

Compatibilizing PP and PET – an approach for recycling of unseparable plastic streams

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Overview

▪ Introduction

- Short status of plastics recycling in Europe
- Upcoming challenges
- Why blends? – the motivation behind
- Compatibilising the phases

▪ Materials & Methods

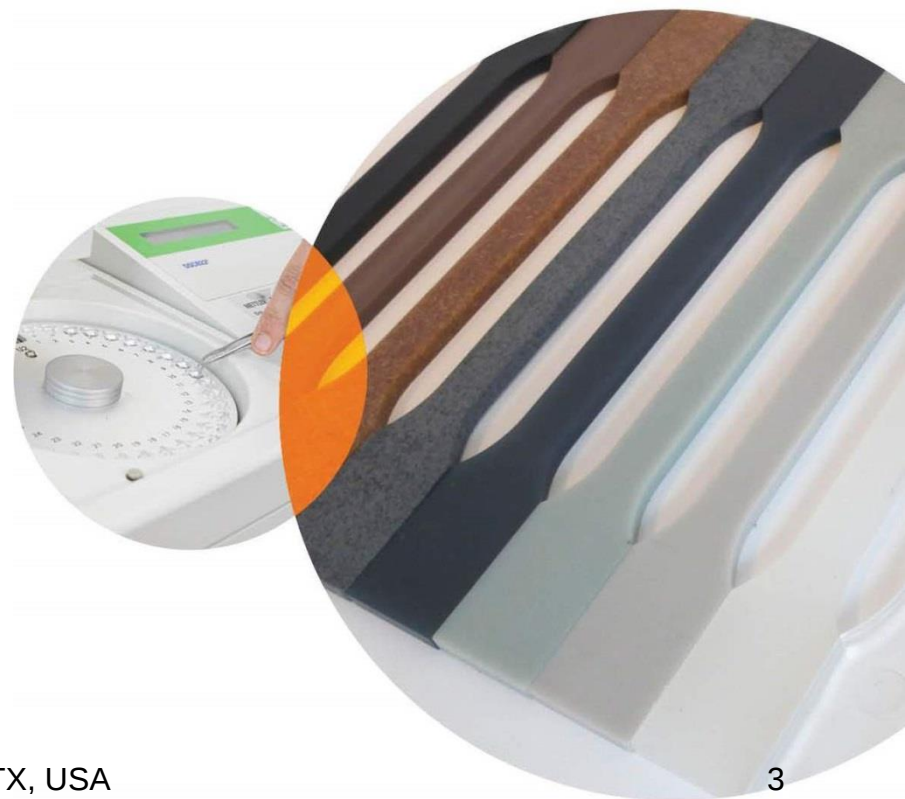
▪ Results & Discussion

- Influence of formulation
- Influence of processing route
- Stability of blend phase distribution

▪ Conclusions



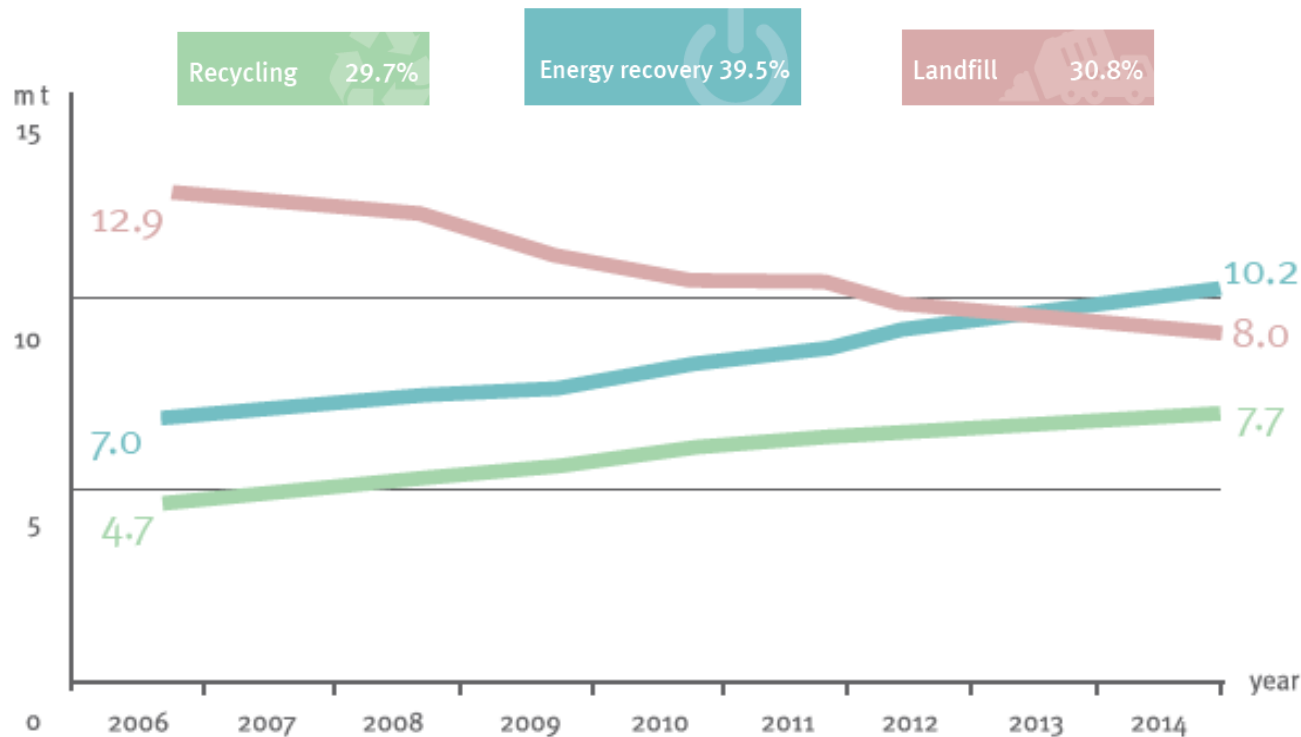
Introduction





Introduction

- Plastics recycling is an important business in Europe
 - annual post-consumer plastics waste is approx. 25 million tonnes



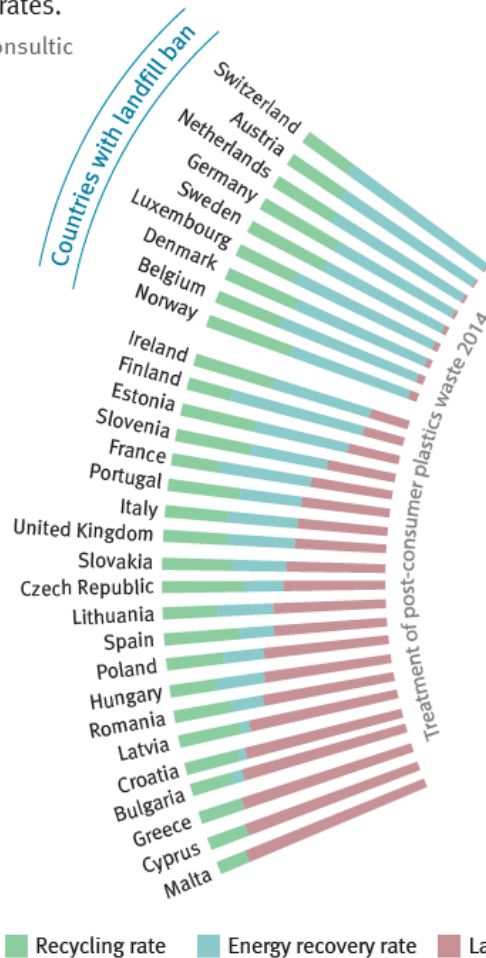
source: *Plastics the facts 2016*, www.plasticseurope.org



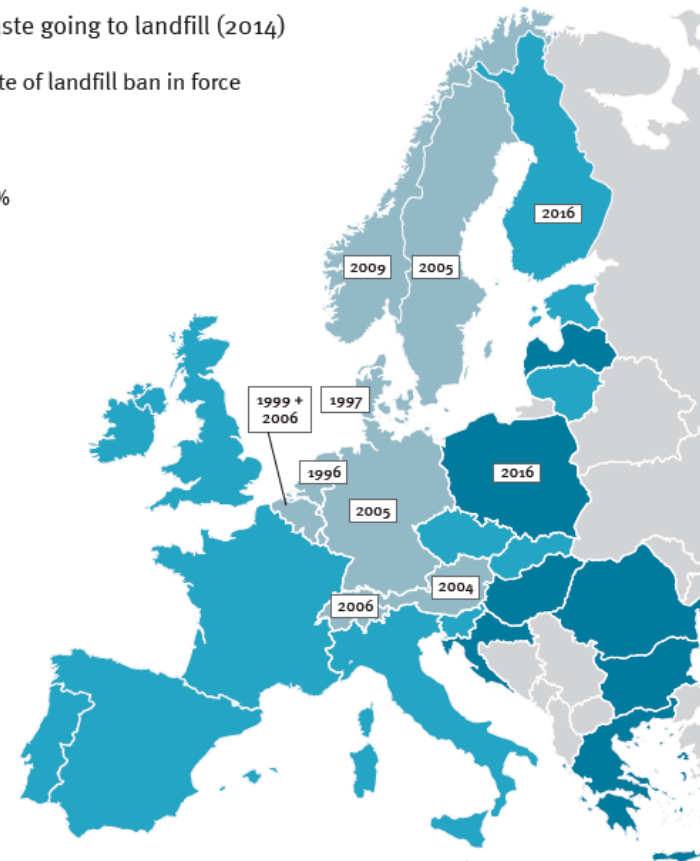
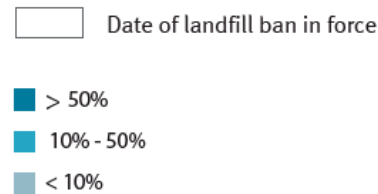
Introduction

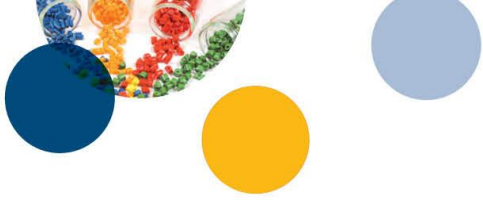
In 2014, landfilling was still the 1st option in many EU countries. In general, countries with landfill ban achieve higher recycling rates.

