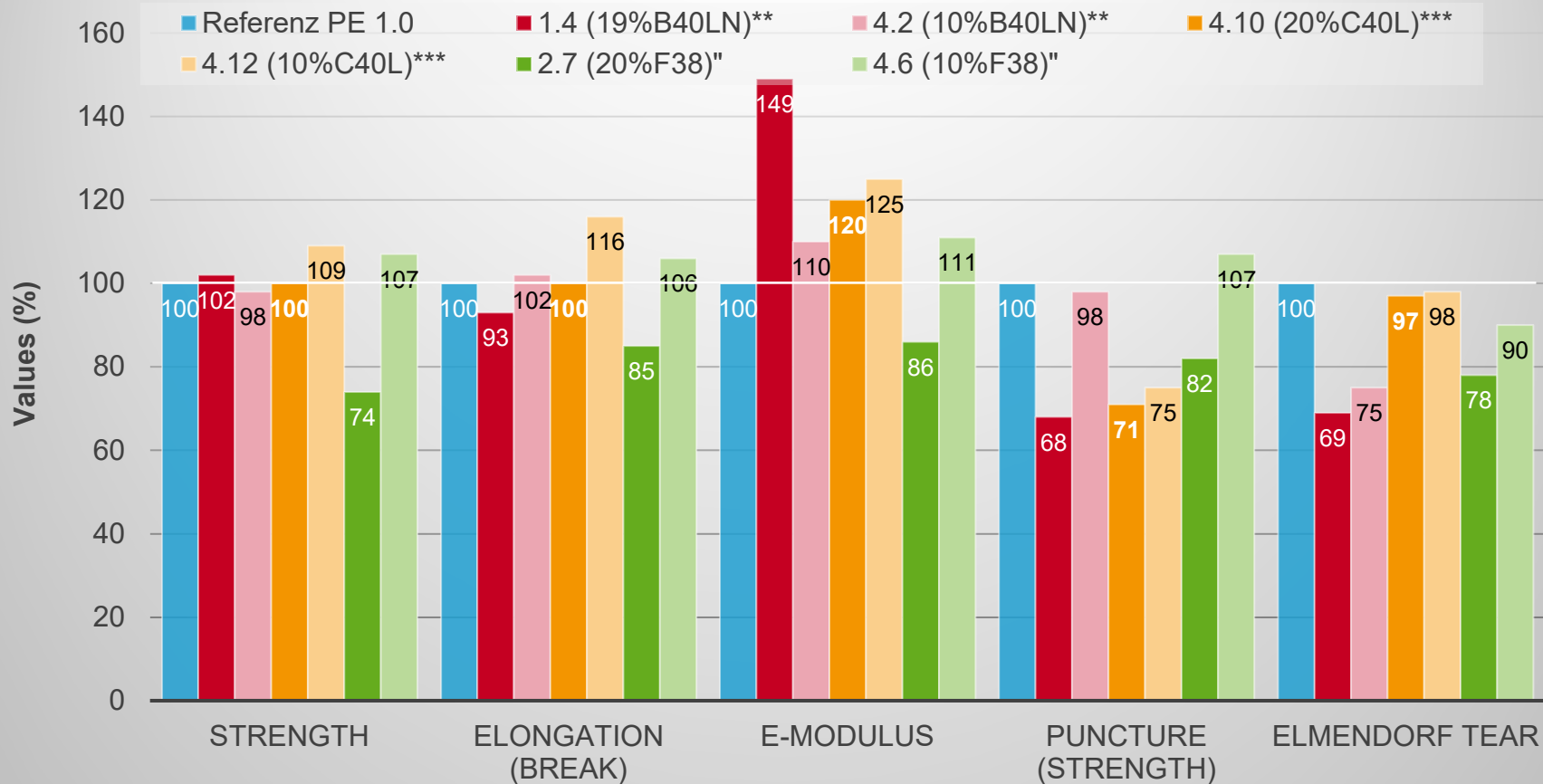


All components mixed as salt & pepper blends prior to blown film process directly!

\*\* = 5% Fusabond E226  
 \*\*\* = 3% Fusabond E226  
 “ = 2% Fusabond E226

# Comparison of mechanical properties in transversal direction (TD) (Dilution with compatibilizer)

Monolayer film of regranulate blends (TD)



All components mixed as salt & pepper blends prior to blown film process directly!

