INDEX

1. DESCRIPTION OF TECHNOLOGY
2. CURRENT DISTRIBUTION
3. REGULATORY FRAMEWORK
4. STANDARDS, CERTIFICATION AND LABELLING
5. INTERACTIONS BETWEEN BIOPLASTICS AND MECHANICAL RECYCLING
6. BENEFITS AND CHALLENGES
   6.1 Benefits
   6.2 Challenges
7. SORTING
   7.1 Sorting with NIR-technology
8. RELEVANT STANDARDS FOR RECYCLING
1. DESCRIPTION OF TECHNOLOGY

Mechanical recycling is a method by which waste materials are recycled into “new” (secondary) raw materials without changing the basic structure of the material. It is also known as material recycling, material recovery or, related to plastics, back-to-plastics recycling.

Post consumer plastic waste can be a very inhomogeneous and potentially contaminated waste fraction. It comprises a huge range of material types, with shape and size ranging widely, and in many cases the input material is composed of different material types (e.g. multilayer films or composite items). The material passes extensive manual or automated mechanical sorting processes in specialised facilities, designed to separate the different material streams. The proper identification of materials is essential for achieving a maximised purity of recyclates. For this purpose, various technologies such as near infrared spectroscopy (NIR), laser or x-ray techniques are available. After cleaning and grinding processes, the material is recovered by remelting and regranulating. The resulting recyclates can be processed with all common technologies of plastics conversion.

In plastics recycling, the handling of pre-consumer (pre-industrial) material and post-consumer material need to be distinguished. In principle, the technology of mechanical recycling is applicable to both bio-based conventional plastic and to most grades of biodegradable plastics. In particular, the in-house recycling of mono-material scraps\(^1\) is practiced in many cases both for conventional plastics and for bioplastics.

2. CURRENT DISTRIBUTION AND PROSPECTIVE OF TECHNOLOGY

Mechanical recycling is a well-established technology for the material recovery of conventional plastics, such as polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP) and polystyrene (PS). Its main advantage is that part of the resources consumed for the production of the plastic materials is not wasted, but preserved for a use in the same, similar or different application.

According to PlasticsEurope, in Europe on average 26 percent of post-consumer plastics waste were recycled in 2012.\(^2\) This figure covers the overall material recycling (both mechanical recycling and feedstock recycling).\(^3\)

With further efforts for waste collection and treatment systems in Europe, the volume of recycled and recovered plastics waste should increase. Also, the legal framework will most likely pose new requirements to the industry to extend the share of recycling and recovery over time.

Mechanical recycling of products and packaging made from bioplastics is possible from a technical point of view. As a matter of fact, in house and post-industrial waste is normally recycled using conventional techniques. Products made with biobased equivalents of conventional polymers (so-called drop-ins) do not differ from fossil based products when it comes to mechanical recycling. Other innovative biopolymers can be also recovered with mechanical recycling, especially when sufficient volumes of homogenous waste material streams are available, either through separate collection or through sorting routines.

Certified biodegradable products are designed intentionally to be recovered by means of organic recycling. They are thus treated in composting plants or by anaerobic digestion. Mechanical recycling is not the most suitable recovery option for these materials, although they usually have no negative impacts on recycling streams.\(^4\)

---

\(^1\) Material that originates from the production or converting of resins (process scrap, e.g. start-up, shut-down, rejects, trimmings, etc.) and is fed back to the production process.


\(^3\) Feedstock recycling means the conversion to monomers or production of new raw materials by changing the chemical structure of plastics waste through cracking, gasification or depolymerization, excluding energy recovery and incineration.

\(^4\) European Bioplastics e.V.: The behaviour of bioplastics films in mechanical recycling streams. April 2015.
3. REGULATORY FRAMEWORK


The Landfill Directive foresees that only treated waste ends up in landfills (Article 6 a). This means that waste has to be recycled, or organically recovered or incinerated before the residues may be landfilled.

According to the PPWD, as of now, a quota of 22.5 percent (by weight) of the plastics packaging waste has to be recycled back to plastics.

3.1 Review of waste policy and legislation

In July 2014, the European Commission adopted a legislative proposal and annex to review recycling and other waste-related targets in several Directives. Concerning the Waste Framework Directive, recycling and preparing for re-use of municipal waste should be increased to 70 percent by 2030. Concerning recycling and preparing for re-use of packaging waste, the material-specific targets should gradually increase between 2020 and 2030, to reach 60 percent for plastics by the end of 2030. Having deleted the “Circular Economy Package” from its 2015 agenda, the European Commission announced a new proposal for 2015.

4. STANDARDS, CERTIFICATION AND LABELLING

The standardisation of recycled plastics largely has been driven by the Packaging and Packaging Waste Directive 94/62/EC (PPWD). It requires that member states ensure that packaging complies with “essential requirements” (laid down in Annexe II) which have been “translated” into standards by CEN. One of them, EN 13430, covers the requirements relating to the material recovery of packaging.

Plastic recyclates are dealt with by the standards of the EN 1534x series. These standards define minimum quality criteria of recycled plastics made of PE, PP, PS, PVC and PET. There are no specific requirements for bioplastics.

Biobased equivalents of conventional polymers will use the existing corresponding code (e.g. biobased LDPE will use code “4”). For all the other bioplastics, specific recycling codes do not yet exist. These are therefore labelled with the code “07” for “other plastics”. From a technical point, this type of material identification is becoming much less important for recyclers due to the increasing use of automated sorting (e.g. with near-infrared technology).

The conformity with the above-mentioned standards so far is not item to certification. The companies themselves are responsible to meet the standards.