Source: Consultic



Plastics waste going to landfill (2014)





Introduction

- What will be the next steps?
- EU legislation sets new goals with the new regulations
 - recycling quote: 50% from 2025, 55% from 2030 for plastics packaging
 - collection quote of 77% for plastic bottles from 2025, 90% from 2029
 - mandatory minimum recycle content in bottles of 25% from 2025
 - fee for not recyclable plastics packaging of 800 €/t from 2021
 - anti-littering: producers have to pay for cleaning
 - ban of some single use plastics
- the question is how to reach that?



Introduction

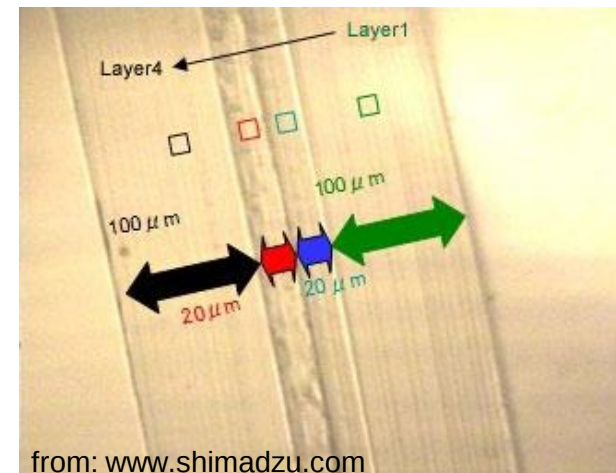
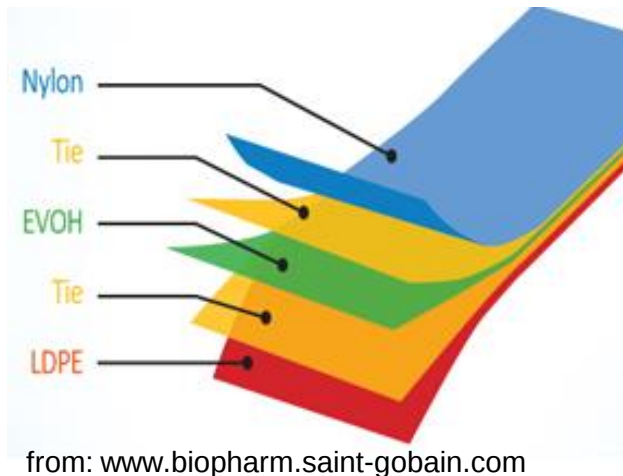
in Austria:

- bottles are already well collected (71%) and recycled, but these are only a small share of the set target of 50% overall packaging recycling quote
- other applications are still underdeveloped in regard to mechanical recycling
 - also due to lack of incentive for commercial waste
- also, some products are said to be non-recyclable, especially multilayer materials



Introduction

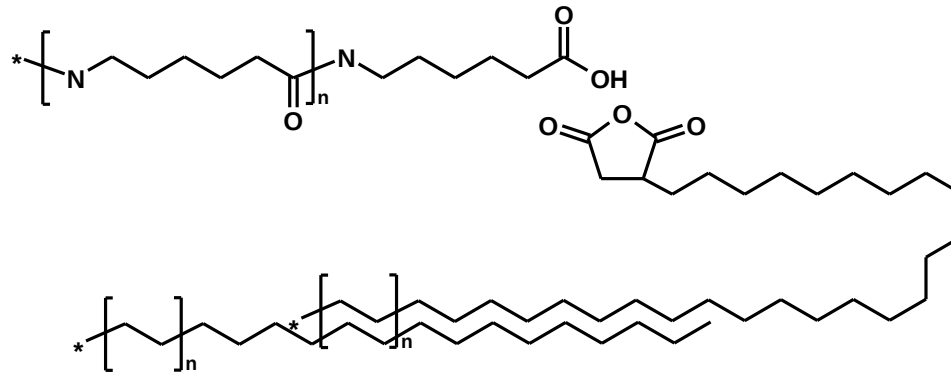
- tailoring properties via multimaterial combinations is a widespread approach in packaging films to fulfil the different requirements
- in film production, off spec rolls and edge trim represent high volumes (although only low percentage of the production itself) which cannot be re-used due to incompatibility



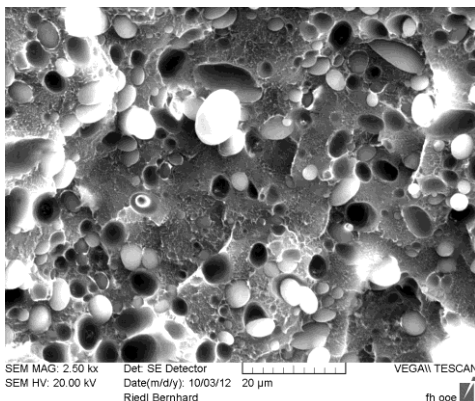


Compatibilisation

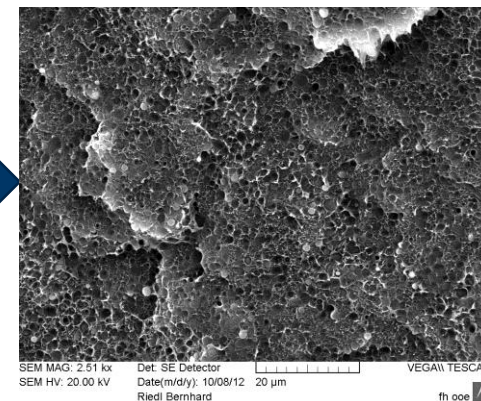
- for binary blends, adding bi- or multifunctional materials, which can interact with both material phases present, improve materials properties due to reducing dispersed phase size