\*\* = 5% Fusabond E226  
 \*\*\* = 3% Fusabond E226  
 " = 2% Fusabond E226



# Major conclusions (Copolyamides, CoPA)

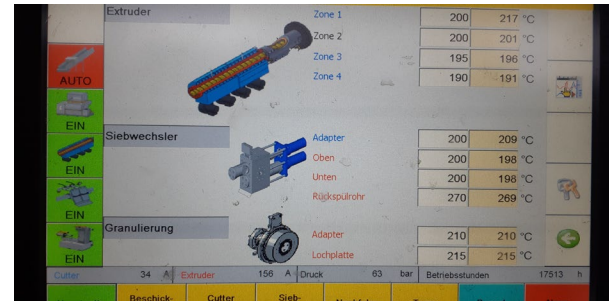
- PE/CoPA structures showed similar processability compared to PA6
  - < 10% CoPA in PE stream: processable without any compatibilizer
  - $\geq 10\%$  CoPA in PE stream: compatibilizers needed for sufficient mechanical and optical performance
- 2-3% compatibilizer sufficient to homogenize structures up to 20% CoPA (vs. 5% for PA6)
  - possible due to lower melt points and less crystallinity of CoPA
- 3 possibilities to add compatibilizer (in original film, during regranulation, or in final film processing)
  - Nevertheless salt & pepper blending is easier due to lower melt points and/or crystallinity levels
- Lower regranulation temperature of  $\sim 200 - 220$  °C provided satisfying results
- **NO drying steps** necessary
- Manufacturing of PE/CoPA regranulates might be easier compared to PE/PA6 by using standard single screw machinery. Resulting blends showed also quite acceptable visual and mechanical properties

# Agenda

- Review of Part 1 “Mechanical recycling of PE/PA6 multilayer film waste”
- Project with Institute Cyclos-HTP (New results on PE/PA6 multilayer film waste)
- Is mechanical recycling of PE/CoPA multilayer film any different?
- How is the mechanical recycling of structures with both PA and EVOH?
- Outlook

# What has been done in phase 3 (CoPA / EVOH structures)?

- Original film: PE / CoPA / EVOH Multilayer films with different Copolyamides (typical thermoforming structure)
- Regranulation (S Gran 95, NGR, Austria)



- Morphologies of regranulates analyzed
- Monolayer blown films (40 $\mu$ m) made from regranulate blends in semi-tech scale; dilution series with and w/o compatibilizer (during blown film process)
- Visual & morphological evaluation; analysis of mechanical properties of monolayer films



# Film structures (180µm total)

- Reference: PE/PE/tie/EVOH<sup>\*\*</sup>/tie/PE/PE
- Trial C1: C40LN<sup>\*</sup>(18µm)/tie/PE/tie/C40LN(18µm)/EVOH<sup>\*\*</sup>(15µm)/C40LN(18µm)/tie/PE
- Trial C2: C40LN<sup>\*</sup>(18µm)/tie/PE<sup>\*\*\*</sup>/tie/C40LN(18µm)/EVOH<sup>\*\*</sup>(15µm)/C40LN(18µm)/tie/PE<sup>\*\*\*</sup>
- Trial C3: C37LC<sup>#</sup>(18µm)/tie/PE/tie/C37LC(18µm)/EVOH<sup>\*\*</sup>(15µm)/C73LC(18µm)/tie/PE

\* Ultramid<sup>®</sup> C40LN (BASF SE) = high viscosity (RV= 4,0), lubricated, nucleated PA 6/6.6, Tm: 189°C

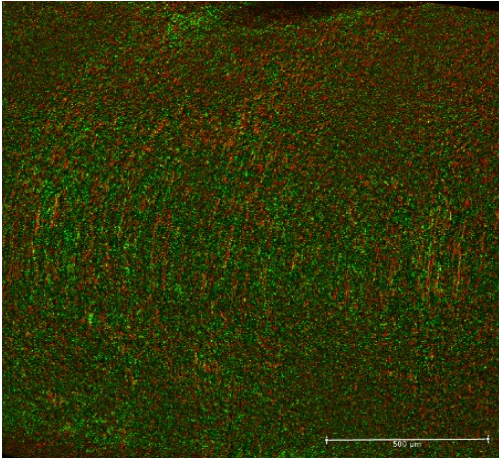
\*\* EVAL T101 (Kuraray EVAL Europe GmbH)

\*\*\* Retain 3000 (compatibilizer, Dow Chemicals Inc.), 2 x 2,5% incorporated

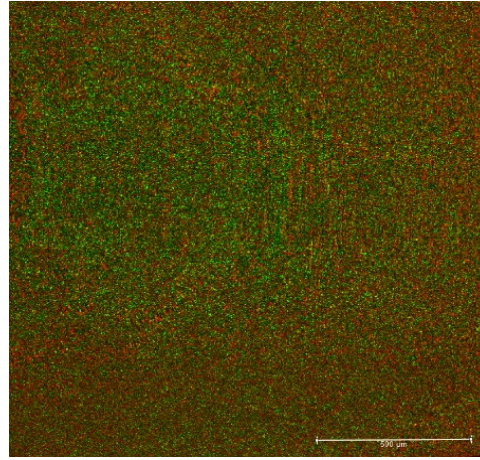
# Ultramid<sup>®</sup> C37LC (BASF SE) = med-high viscosity (RV 3,7), lubricated PA 6/6.6, Tm: 182°C  
(nucleating MB added)

