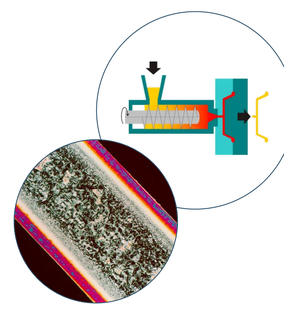
THE EFFECT OF PRESSURE PULSES ON CRYSTALLIZATION OF i-PP: A DILATOMETRIC STUDY

Susanna Formenti[1], Andrea Brivio[1], Dario Cavallo[2], Francesco Briatico Vangosa[1]

[1] PolyEngLab, Department CMIC, Politecnico di Milano
[2] Department of Chemistry and Industrial Chemistry, University of Genova

Step-like pressure changes during polymer solidification are often encountered in melt processing (e.g. injection moulding). Similar to the effect of shear flow pulses, short-term pressurizations can **accelerate crystallization** process due to the formation of **additional nucleation precursors**.

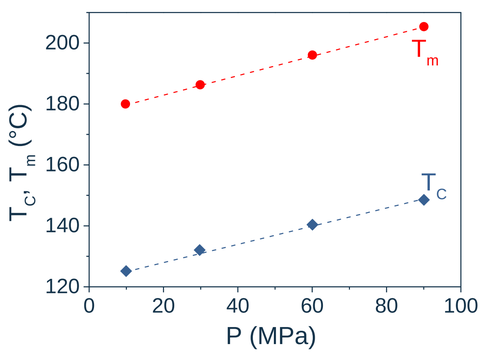
We investigate effect of **hydrostatic pressure pulses** on the crystallization kinetics of isotactic polypropylene by means of high pressure dilatometry and in-situ X-ray diffraction to assess **specific volume/cristallinity changes during isothermal crystallization** upon pressure pulses.



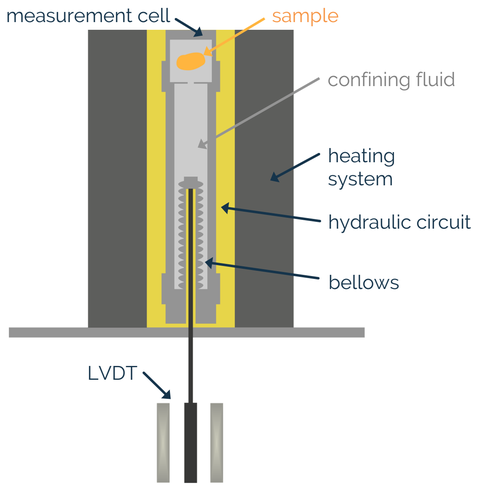
Experimental

Material

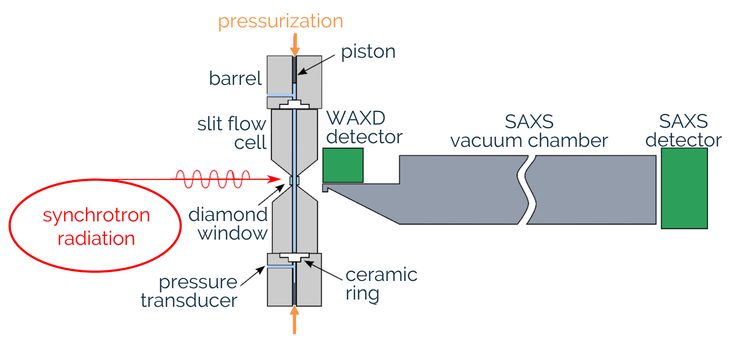
i-PP pellets
Mw = 365 kg/mol
Mw/Mn = 5.4
Tg ≈ - 10 ° C



