Master's Thesis Engineering Technology

2021-2022

Microinjection moulding and material testing of polyolefins on a small scale

Cannas Luca

Master of Chemical Engineering Technology

Context

Today, the development and study of **new materials** is an exceptionally **long** and **costly** process. In addition, to study the processing behaviour requires **copious amounts of material**. In quick time-to-market scenarios, going through these cycles requires using fast techniques and many of those are readily available. The most challenging of all the required steps is the **polymer processing step**. To accelerate the material development stage, the required amount of material used in the processing step, analyses methods, and system purging should be decreased. For this study, the suitability of **microinjection moulding** for small-scale polymer research is analysed [1] [2].

Polypropylene (PP)

- 515A (Sabic)
- PHC31-81 (Sabic)
- XXX (Sabic)

515A and PHC31-81: **Pelletized**; XXX: **Powdered**

- Mechanical properties
- Thermal + chemical resistance
- Versatile processability
- Low density
- Low cost


Figure 1: Fanuc ROBOSHOT S-2000i308 injection molding machine [3].

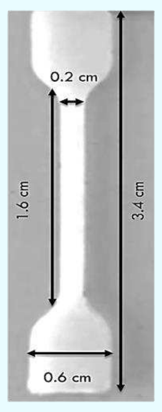

Figure 2: Tensile bar dimensions (0.2g).


Figure 3: PP25 and PP08 rigid probes.

Objectives

Material reduction

- Part fabrication
  - 0.2/2g→ 0.2/1g
  - Single shot
- System purging

Examination conventional mechanical testing techniques

- Small ←→ Normal sized samples

Rheological analysis

- PP25 (79044)
- PP08 (5681)

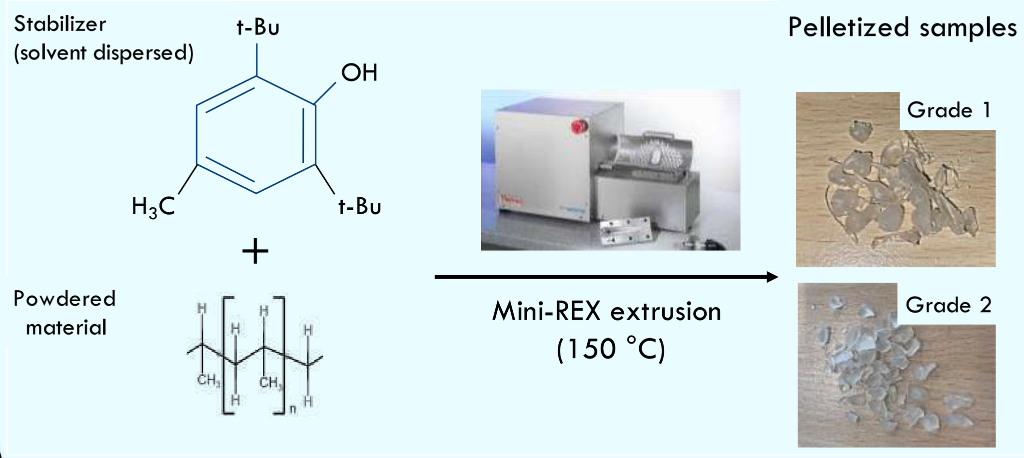

Figure 4: Pelletization procedure for powdered materials [4].