75HDPE-25PA6



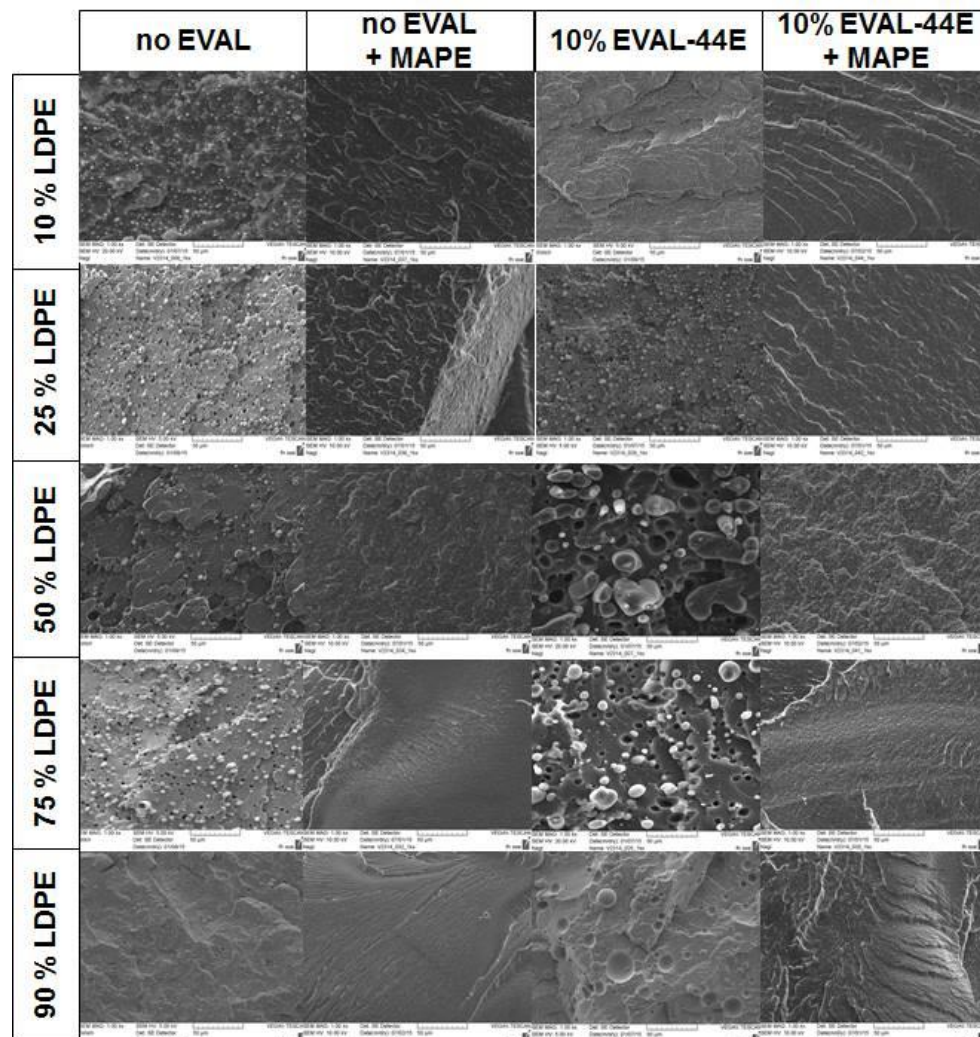
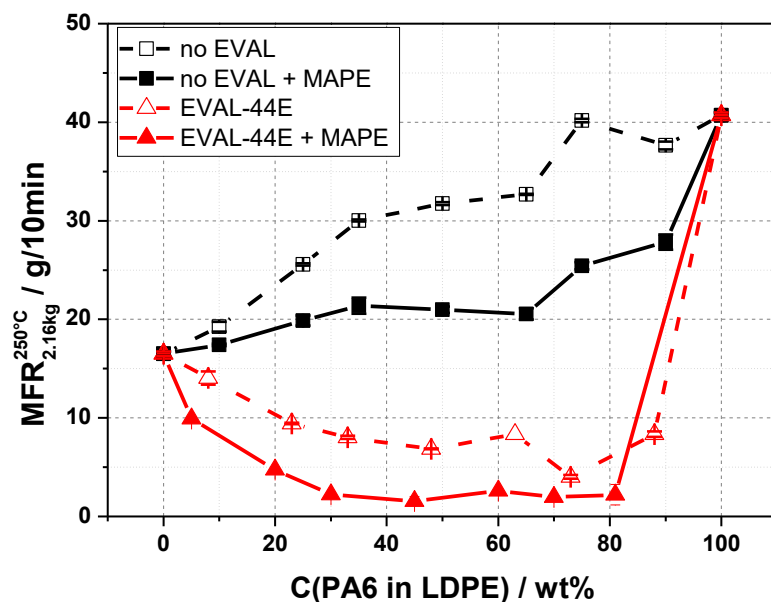
+ 2% MAH-PE





Compatibilisation

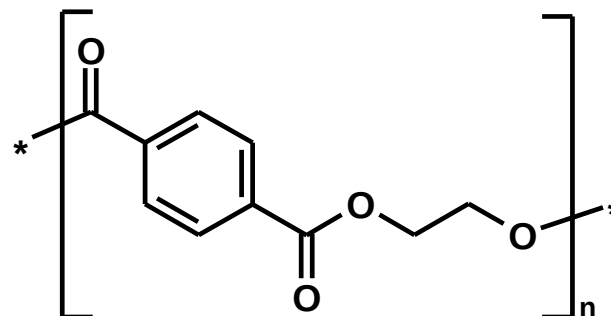
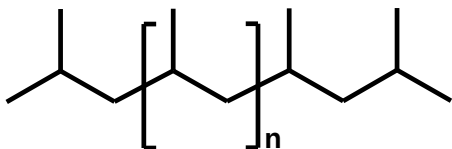
- is also possible for multiphase systems, the compatibilizer has to be adjusted to the blends components





Aim of the work

- investigate the effects of composition and processing on the properties of PP-PET blends
 - with and without compatibilisation
 - processed via twin and single screw extrusion
- to better understand the mechanisms taking place in this blend system





Materials & Methods





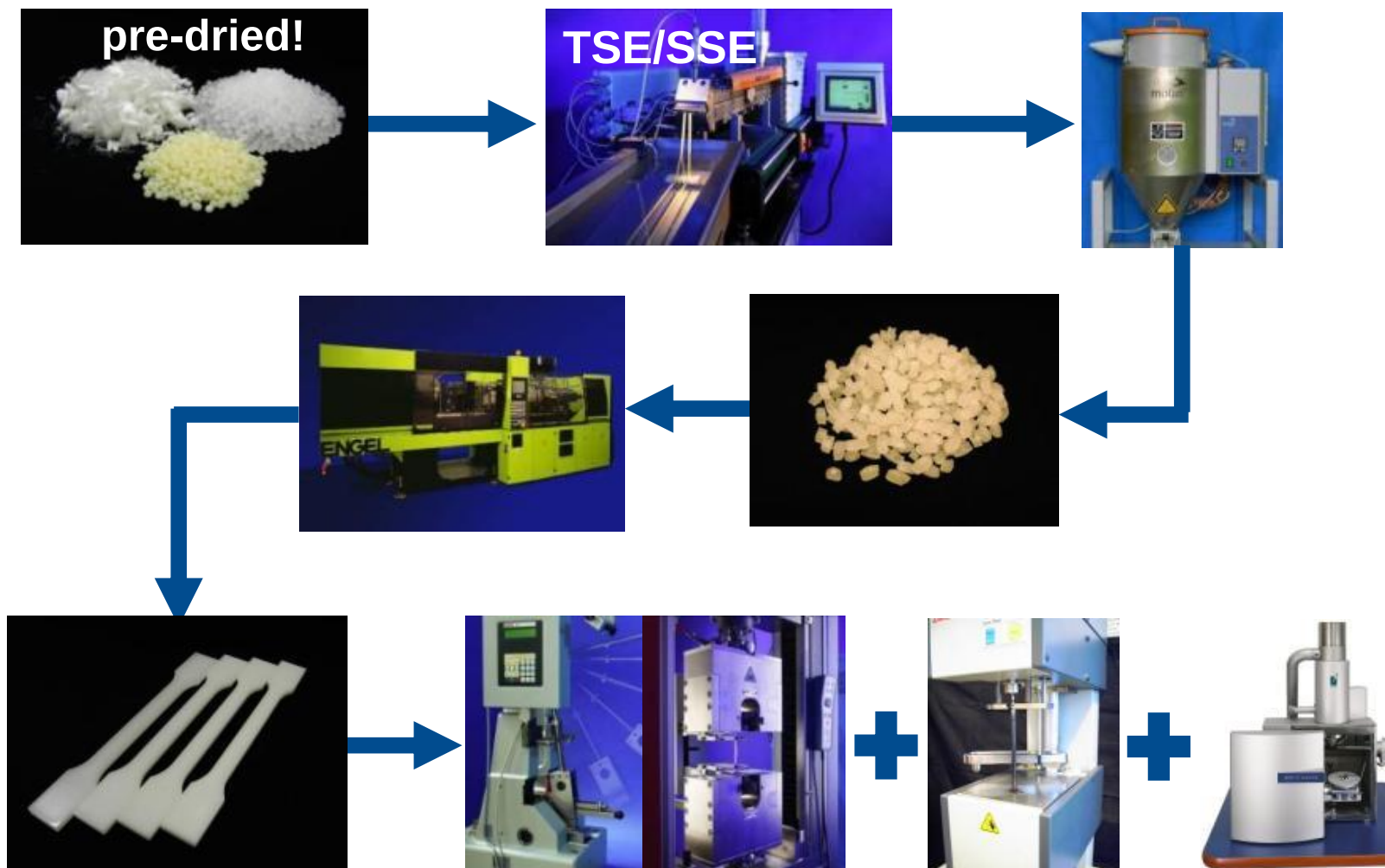
Materials

Blend constituent	MFR/MVR (@ 2.16kg)
PP-2	2 g/10min @ 230°C
PP-55	55 g/10min @ 230°C
PET	40 cm ³ /10min @ 280°C
MAPP	70 g/10min @ 230 °C

- formulations prepared:
0, 10, 25, 50, 75, 90, 100 wt% of PA6 in LDPE
- MAPP was added as 2 (or 5) wt%, reducing PP share for 2 (or 5) wt% and keeping PET constant

