WHITE PAPER

MECHANICAL RECYCLING OF POLYETHYLENE

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Important considerations for the mechanical recycling of polyethylene

Polyethylene is employed in a wide range of applications with ever increasing sophistication. Advanced polyethylene based structures enable the creation of products which are lighter, more durable and more cost effective than those created from many other materials. However films coextruded with a diverse range of layers of different plastics or mixed grades of polyethylene sourced from diverse applications can be challenging to mechanically recycle without introducing some quality and performance deficits. This white paper explores the benefits and limitations of mechanical recycling of polyethylene as a function of its application.

POLYETHYENE (PE) IS THE POLYMER TYPE MOST COMMONLY USED FOR PACKAGING APPLICATIONS IN AUSTRALIA. DEPENDING ON THE POLYMERISATION METHOD AND THE TARGETED POLYMER CHAIN STRUCTURE, POLYETHYLENE CAN RANGE FROM TRANSPARENT AND FLEXIBLE TO TRANSLUCENT AND RIGID. THIS MAKES PE VERY ADAPTABLE TO A VARIETY OF PACKAGING APPLICATIONS. GLOBALLY THERE ARE HUNDREDS OF UNIQUE GRADES OF PE, EACH TAILORED TO A PARTICULAR TYPE OF PROCESSING AND FINISHED PRODUCT APPLICATION.

Low density polyethylene (LDPE) is clear and flexible, which makes it very suitable for film applications of all types. LDPE is also used for extrusion coating of paperboard or other substrates, as well as for bottles and closures.

Linear low density polyethylene (LLDPE) grades also exhibit clarity and flexibility and are frequently selected for film applications where strength and toughness are important. Many PE films use a blend of LDPE and LLDPE for the best balance of processing and performance.

High density polyethylene (HDPE) grades are rigid, making them ideal for bottles, tubs, tanks and drums. HDPE can also be used for dry food packaging films (e.g. cereal or pet food) where the packaging must protect against moisture transmission to achieve the desired shelf life.

Outside the realm of packaging, PE is also used for pressure pipes to transport water and gas, large water tanks, wheelie bins and reusable agricultural produce crates.

Each application has its particular requirements for processing and finished product performance. Pipes and large drums for bulk chemicals require grades that have high melt strength so that the unsupported molten polymer holds its shape very well as it cools. Applications like wheelie bins, crates, caps and closures utilise resins that flow very easily in the molten state as they are injected into a mould. While both applications typically use HDPE, if a wheelie bin grade were used to manufacture large pipes, all that would be produced is a puddle of plastic.

Large drums for bulk chemical storage require a polymer that is very resistant to stress cracking and solvent migration. In contrast, milk bottles have a brief shelf life in a chemically benign environment and the focus is on fast processing and stiffness for low bottle weight. Low defect levels are also critical, as gels in the

polymer can cause holes in milk bottles which are produced at an increasingly reduced wall thickness. The characteristics that are important for the different applications are often in competition with each other, which is why so many unique and specifically developed PE grades are available.

MECHANICAL RECYCLING

Mechanical recycling is the most suitable recovery option for pure polymer streams. The energy use and emissions saved in comparison to other end of life options is considerable. However, there are limitations to this technology, and a significant proportion of mechanically recycled plastics are unsuitable for use in the original applications. The Australian Packaging Covenant Organisation (APCO) reported that the recovery rate for plastic packaging in 2018-2019 was only 18%, which is the lowest of all material types. The average post-consumer recycled (PCR) content in plastic packaging during the same period was only 4% across all polymer types[1].

Mechanical recycling involves the collection, sorting, cleaning and reprocessing of waste plastics. The quality of recycled polymers is typically lower than the equivalent virgin material which can lead to issues with processing and performance. This deficit is largely a result of a mixture of plastic types in the feed, as well as the presence of pigments and other contaminants such as paper and adhesives. Consistency is key for plastics processing and product quality. The variable nature of mechanically recycled polymers greatly limits the options for the incorporation of recycled content into packaging.

Mechanically recycled flexible packaging is likely to contain a mix of various grades of HDPE, LLDPE and LDPE which will pose a technical challenge for reprocessing and for the delivery of product performance. Films are often coextruded with a diverse range of layers of different plastics selected for moisture or gas barrier or other specific performance requirements. As long as plastic packaging employs coloured and multi-material designs, mechanically recycled plastics will invariably come back with quality and performance deficits.

The collection of plastic films and soft packaging is quite limited, especially from post-consumer sources. In 2018-2019, the recovery rate for all post-consumer flexible plastic packaging was just 5%[1]. Most materials recycling facilities (MRFs) do not have the capability of sorting plastic films from paper, so much ends up in landfill. One of the most accessible options for consumers wishing to recycle flexible plastic packaging is the REDcycle collection system. However, the material from these bins does not make its way back into packaging. The soft plastics collected in these bins are instead recycled into larger durable items such as bollards, signs or asphalt additives which can handle the mixed plastics' properties[2].

The most circular products produced by mechanical recycling are PET beverage bottles and HDPE milk bottles. These applications use largely unpigmented resins, and are available in sufficient volume and quality to make the separation economic. There are also processes available to make these recycled products suitable for food contact applications. There is a high demand for these recycled grades, and the dairy industry is currently unable to obtain sufficient food grade rHDPE to meet its sustainability targets.

> MECHANICAL RECYCLING IS AN IDEAL SOLUTION FOR HIGH PURITY POLYMER STREAMS. HOWEVER, PROCESSING, PERFORMANCE, COMPLIANCE AND AESTHETIC REQUIREMENTS MEAN THAT A CONSIDERABLE SHARE OF POLYMER PACKAGING IS NOT SUITED TO MECHANICAL RECYCLING.

RECYCLED POLYMERS IN FOOD CONTACT APPLICATIONS

In Australia, the suitability of materials for food contact applications is determined based on regulations from the EU or the US Food and Drug Administration (FDA). While the FDA does not have additional requirements for recycled polymers beyond those specified for virgin resins, it does offer guidance on testing for suitability. Upon request, the FDA will assess data submissions for recycling processes and issue No Objection Letters (NOLs). Often, there are limitations placed on the PCR input material as well as restrictions on the end use application. Many NOLs require the input material to come from food packaging, necessitating the use of advanced sorting technologies.

The European Food Safety Authority (EFSA) is yet to issue a favourable assessment of mechanical recycling for polymers other than PET into the vast majority of food contact applications.

A COMPLETE SOLUTION TO CIRCULARITY

Mechanical recycling is an ideal solution for high purity polymer streams. However, processing, performance, compliance and aesthetic requirements mean that a considerable share of polymer packaging is not suited to mechanical recycling. Fortunately mixed polymer streams make an ideal feedstock for circular advanced recycling, where plastics are broken down to the basic building blocks required for new polymer production. Circular advanced recycling offers a proven avenue for mixed plastic waste to be transformed into food contact suitable materials of virgin equivalent quality.

REFERENCES

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