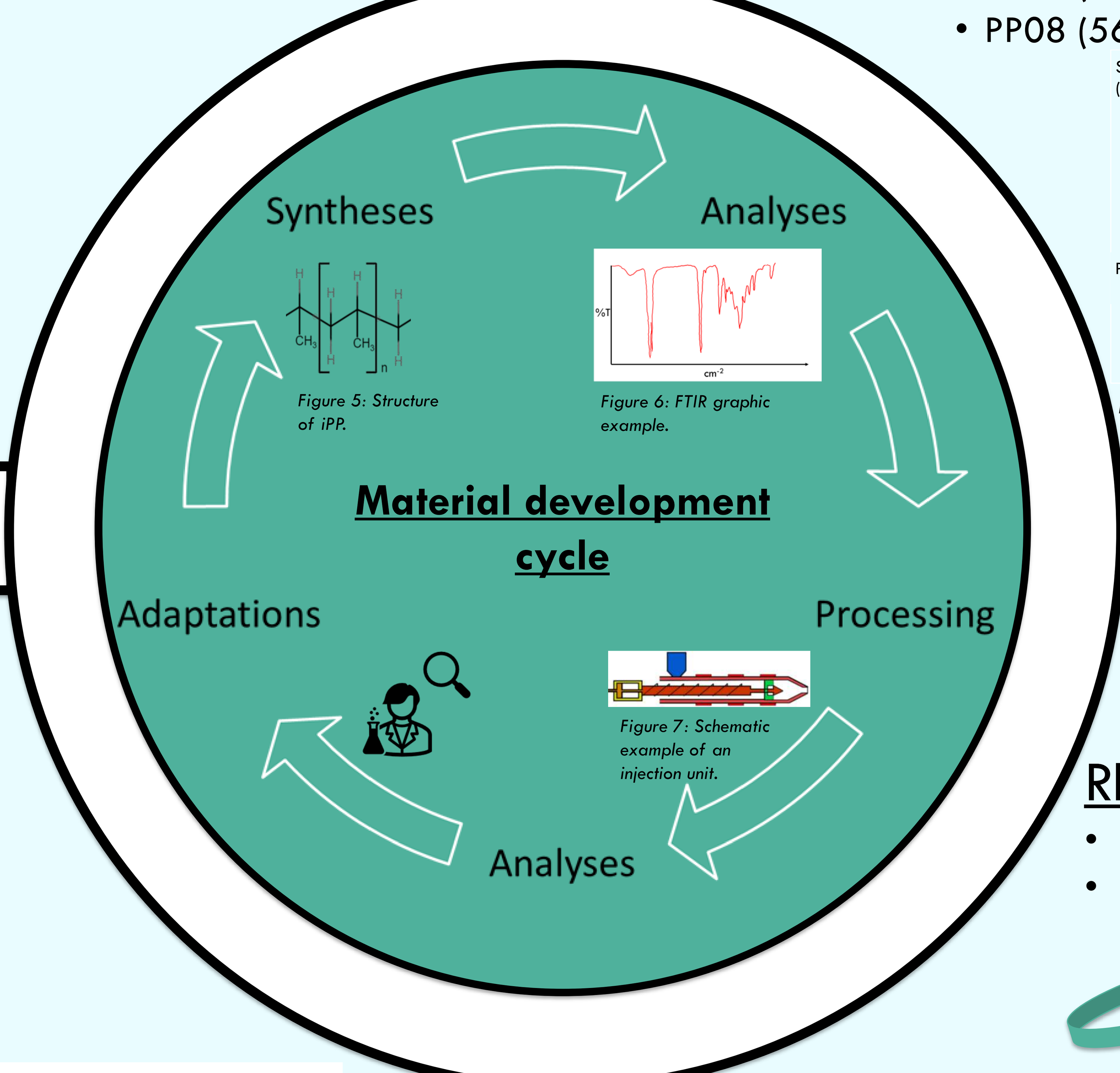

Figure 5: Structure of iPP.

Figure 6: FTIR graphic example.

Figure 7: Schematic example of an injection unit.

Results

Material reduction

- Single shot with 3.00 g material
- Recommendation for new mould design (shorter sprue and channels)

System purging

- Injection pressure (++), temperature (+), and screw RPM (+)
- Complete purge with approx. 14 g material

Rheological analysis

- PP25 (stdev = 1 – 3%, mean η^* difference to Carreau – Yasuda =< 2%)
- PP08 (stdev = 35 – 40%, mean η^* difference to Carreau – Yasuda =< 18%)

Mechanical analyses (difference from normal sized part)

- Tensile strength (Rm ± 7%, stdev = 1.15%)
- Flexibility (E-modulus ± 2.73%, stdev = 9%)

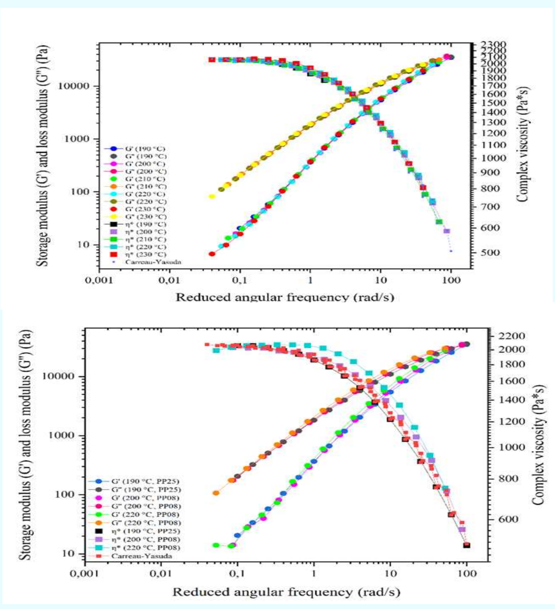
Figure 12: Comparison of PP25 (top) and PP08 (bottom) TTS, (T_{ref} = 190°C)

