Mechanical recycling of post-consumer polyethylene packaging waste

A research project involving
research student Ezgi Ceren Boz Noyan
and post-doc Abhijit Venkatesh,
supervised by Professor Antal Boldizar

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Environment Fund

General problem

Strong incentives for increased plastics recycling, such as seen in public debate, legislation and industry.

Currently in EU, about 10 % of consumed plastics are mechanically recycled into new products.

What about the obstacles? Expected properties and processability?

Purpose

To study **the influence of recycling process** on the functional properties of next generation products.

Departing from **large-scale sorted polyethylene packaging waste** (flexible film and rigid fractions),what are the **effects of washing, compounding and shaping processing** on the final properties?

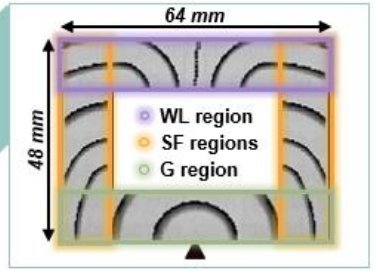
Sample preparation

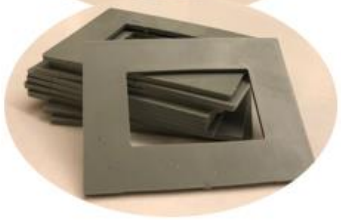
Lab-scale processing

Washing
- 25 °C, with water only
- 25 °C, with detergent
- 80 °C, detergent, NaOH

Compounding
- 200 °C
- 240 °C
- 260 °C

Injection moulding



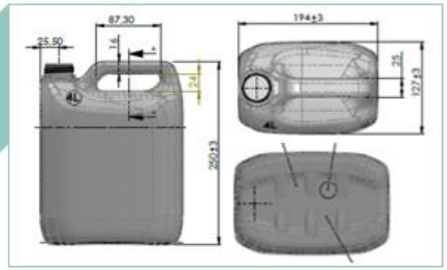


Pilot-scale processing

Washing
- 40 °C, with detergent
- 40 °C, with detergent, NaOH
- 80 °C, with detergent, NaOH

Compounding
- with vacuum
- without vacuum
- with water and vacuum

Blow moulding



Main results

Washing and compounding at **severe conditions can degrade** the polyethylene and **reduce the thermo-oxidative stability.**

Washing at 40 ºC or less with detergent instead of at 80 ºC with also NaOH.

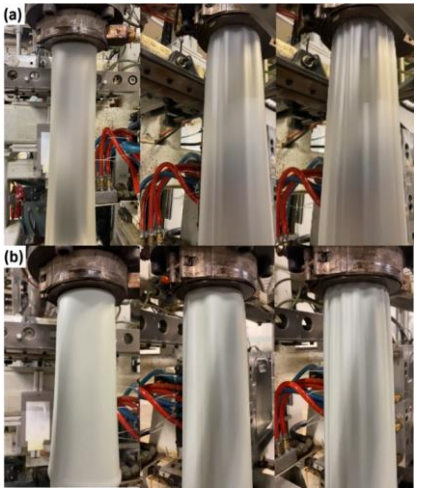
Compounding at 200 ºC and short residence time instead of at 260 ºC and prolonged mixing settings.