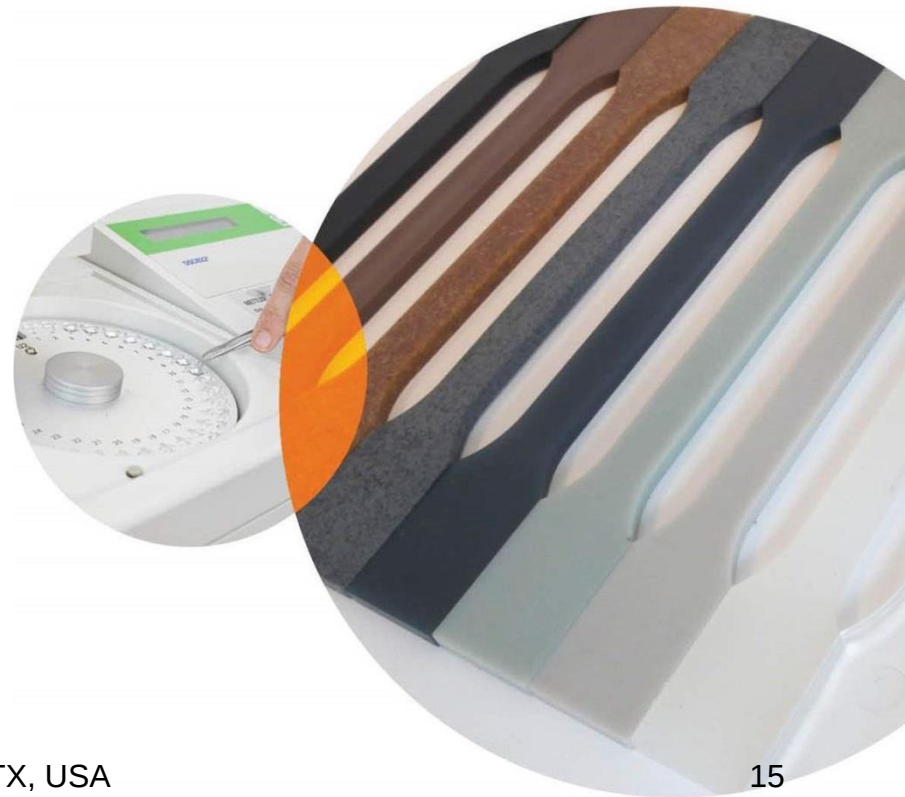


Methods





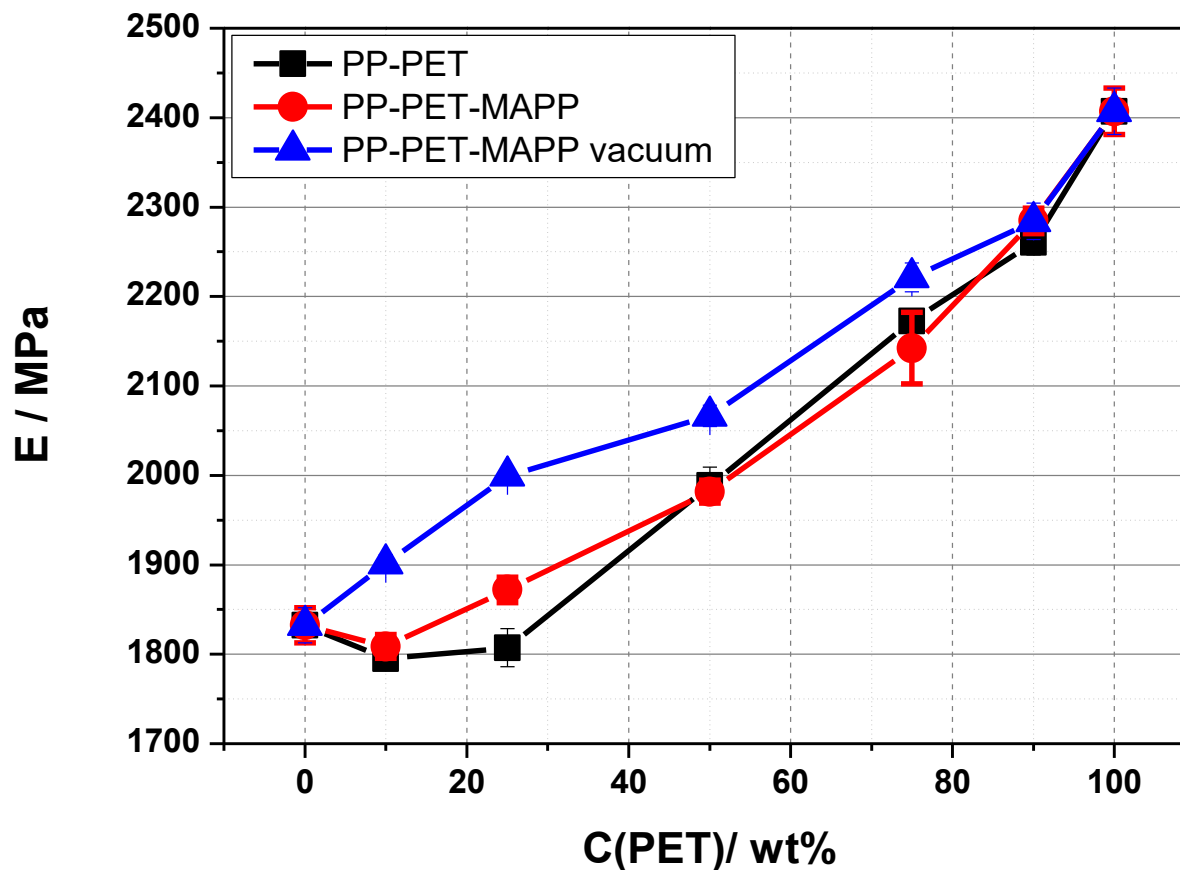
Results & Discussion





Results – Twin screw extruder

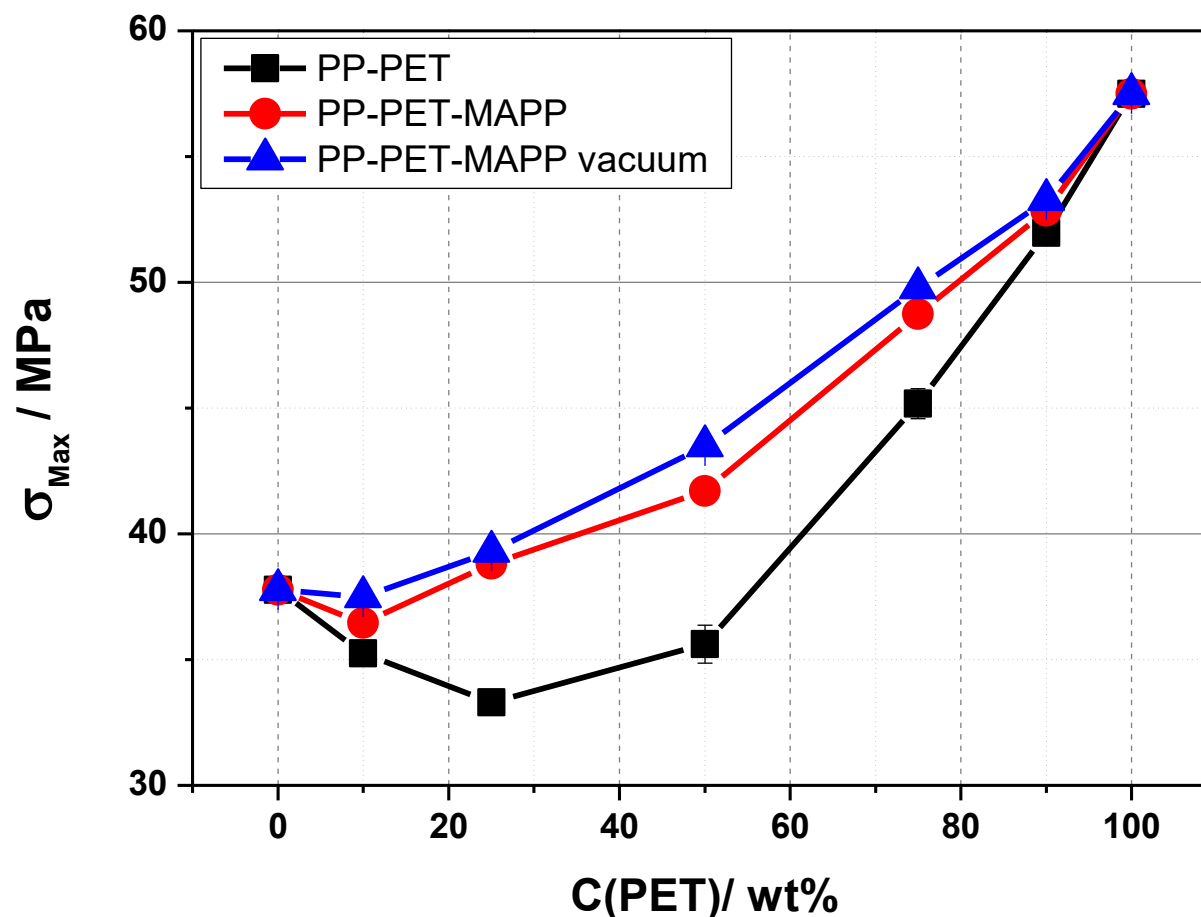
- elastic modulus shows nearly linear behaviour due to good dispersion, vacuum degassing is improving the materials properties





