20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

A quick micro indentation-based approach for qualitative yield stress assessment in polyolefins

Sujith D. Namnidi[1], Stan F.S.P. Looijmans[2], Lambèrt C.A. van Breemen[3]

[1] Processing and Performance of Materials, Eindhoven University of Technology, Netherlands. s.d.namnidi@tue.nl
[2] Processing and Performance of Materials, Eindhoven University of Technology, Netherlands. s.f.s.p.looijmans@tue.nl
[3] Processing and Performance of Materials, Eindhoven University of Technology, Netherlands. l.c.a.v.breemen@tue.nl

Paper ID: 554
Symposium S1: Mechanical behavior of polymers and biopolymers: theory, simulations and testing

Abstract

Polymer circularity through mechanical recycling is limited by incomplete separation of mixed plastic waste. Current sorting methods distinguish polymers by material type but struggle with molecular-grade variations. This is especially true for common polyolefins like polypropylene and polyethylene, whose molecular structure and morphology strongly affect mechanical performance. This includes properties such as the yield stress and elastic modulus that are critical for applications. Rheology and compression testing can probe these differences but are slow and require large samples, limiting their use in rapid recycling workflows. To address this challenge, we introduce a rapid, small-scale method to differentiate polymers by yield stress using micro indentation. Many existing indentation methods are affected by viscoelasticity, post-yield behaviour, or require post-indentation imaging, restricting their use in fast sorting. With the knowledge of indentation deformation mechanisms and tip geometry, we identify a region of the indentation curve where stiffness mainly reflects plastic deformation confined to yield, avoiding post-yield flow. This is crucial for mixed waste, where varying post-yield behaviour can interfere with the results. We compare this indentation parameter with yield stress from uniaxial compression tests over various strain rates using 13 polymer grades, including polypropylene homopolymers, copolymers, recycled

grades, HDPE, LDPE, and LLDPE, which are the major components of recycling streams. The method distinctly separates all 13 materials by yield stress. A linear correlation exists between indentation slope and compressive yield stress, confirming the indentation response as a reliable and quick substitute. Additionally, the rate dependence of the yield stress also aligns qualitatively between the two methods. X-ray diffraction provides insights into the crystal microstructure that is at the origin of the trends observed in the yield stress for different molecular grades, supporting this study with established structure-property relations. This work establishes a micro indentation-based method for a rapid, structure-sensitive assessment of polymer yield stress assessment. By enabling small-scale, high-throughput screening, it offers a practical way to distinguish various grades among polyolefins dominant in recycling. This capability is helpful for both academic research and addressing recycling challenges requiring quick identification of mechanically compatible materials.

Keywords:

Mechanical characterization Micro indentation Circularity of polymers