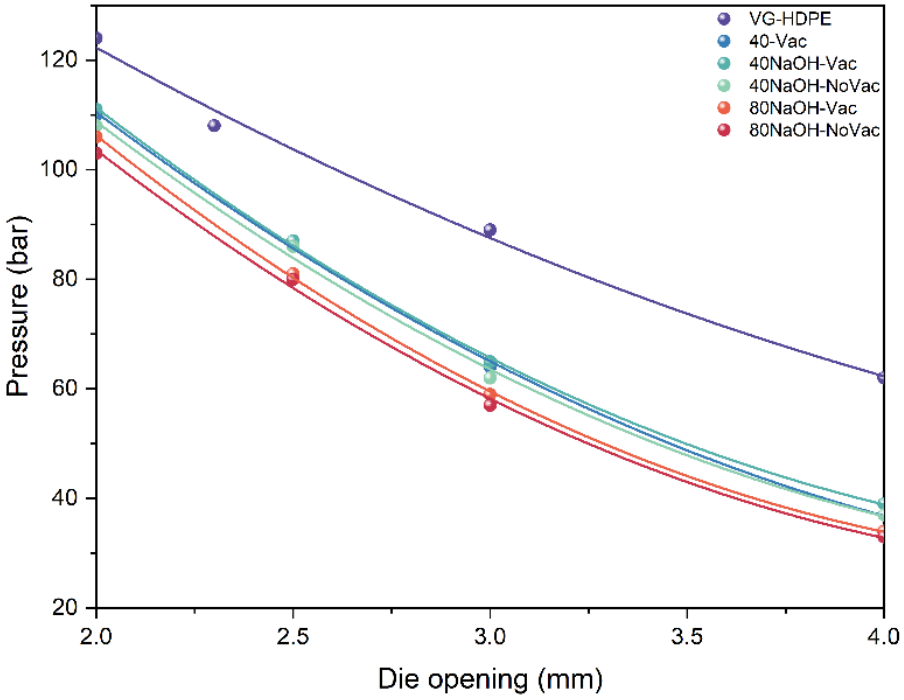
Lab-scale processing

Sample	T_{ox} (°C)
S_LW-W_200	215
S_LW-W_240	209
S_LW-D_240	222
S_LW-W_260	202
N_LW-W_200	215
N_LW-W_240	213
N_LW-D_240	218
N_LW-W_260	202
N_IW_200	229
N_IW_240	226
N_IW_260	218

Mould blowing

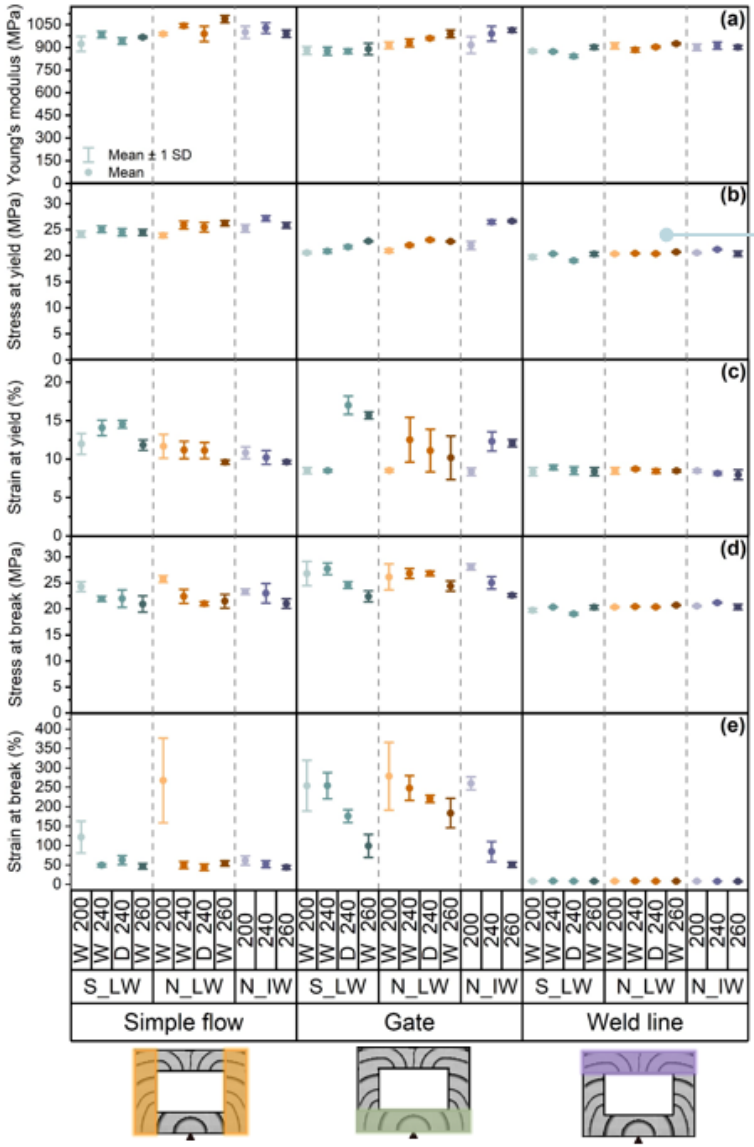
- Shaping of the parison (the tube)
- Inflating the parison
- Cooling