Results – Twin screw extruder

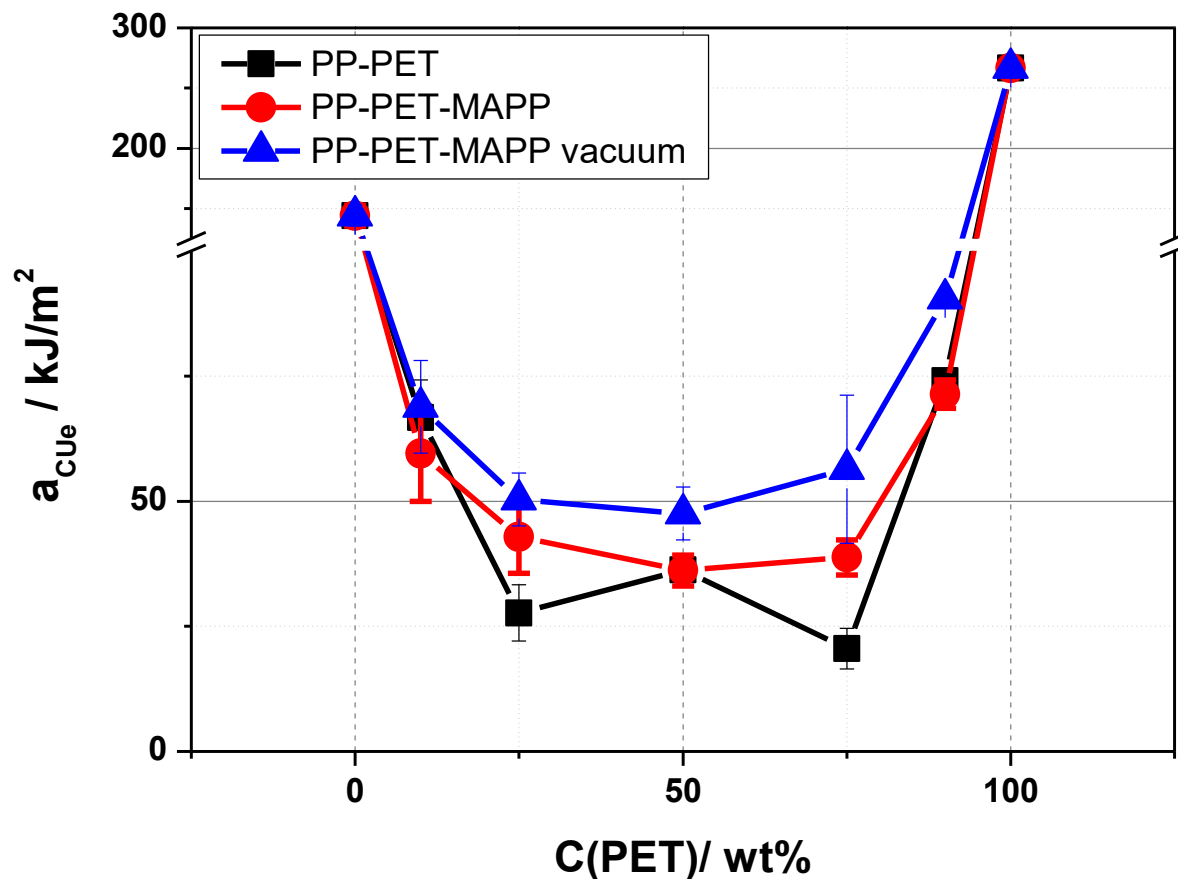
- compatibilizer improves interaction, vacuum degassing even further





Results – Twin screw extruder

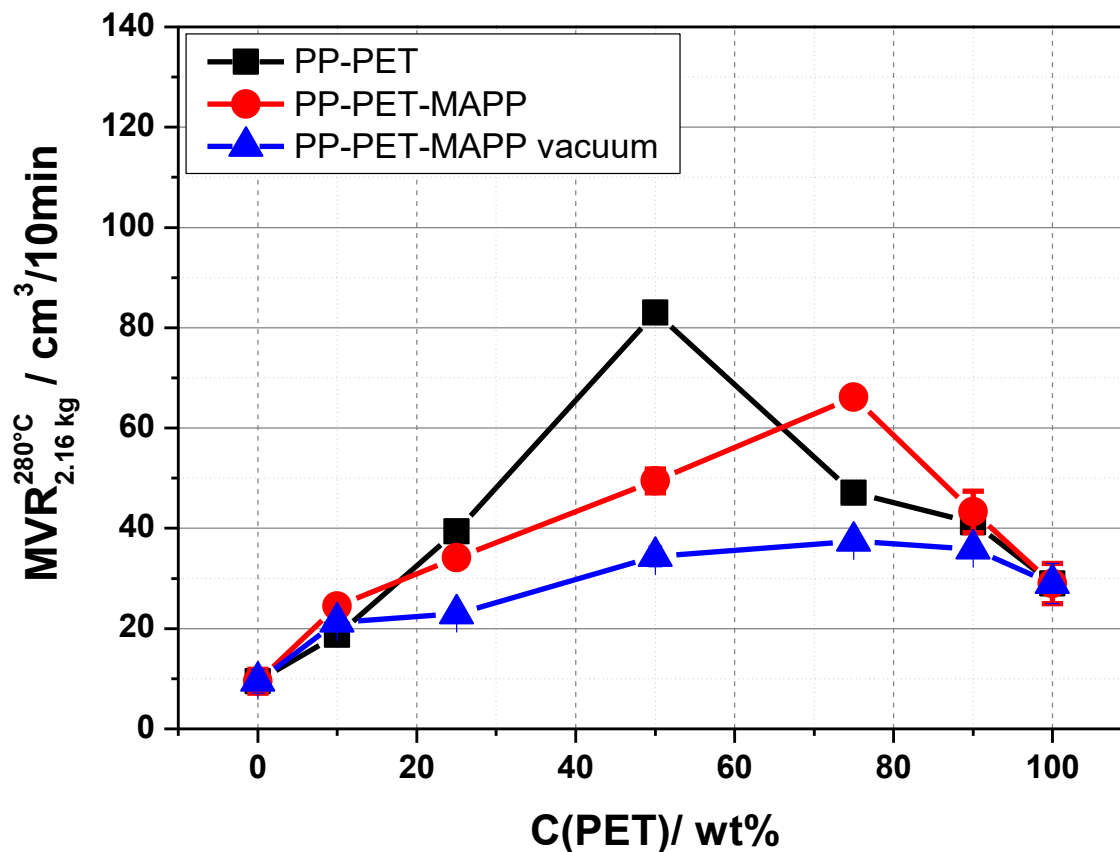
- Unnotched Charpy impact strength shows effect similar to tensile strength





Results – Twin screw extruder

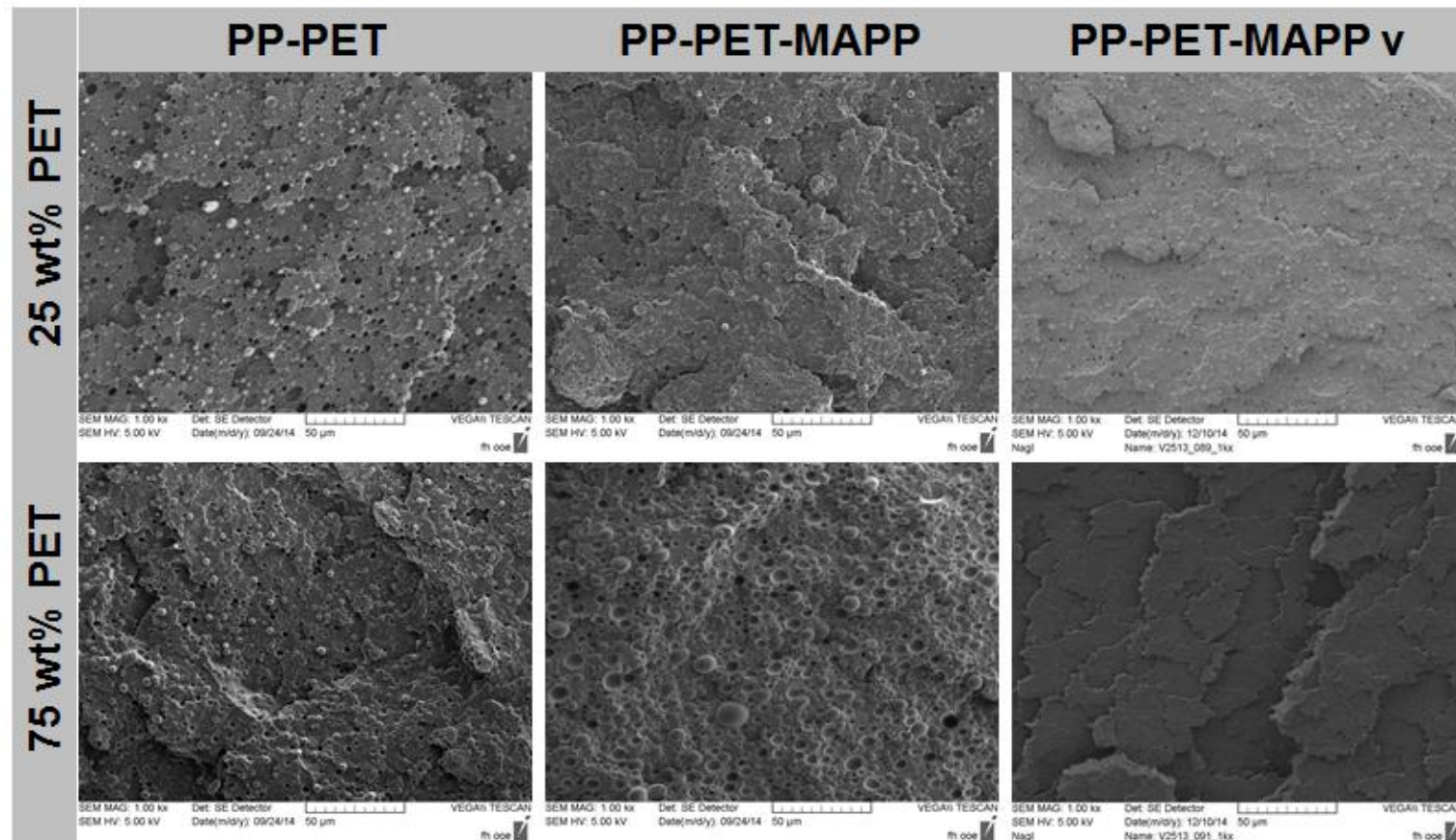
- viscosity increases (MFR decreases) with compatibilisation and even further with vacuum degassing