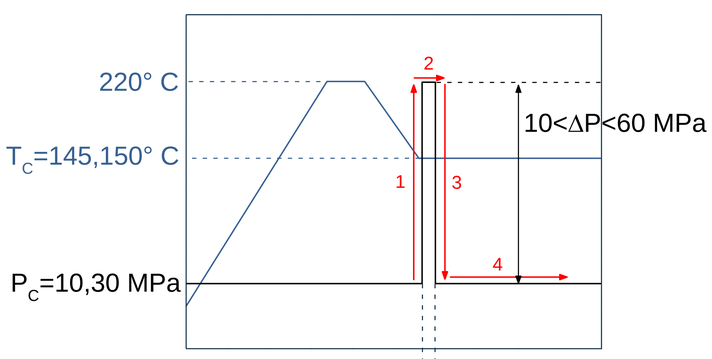
Confining fluid dilatometry

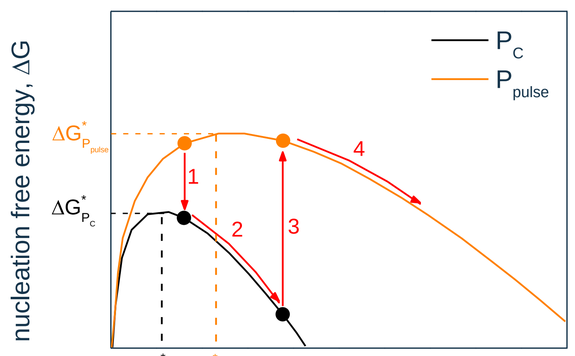


In-situ X-ray diffraction



'short-term' pressure protocol



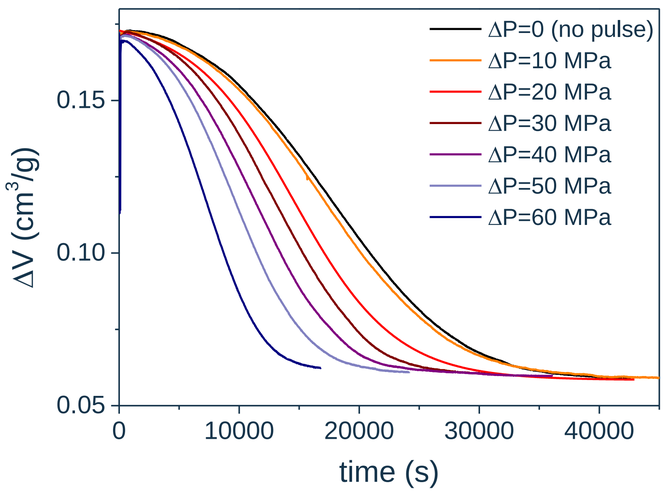


t pressurization << t crystallization

↓

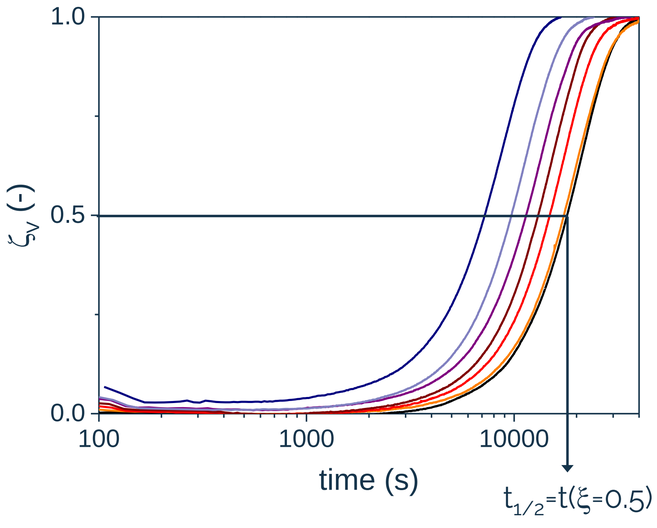
nucleation separated from spherulite growth

