Circularity in flexible packaging: polyamide recycled from post-industrial scrap

Oriented film evaluated in a multilayer packaging demonstrator

Cast and oriented r-PA from printed flexible packaging industry scrap used in a new product cycle

Drivers

The EU's target of 10 Mtonnes recycled plastics in the marketplace by 2025 has elicited widespread commitments from public and private actors in European plastics value chains. In 2018 Multicycle partner AMCOR pledged that all their packaging would be recyclable or reusable by 2025, through a focus on design for recycling, implementing high recyclate content in products, and collaboration along the value chain for systemic change. The MultiCycle approach aligns with these priorities and can potentially encourage the recycling market in materials such as polyamide provided its physical (dissolution based) recycling route can deliver recyclates of sufficient quality for flexible packaging applications.

In this case study, polyamide recovered from mixed post-industrially sourced scrap packaging film, r-pi-PA, has been evaluated as part of a demonstration design for a liquid fill stand-up pouch typically used in home and personal care applications.

Approach

r-PA was recovered both at small technical scale by Fraunhofer IVV from a tailor-made, non-printed laminate of PA and PET, and at industrial pilot scale on ther MultiCycle demonstration plant at LOEMI GmbH from mixed printed PA / PE shredded post-industrial scrap provided by AMCOR. The resultant materials were analyzed for a range of physical, mechanical and chemical properties to inform onward conversion processing conditions.

Key Features

- Post-industrial r-PA obtained by a non-chemical recycling route successfully extruded into cast film and biaxially oriented
- First demonstration of oriented PA film with a substantial (30%) recyclate content
- Successful conversion into a multilayer structure and product mockup (stand-up pouch for liquid fill)

With an oriented layer application in mind, r-PA has been used to produce cast thick film extrudates with subsequent biaxial stretching to target thickness. r-PA was used at 30% in a blend with virgin-PA both to extend the use of the quantities of recyclates available and in order to assure consistent film thickness. The final laminate three-layer structure required by the target product design was produced at lab scale, and the laminate sheets resulting were used for craft scale printing and final mock-up production.

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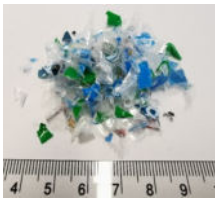
Industrial Case Study

Key features

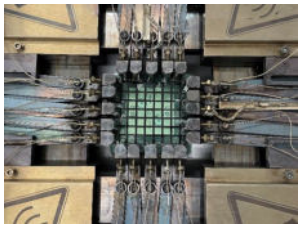
Material	T_g (°C)	T_{melt} (°C)	Density (g/cm^3)
R-pi-PA	47	221	1.13
Ref. v-PA	52	220	1.14

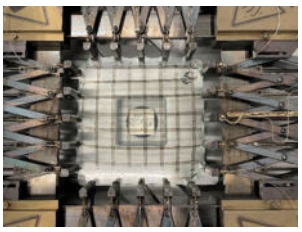
Cast film extrusion



Carry over of colour from original inks

Biaxial Orientation





✓ Stretching from 120µm to 15µm

Film Properties relative to virgin

✓ Mechanical (modulus, tensile strength, elongation at break)
≠ Optical (colour, haze)
✓ Optical (transparency, clarity)
✓ Oxygen permeation

Demonstrator	Stand-up pouch for liquid fill
Structure	*O*PET//**r-pi-*O*PA**//vPE
Recycle Content	30% in *O*PA. 3% in total

This study demonstrates for the first time as far as we know the production of oriented PA film with 30% recycle content

Results and Benefits

Melt and glass transition temperatures of r-PI were found to be similar to virgin values. The most obvious property variation was colour. For small technical scale materials this was associated with heat exposure during downstream compounding (the powder obtained directly from the recycling process was white). For printed materials colouration was clearly due to carry over of original ink shades.

Cast film extrusion and biaxial stretching trials were successful for both recycles. Ex-AMCOR r-pi-PA was cast at 120µm thickness and stretched at 3.3 x 3.3 (machine x transverse direction) to 15µm thickness. Film optical properties other than haze were comparable to virgin film. Mechanical properties were also broadly comparable to virgin PA. Recycle containing films had slightly higher modulus and slightly lower tensile strength and elongation at break. Oxygen barrier performance was unaffected. Ultimately, the oriented film was successfully incorporated as the middle layer (contributing burst resistance and aroma barrier) in a three-layer laminate design for a stand up pouch for liquid fill requiring high packaging stability and chemical resistance.

This study demonstrates for the first time as far as we know the production of oriented PA film with 30% recycle content. Building on this novel achievement could potentially foster high-value end-use demand for r-PA and, with a viable circular pathway to high quality recycle identified, encourage market development and growth to meet the packaging industry's needs for sustainable materials and value chains.

Further Steps

This case study has shown for the first time that a dissolution based (i.e. physical) recycling route can provide r-PA suitable for making oriented film. Further work lies ahead both to scale up and to develop further strategies to accommodate, reduce, and eventually eliminate optical property variations. Motivated by their public commitments, the signs are that the industry is up for such a challenge.

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SPIRE PROJECT

In line with the ambition for a Circular Economy in Plastics, MultiCycle has delivered an industrial recycling pilot plant for multilayer flexible packaging and fibre reinforced thermoplastic composites using a novel selective dissolution process to recover pure single polymers suitable for processing back into the value-added applications from which they arose.

Advanced and sustainable recycling processes and value chains for plastic-based multi-materials

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