Results – Twin screw extruder

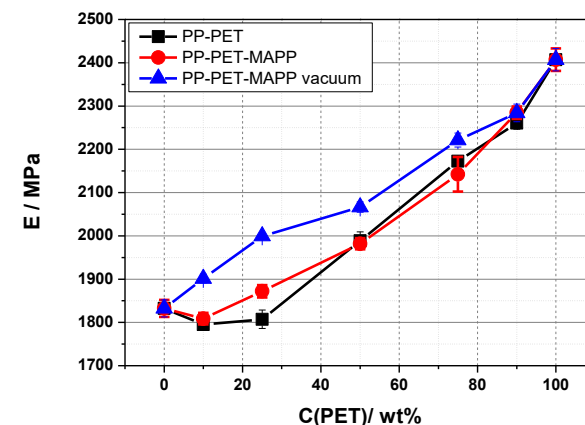
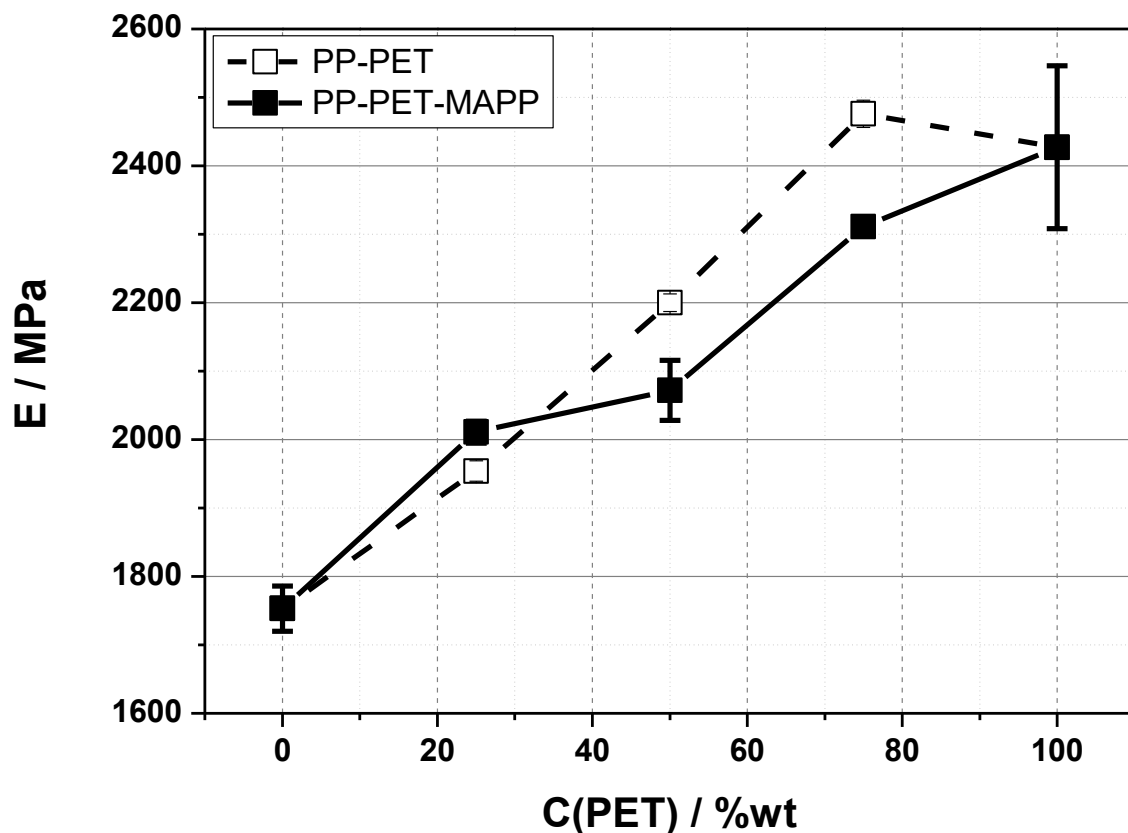
- morphology confirms findings, shows two regimes depending on the main blend component





Results – Single screw extruder

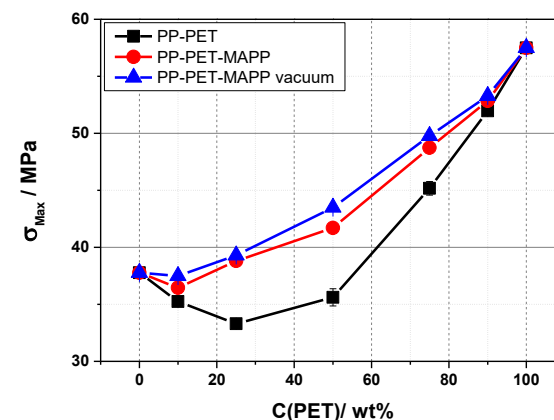
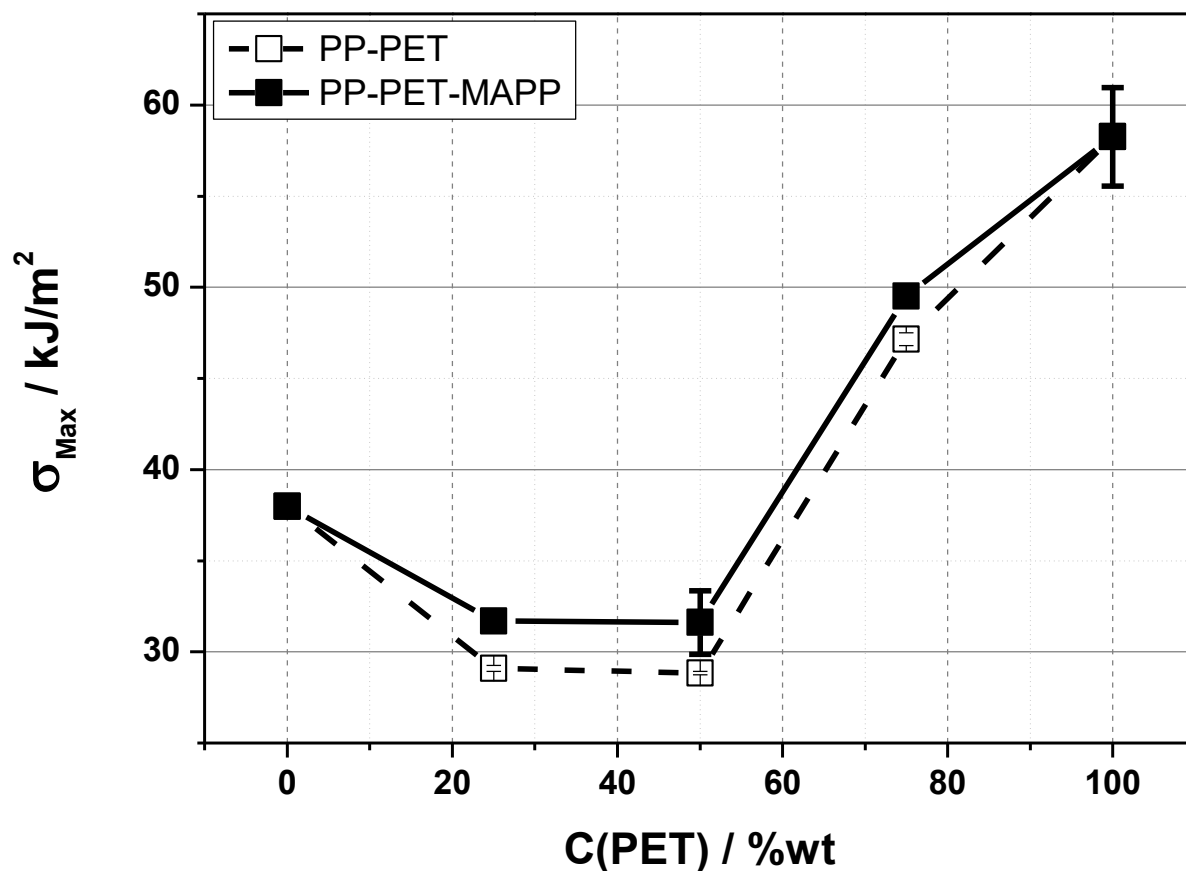
- nearly linear behaviour found again, but MAPP shows only limited improvement – SSE & TSE show similar behaviour