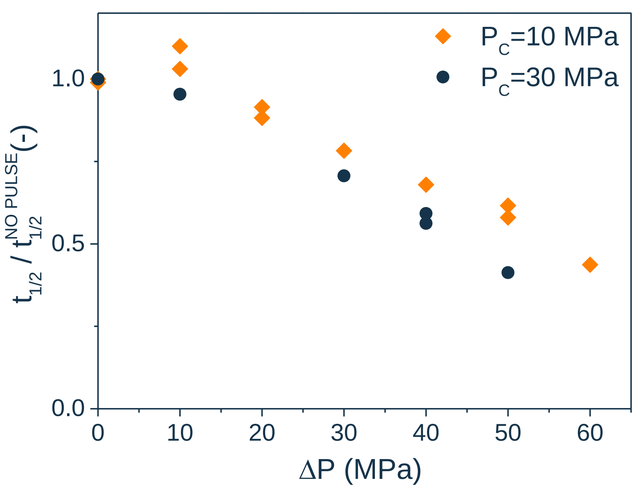
Results



space filling

$$\xi(t) = \frac{\tilde{v}_0 - \tilde{v}(t)}{\tilde{v}_0 - \tilde{v}_\infty}$$





Avrami theory

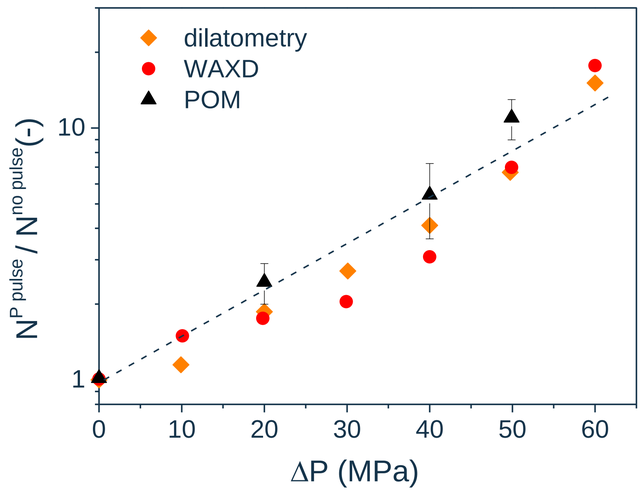
Assuming three-dimensional heterogeneous nucleation:

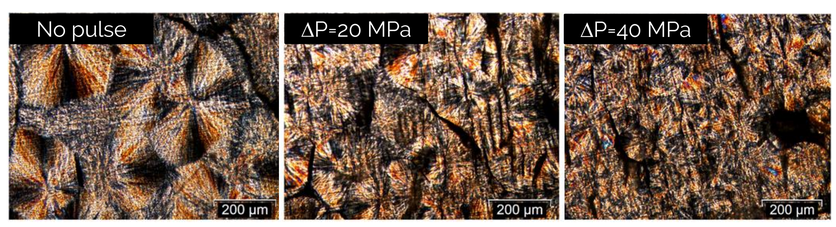
$$\xi(t_{1/2}) = 1 - \exp\left(KNG^3 t^n\right) = 0.5$$

↓

$$\frac{N^{Ppulse}}{N^{nopulse}} = \left[\frac{t^{\ nopulse}_{1/2}}{t^{\ Ppulse}_{1/2}}\right]^n$$

relative nucleation density





ΔP increases → **number of active nuclei increases**

Conclusions

- Enhancement of crystallization kinetics proportional to magnitude of pressure pulse
- Pulse magnitude have no effect on final amount of crystallinity
- Acceleration is linked to increase of number of active nuclei after the short term pressurization, as confirmed by ex-situ optical microscopy observations

References

L. Zhang, M. van Drongelen, G.C. Alfonso, G.W.M. Peters, EPJ, 71(2015) 185-195
P. Zoller, Y.A. Fakhreddine, Thermochimica Acta, 238 (1994) 397-415
E.M. Troisi, S. Formenti, F. Briatico-Vangosa, D. Cavallo, G.W.M. Peters, EPJ, 85 (2016) 553-563
H. Ito, Y. Tsutsumi, K. Minagawa, J. Takimoto, K. Koyama, Colloid Polym Sci, 273 (1995) 811-815