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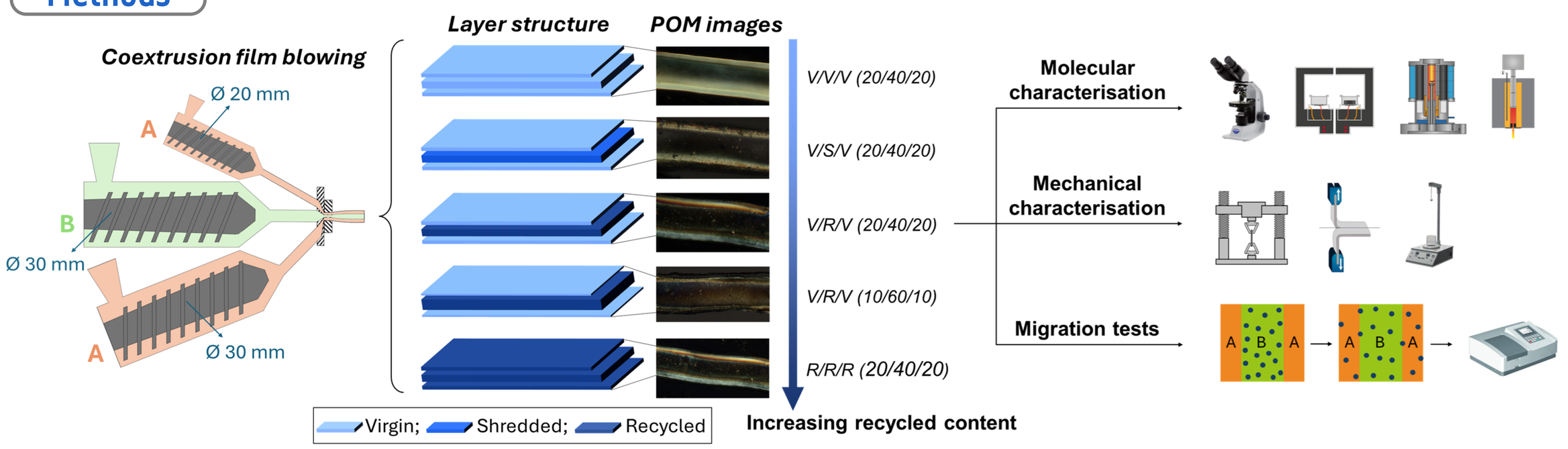
RECYCLABLE MULTI-LAYER FILMS FROM VIRGIN AND RECYCLED POLYETHYLENE

Flexible polyethylene films are widely used across packaging applications due to their lightweight nature and protective performance. Yet, their current design and use raise several challenges:

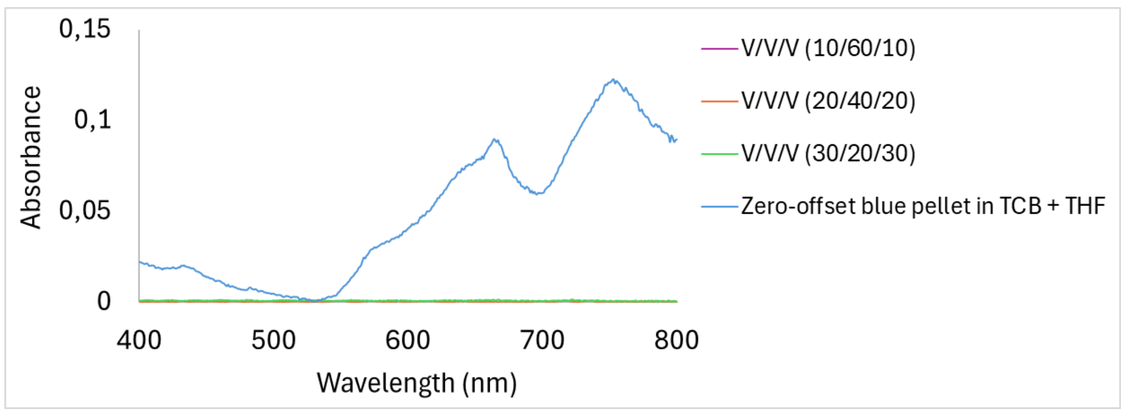
- **Sustainability concerns:** increasing material consumption, persistent plastic waste, and associated CO_2 emissions.
- **Regulatory pressure:** upcoming EU requirements on recycled content cannot be met easily, as impurities in recycled PE may migrate and restrict its use in food-contact applications.
- **Performance limitations:** single-layer PE films often fail to deliver the required combination of mechanical, thermal, and optical properties.
- **End-of-life issues:** conventional multilayer films achieve high performance but are extremely difficult to recycle.

Proposed approach: develop recyclable, mono-material multilayer PE structures that combine recycled LDPE in the core layer with virgin ULDPE as outer protective layers. This architecture aims to ensure high material quality, functional performance, and compatibility with closed-loop recycling.

Methods



Migration tests



Migration behavior

A blue colorant was placed in the middle layer of three multilayer films with different outer-layer thicknesses.

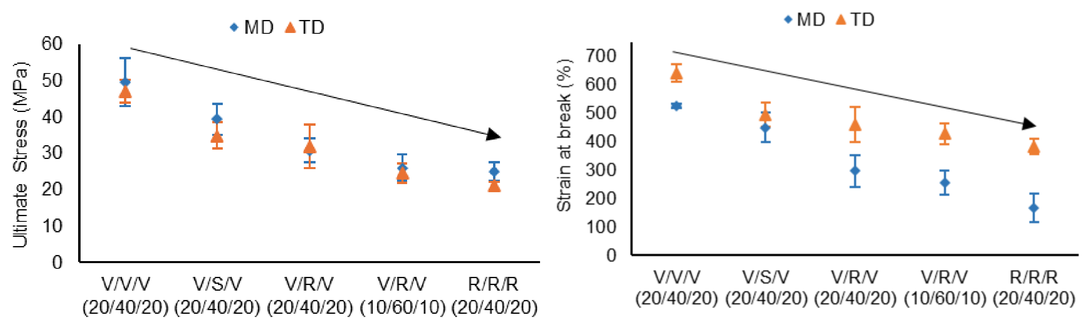
Results:

- **No colorant migration** was detected in any film after 4 days of refrigerated storage (contrast: dissolved pellet shows clear absorbance).
- Outer layers **≥10 µm** provide an effective barrier.

Overall :

Adequately thick ULDPE outer layers prevent leaching and indicate **no cross-contamination risk** for potential food-contact use.

Mechanical property



Tensile behavior

- **Ultimate stress:** decreases moderately as the recycled fraction increases. This trend is linked to hard particles, air bubbles, and heterogeneities introduced during reprocessing, which act as stress concentrators and reduce load-bearing capacity.
- **Strain at break:** also shows a noticeable decline, driven by higher crystallinity and reduced chain mobility in recycled LDPE, leading to lower ductility.

Overall:

the incorporation of recycled material diminishes tensile performance, but the reductions remain moderate and predictable, allowing stable behavior in multilayer PE films.

Conclusion

Recyclable mono-material PE multilayer films can incorporate high levels of recycled LDPE while maintaining acceptable mechanical performance and ensuring no detectable migration through the ULDPE outer layers. This structure offers a viable path toward high-quality, food-contact-compatible packaging within a circular materials framework.

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