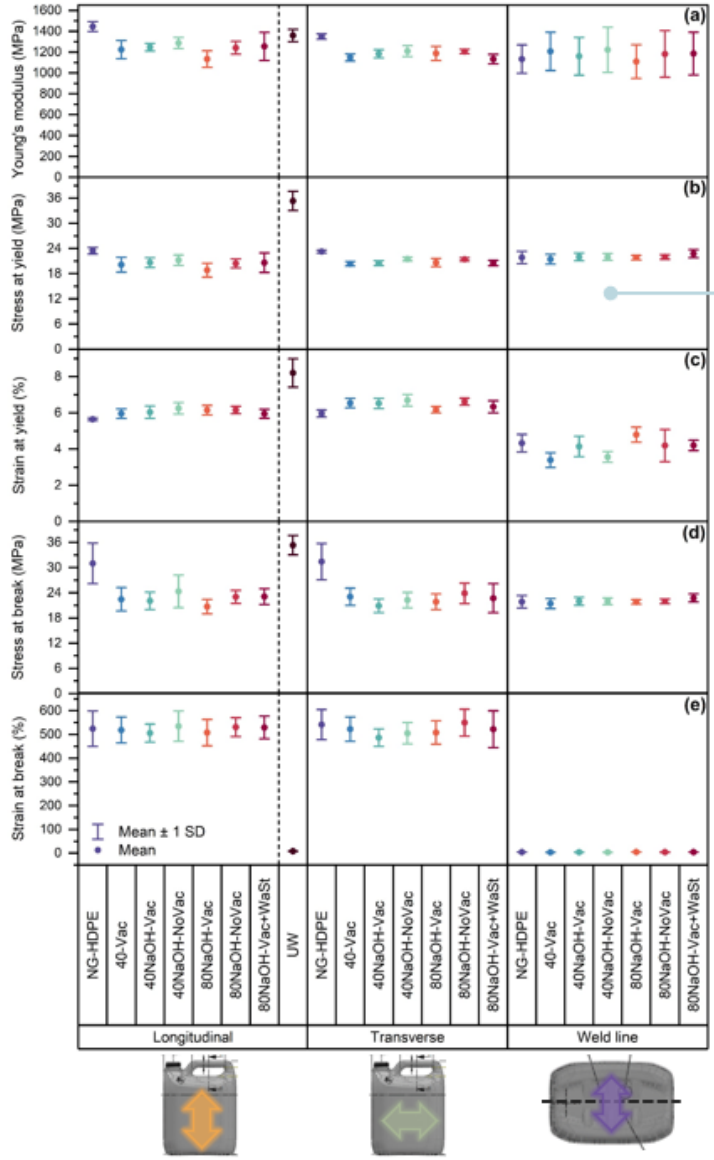
The recycled packaging PE showed lower flow resistance, as seen from lower pressure at given die opening and similar low tendency for pleating.

Lab-scale processing



19-21 MPa

Industrial-scale processing



General conclusions

At recycling of post-consumer packaging waste, care should be taken to

- Contamination and purity
- Durability aspects, such as due to **polymer degradation and the content of active thermo-oxidative stabilizers**
- **A shift of processing parameters at shaping,** mainly according to the rheological properties

Publications

Mechanical and thermal properties of mixed PE fractions from post-consumer plastics packaging waste. Boz Noyan, E.C.; Venkatesh, A.; Boldizar, A., ACS Omega, 2022, 7, 45181-45188. doi: 10.1021/acsomega.2c05621.

Washing post-consumer flexible polyethylene packaging waste. Boz Noyan, E.C.; Venkatesh, A.; Boldizar, A. Recycling, 2022, 7, 90. doi: 10.3390/recycling7060090.

A comparison between laboratory-scale and large-scale high-intensity washing of flexible polyethylene packaging waste. Boz Noyan, E.C.; Boldizar, A., Polymer engineering and science, 2024, 64, 1877-1886. doi:10.1002/pen.26674.

Rheological and functional properties of mechanically recycled post-consumer rigid polyethylene packaging waste. Boz Noyan, E.C.; Rehle, F.; Boldizar, A., Materials, 2024, 17, 1855. doi: 10.3390/ma17081855.

Blow moulding of mechanically recycled post-consumer rigid polyethylene packaging waste Boz Noyan, E.C.; Boldizar, A. Accepted to be published in Polymer engineering and science.

Thesis ”Mechanical recycling of polyethylene packaging waste” to be defended on October 18th at 10.00 in room VDL, Chalmers.