Flexible packaging products from high post-consumer recycled PP content film structures

Circular plastics in personal care applications

Cast and oriented r-PP from unsorted post-consumer flexible waste used in lotion sachets and liquid pouches

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 recycle 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 polypropylene provided its physical (dissolution based) recycling route can deliver recyclates of sufficient quality for flexible packaging applications.

This case study looks at an evaluation of MultiCycle post-consumer waste derived polypropylene recyclates (r-pc-PP) in lotion sachet and stand-up pouches, both commercially relevant packaging formats for home and personal care applications.

Approach

Fraunhofer IVV and AMCOR have collaborated to analyze the physical, mechanical and chemical properties of r-pc-PP recovered from mixed-polyolefinic post-consumer waste (ex-Meilo GmbH & Co. KG.) treated in the the MultiCycle integrated industrial pilot plant at LOEMI GmbH, and from tailor-made samples of post-industrial scrap recovered at small technical scale. Following preliminary assessments of processability relative to virgin materials, designs were developed for packaging structures for the targeted flexible packaging applications. r-PP has been processed via cast film extrusion and subsequent biaxial stretching to produce oriented films. Progressive monoline processability trials were conducted at 50% and 100% r-polymer content and subsequently for two three-layer cast film structures on a larger pilot production scale. Packaging product mock-ups have been produced at craft scale from the resultant multilayer films, to evaluate factors such as printability and product appearance for designs incorporated the new recyclates.

Key Features

- Post-consumer r-PP successfully extruded into cast film and biaxially oriented
- Multilayer structures with <30—50% recyclate produced at lab and pilot scale for use in demonstration packaging product forms
- First time demonstration of use of recyclates sourced from co-mingled, printed flexibles from household municipal waste without special pre-sorting

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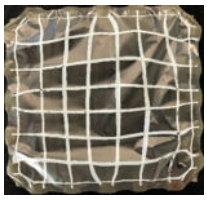
Industrial Case Study

Key features of r-PP demonstrators

Material	Melt Flow Rate (g/10min)	T_{melt} (°C)	Density (g/cm³)
r-pc-PP	8.4	163	0.89
R-pi-PP	5.2 - 8.1	163 - 164	0.88 - 0.89
Ref. v-PP	1.2	166 - 168	0.89 - 0.91

Biaxial Orientation



✓ Stretching to 4µm without breaking

Cast film extrusion

100% virgin 50% r-PP 100% r-PP

Film Properties relative to virgin

✓ Mechanical (modulus, tensile strength, elongation at break)
≠ Optical (colour, gloss, clarity), Odour
✓ Oxygen / water vapour permeation
~ Seal time and strength

Mock-ups

✓ Printing
✓ Whole product design

Demonstrator	Structure	Recyclate Content
Sachets for lotion samples (Pilot)	*O*PP//met-*O*PP//**r-pc-PP**	Max 50.7% in PP coex sealing film. Max 33.6% in total laminate
Flow wrap for wet wipes (Lab)	**r-pc-*O*PP//r-pc-PE**	72% in PE co-ex sealing film. TBC in total laminate.
Sachets for lotion samples (Lab)	**r-pc-*O*PP**//met-*O*PP//**r-pc-PP**	Max 50.7% in PP coex sealing film. Max 51.3% in total laminate

All the structures produced demonstrate high r-pc-PP inclusion levels, exceeding 30—50% in the total laminate

Results and Benefits

Whilst melt temperatures and densities were in line with virgin PP, the higher melt flow rates (i.e. lower viscosities) observed for all the r-PP materials evaluated dictated a cast film processing route for further assessment. Extruded r-pc-PP films cast at 90µm thickness were successfully stretched at 2x 2 and 4x4 ratios (machine x transverse direction) to target thickness of 22.5 and 4.7 µm respectively, without tearing or obvious incidence of gel defects. Subsequently 800µm thick 100% r-pc-PP film was biaxially stretched at a ratio of 9 x 7 for the purposes of producing demonstrator products.

Product designs for evaluation (see panel above) featured two sachet designs for lotion samples, one at pilot scale using 50% r-PP in the coex sealing layer and another at lab scale, plus a further lab scale demonstration of a flow wrap for wet wipes which also utilized r-pc-PE recovered using the MultiCycle process. The latter two examples incorporate the oriented r-PP film described above. All the structures produced demonstrate high r-pc-PP inclusion levels, exceeding 30—50% in the total laminate.

Currently there are virtually no significant sources of r-PP available in the market. The progress made in the course of these evaluations represents as far as we are aware a first-time demonstration of the ability to make flexible packaging products from high r-PP film structures. In particular the ability to stretch the film to produce oriented r-PP is a break through. These results point towards a route for high-end application suitable r-PP and hence the potential to open up a market for recyclates in flexible packaging.

Further Steps

Ultimately further work will be required to improve aspects of performance of the new materials where these differ from the virgin benchmark, and to deepen understanding of how to fully tune the holistic packaging design to accommodate the particular characteristics of recyclate based films. However it should be recognised that these promising results are the start of a new and exciting journey.

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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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