Results – Single screw extruder

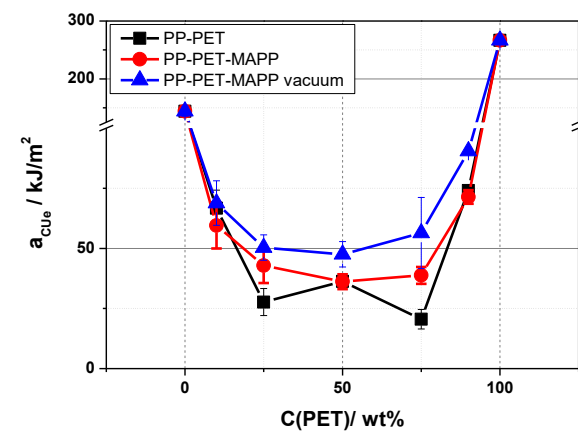
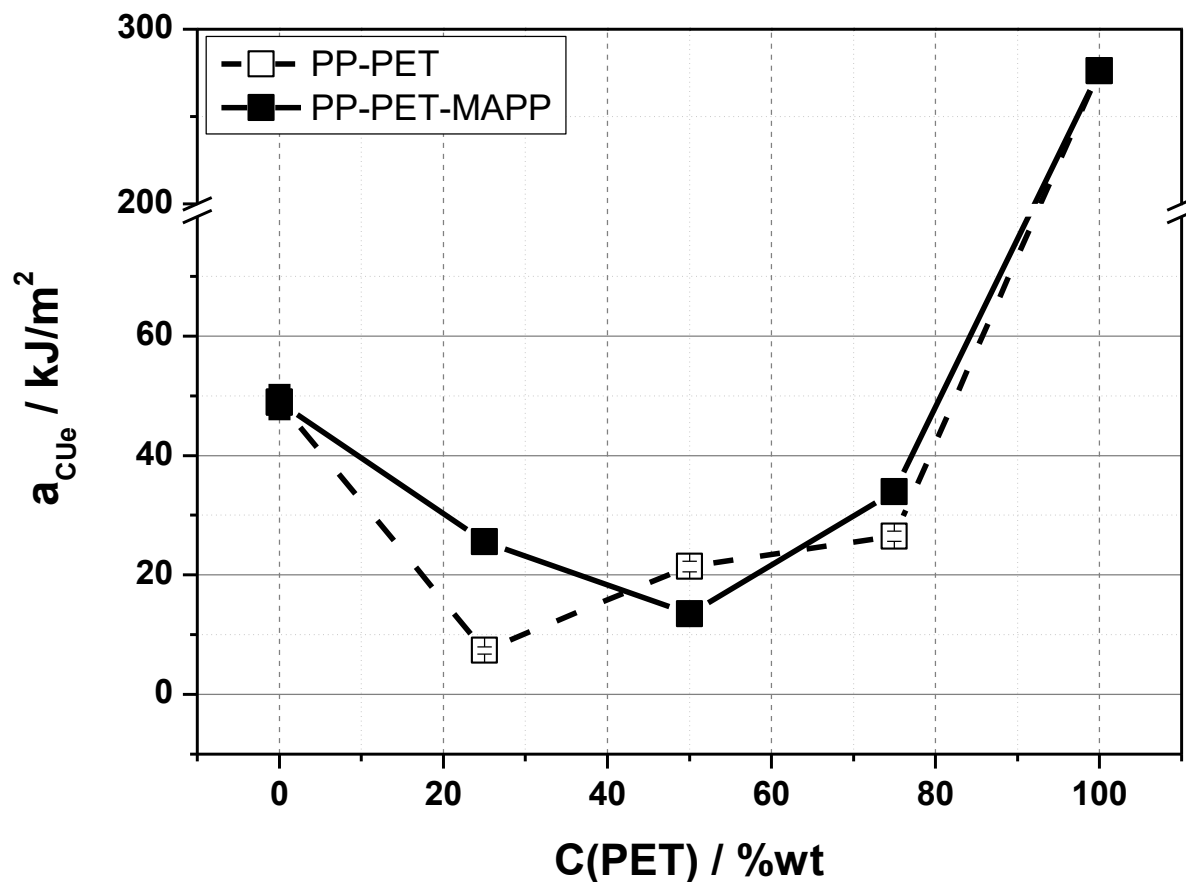
- decrease suspected to be from hydrolysis and incompatibility, MAPP shows some benefit – SSE & TSE show similar behaviour





Results – Single screw extruder

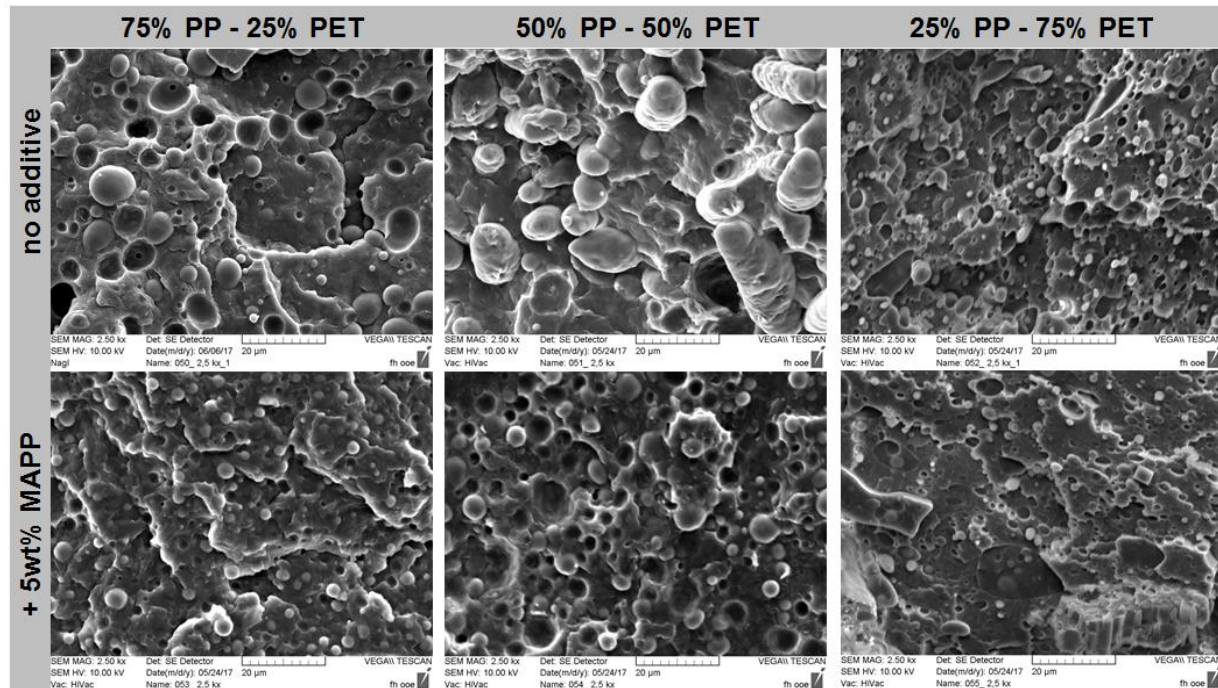
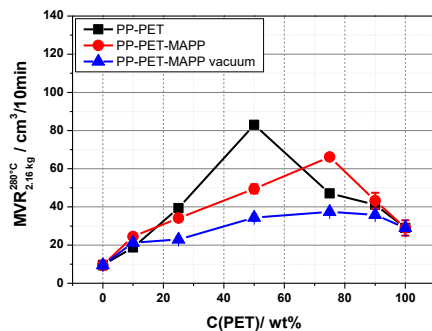
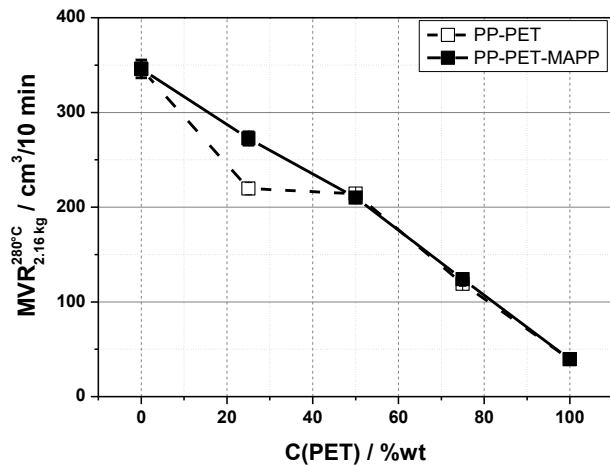
- mechanical properties due to incompatibility, MAPP shows some benefit – SSE & TSE show similar behaviour