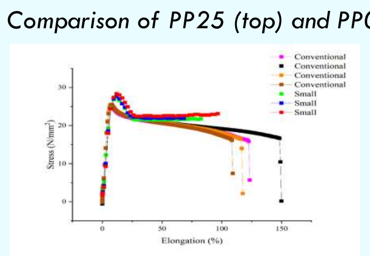
Figure 13: Tensile strength tests in function of the percentage elongation.

Analyses

Rheometry

- Viscoelastic behaviour
- Purging

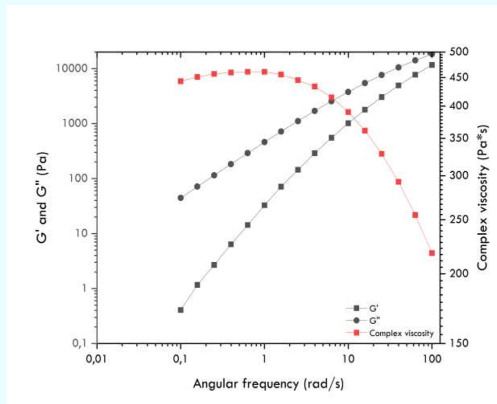
Figure 8: Typical viscosity curve.

Tensile testing

- E-modulus
- Yield strength
- Yield stress
- Elongation

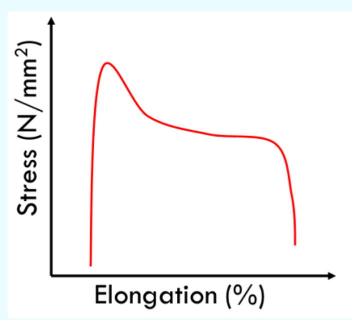

Figure 9: Typical tensile strength curve.

Flexibility testing

- E-modulus
- Yield strength
- Yield stress
- Elongation

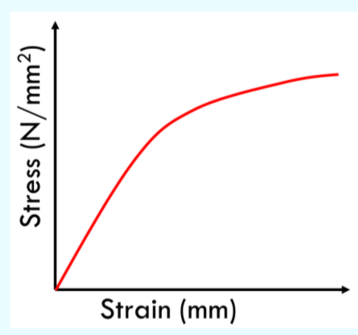

Figure 10: Typical flexibility curve.

DSC

- Thermal properties & behaviour
  → Crystalinity
  →Phase transitional behaviour

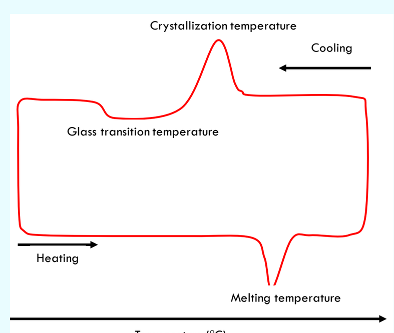

Figure 11: Typical DSC curve.

Supervisors / Co-supervisors / Advisors: Anton Ginzburg, Jules Henrotte

[1] S. Petisco-Ferrero, R. Cardinaels, and L. C. A. van Breemen, "Miniaturized characterization of polymers: From synthesis to rheological and mechanical properties in 30 mg," Polymer (Guildf), vol. 185, p. 121918, 2019, doi: 10.1016/j.polymer.2019.121918.
[2] U. Sancin and B. Dolsak, "Decision Support System for Designing with Polymer Materials – Current Challenges and Future Expectations," Efficient Decision Support Systems - Practice and Challenges From Current to Future, no. June, 2011, doi: 10.5772/18194.
[3] asahikawa-nct.ac.jp, "Asahikawa-nct.ac facilities and factory: practical training factory." https://www.asahikawa-nct.ac.jp/en/facilities/factory/ (accessed Apr. 05, 2022).
[4] https://forward-am.com/material-portfolio/ultrasint-powders-for-powder-bed-fusion-pbf/pp-line/

UHASSELT

KU LEUVEN