# Morphologies IV - Comparison of regranulates

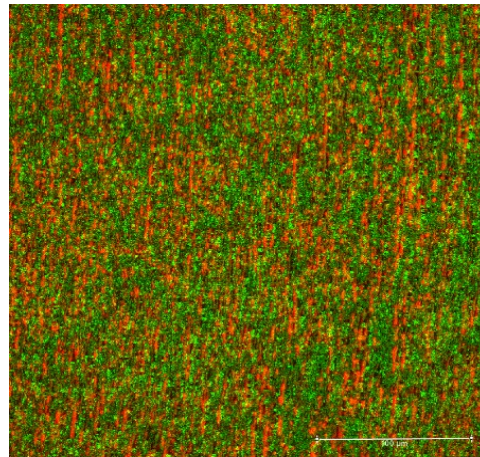
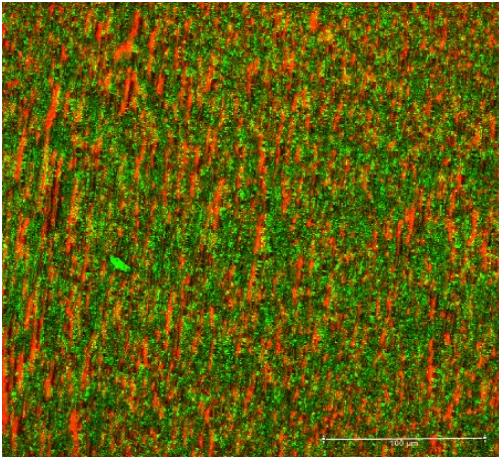
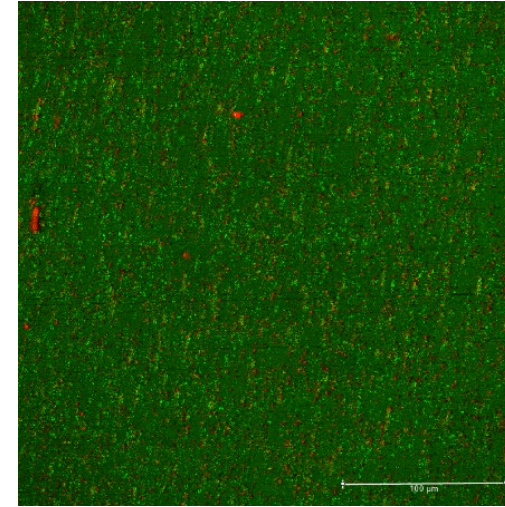
Regranulate C1 (C40LN)\*



Regranulate C2  
(C40LN-pre-compatible)\*\*



Regranulate PE/EVOH#



- \* 33% C40LN / 8%EVOH
- \*\* 33% C40LN / 8%EVOH / 5%E226
- # 5% EVOH, not dedicated reference

# Recipe overview III – 1<sup>st</sup> PE/CoPA/EVOH screening

Trials	Reg C1*(%/ %CoPA)	Reg C2**(%/ %CoPA)	Reg PE#(%)	Comp F## (%)
6.1		100 / <b>34</b>	-	-
6.2	-	50 / <b>17</b>	50	-
6.3	-	25 / <b>8,5</b>	75	-
6.4	50 / <b>17</b>	-	45	5
6.5	25 / <b>8,5</b>	-	72,5	2,5
6.6	25 / <b>8,5</b>	-	75	-
6.7	8 / <b>2,72</b>	-	92	-

\* 34% C40LN / 8% EVOH  
 \*\* 34% C40LN / 8% EVOH / 5% E226  
 # PE Regranulate  
 ## Fusabond E226

All blends mixed on blown film machine as s&p directly!!

Processing information:

- Weber 30 air cooled blown film,
- 30mm screw diameter, L/D = 25
- 50mm die diameter
- 40 µm total thickness
- Temperature profile:  
200°C/210°C/210°C/210°C
- Melt temperature 210-215°C

# First conclusions (PE/(Co)PA/EVOH structures)

- PE/CoPA/EVOH – film waste regranulated at temperature levels of ~ 200 – 210°C
- No degradation, degassing, discolouring etc. observed
- Blown film operation of monolayer films made out of regranulate blends also possible at reasonable temperatures (appr. 210°C) without additional drying !
- Microscopical investigations confirmed less impact of pre-compatibilization to morphologies
- Evaluation of monolayer films in progress, most likely reproduction trials necessary



**Will be continued**

# Agenda

- Review of Part 1 “Mechanical recycling of PE/PA6 multilayer film waste”
- Project with Institute Cyclos-HTP (New results on PE/PA6 multilayer film waste)
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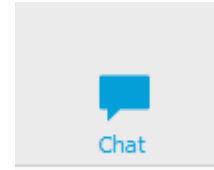
# Next steps

- Completion of cyclos-HTP trials (CoPA, general spec for compatibilizers) *(in progress)*
- Change of Recyclability categorization of PA (out of “contaminant”) in a recycling stream of packaging group “Film and LDPE“ in Minimum Standard\* from German Central Agency Packaging Register *(initiated)*
- Industrial scale trials @ mechanical recyclers *(in preparation)*
- Reproduction trials using EVOH – containing barrier film structures *(in progress)*
- Recyclability study of representative laminates *(via CEFLEX, in preparation)*

**Thank you for listening!**

# Questions

- But please, feel free to ask questions using the **chat**
- Please **raise your hand**, we will call you, unmute yourself and ask your question



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