Results – Single screw extruder

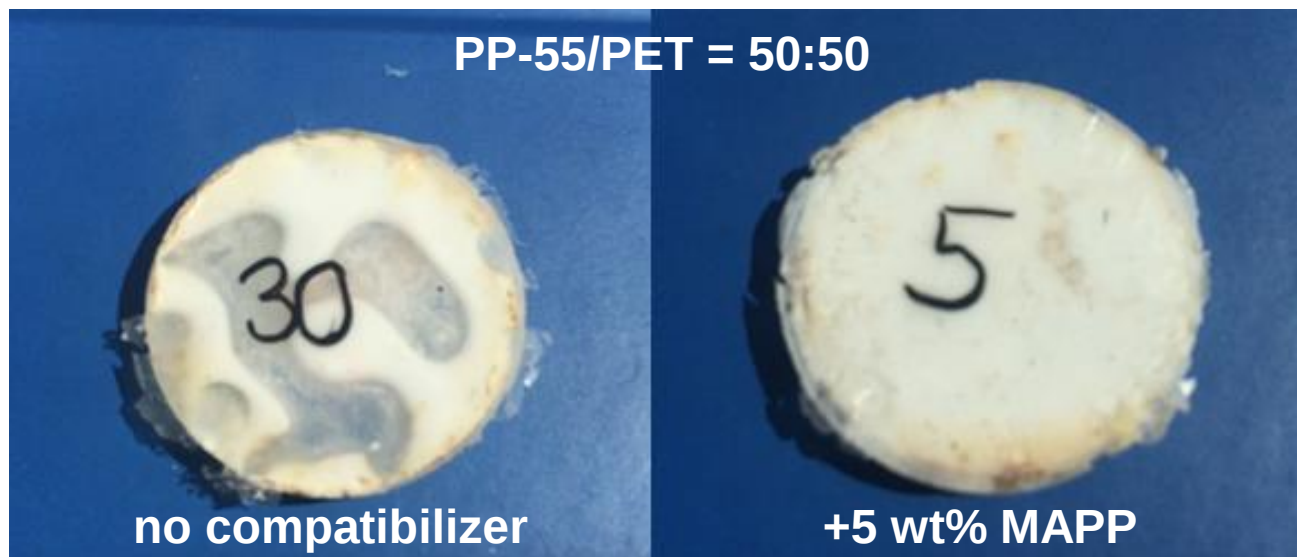
- distributed phase size differences originate from viscosity ratio, MAPP shows some positive effect





Results – Stability of phase distribution

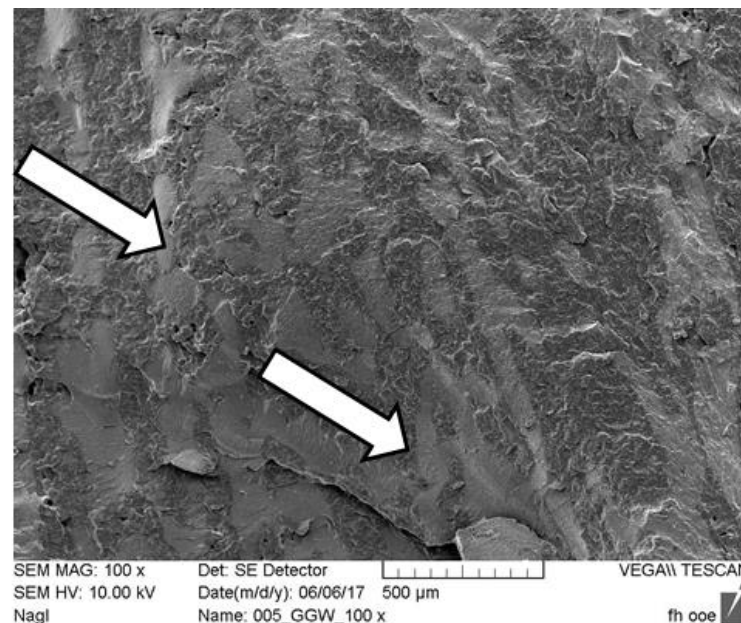
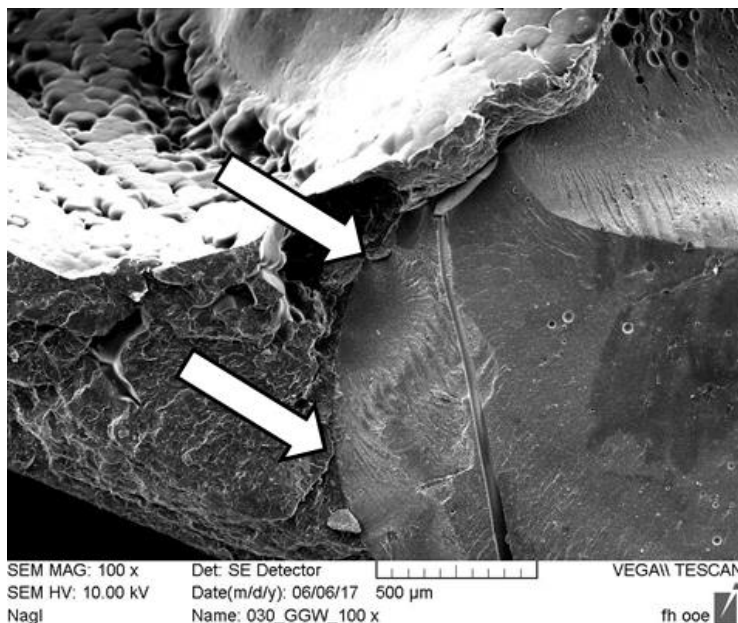
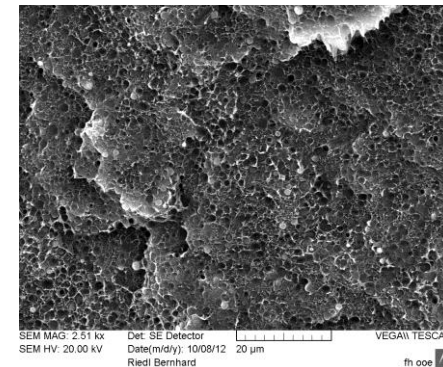
- hot storage experiment (270°C, vacuum, 1 h)
- phase size distribution is stabilized with a compatibiliser, also after hot storage (thermodynamic equilibrium)





Results – Stability of phase distribution

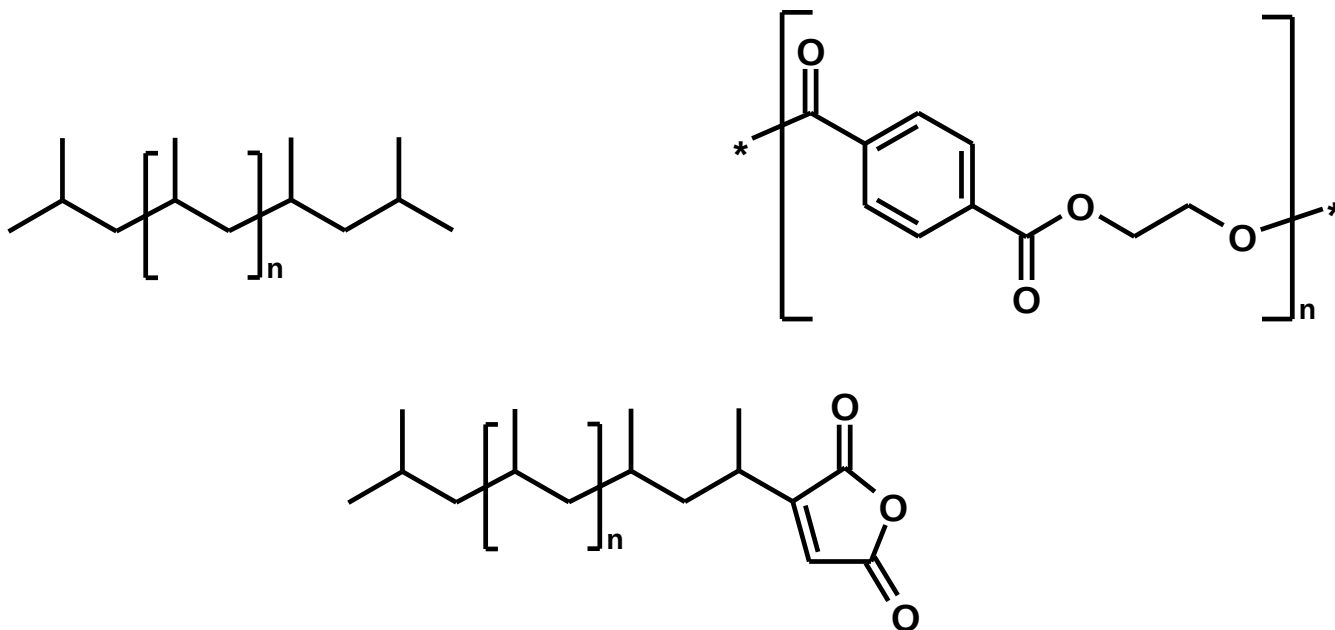
- phase size distribution is stabilized with a compatibiliser, but is coarse compared to other compatibilised blends





Results – Stability of phase distribution

- limited effect of compatibilizer may be due to limited number of MAH-groups in the MAPP or limited bonding sites with the PET





Conclusions





Conclusions

- in the blend system PP-PET
 - quasi-static properties are relatively high due to the mixing intensity of TSE
 - additional improvement is found with the addition of MAPP and vacuum degassing
 - processing with the SSE shows different results, mostly due to a lack of degassing
 - adding a compatibilizer stabilizes the phase distribution, but the phases are relatively coarse compared to other blends
- in general, for PP-PET-blends, hydrolysis has to be considered in addition to compatibility issues
- this shows that for the material mixture, recycling is possible, although pre-processing steps have to be considered for proper post-consumer recycling



Acknowledgements

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- the different company partners for participating in TCKT's projects
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Thank you for your attention!

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