---

5 Treatment according to the LFD means “the physical, thermal, chemical or biological processes, including sorting, that change the characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery”.

6 The standards are listed in section 8.
5. INTERACTIONS BETWEEN BIOPLASTICS AND MECHANICAL RECYCLING

In various countries, plastics collection and recycling systems are in place, focussing mainly on the major plastics with high volumes such as PE, PET, PP and PS. Besides these, there is a wide range of post consumer plastics, which are not being recycled because of their low volume or complexity (multilayer films, blends, composite items). If a separate recycling stream for a certain plastic/bioplastic type exists, the bioplastic can be easily recycled alongside its conventional counterparts (e.g. biobased PE in the PE-stream or biobased PET in the PET stream). The material coordinate system of bioplastics below depicts typical bioplastics and how they are classified according to their biobased content and biodegradability. While biobased equivalents of conventional plastics can and do enter into established systems of mechanical recycling, other types of bioplastics can be integrated depending on the economy of scale.

The waste management systems need to be optimised taking into account the local infrastructure for collection and recycling, local and regional regulations, the total volume on the market and the composition of waste streams. There are general rules applying to conventional as well as to bioplastics to be taken into account:

a) Material properties
Most bioplastics can be made ready for use in material recycling. In some cases, depending on the circumstances, additional steps are required. It may, for example, be necessary for PLA to go through an additional step of polycondensation, or a special crystallisation stage. What effects the mechanical recycling process will have on the required properties of a certain polymer (or on given mixtures of polymers) under real life conditions (e.g. post consumer material) is best answered by practical experience.7

b) Compatibility
Whenever different kinds of plastics products are recycled (be it conventional or biopolymers), the challenge of potential incompatibilities between individual polymers has to be considered. That is why a maximum of uniformity of the processed material stream needs to be achieved.

c) Economical viability
With the implementation of near infrared scanning methods in the sorting of post consumer plastics, the detection of bioplastic types and its forwarding to specified material streams is possible and will lead to a level of purity of recyclates which is uncritical for the majority of applications. Mechanical recycling of plastics is to a lesser extent a question of technical feasibility but more a question of economical viability. The post consumer recycling of bioplastics for which no separate stream yet exists, will be feasible, as soon as the commercial volumes and sales increase sufficiently to cover the investments required. New separate streams (e.g. for PLA) will be introduced in the short to medium term.

Preconditions for establishing mechanical recycling of bioplastics:

- The amount of bioplastics in the recycling stream is growing to a level that justifies additional investments by the recycling industry.
- Markets are developed for the resulting secondary raw materials (closing material cycles).

---

7 Information on different bioplastics materials in post-consumer recycling is available via the KNOTEN WEIMAR International Transfer Centre Environmental Technology GmbH. http://www.bionet.net/sortierung.html?&L=1
6. BENEFITS AND CHALLENGES

6.1 __Benefits

- Material recycling of biobased plastics is successfully applied for post-industrial plastics (e.g. biobased PE and PET).
- Recycling of biobased plastics means prolonged carbon sequestration in products, thus further improving their environmental performance.
- The value of the polymer synthesis with regard to energy and other resource intake is preserved.
- Mechanical recycling allows for multiple lifecycles of a given plastic and thus substitutes and saves virgin material.

6.2 __Challenges

The following challenges also apply to other new and small volume polymers entering the market.

- A market demand for the specific recyclate is a necessary precondition.
- Sorting and mechanical recycling of new polymers requires scale-up in volumes to be economically feasible and might require additional investments.
- Mechanical recycling of post consumer plastics waste requires appropriate collection, transport and sorting systems for clean and homogenous waste streams. Such streams exist in many EU countries for PE or PET. Volumes for the bioplastics PLA a yet to grow to a certain level to make sorting (economically) viable.

7. SORTING

Existing sorting systems can easily identify the so-called “drop-ins” (e.g. Bio-PET, Bio-PET) together with their conventional counterparts. Also other polymers (e.g. PLA or starch blends) can be identified and sorted out if the sorting technology is adapted accordingly, before forwarding it to material recycling. These systems use various technologies such as near-infrared, ultraviolet, x-ray, laser, polarized light, fluorescent light, electrostatic, melt point and other sorting techniques.

7.1 __Sorting with NIR-technology

In Near-Infrared (NIR) Sorting, the material is spread out on a conveyor belt and fed underneath an identification sensor. This sensor uses an infrared beam to identify the plastic type by recognizing a light intensity reading, which is unique for each polymer. The unit then triggers air nozzles that separate the selected materials as programmed. The units are capable of sorting PP, PE, PET, PS and PVC, and can also be programmed to identify biopolymers, carton board and metals. According to a mixed plastics recycling study conducted by Waste & Resources Action Program (WRAP), “NIR (near-infrared) systems can effectively remove PLA and carton board from a mixed packaging stream.”

This is illustrated in Table 1.

<table>
<thead>
<tr>
<th>Polymer</th>
<th>PP</th>
<th>PE</th>
<th>PET</th>
<th>PS</th>
<th>PVS</th>
<th>PLA</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity Achieved*</td>
<td>96%</td>
<td>94%</td>
<td>94%</td>
<td>87%</td>
<td>93%</td>
<td>97%</td>
<td>3tph</td>
</tr>
</tbody>
</table>

*Representative output purity for whole item near infra red (NIR) Sorting
NIR-units are widely used in Europe for sorting bottles. They are state of the art in Germany for sorting mixed post consumer lightweight packaging. NIR systems can be programmed to identify new polymers or variations of polymers. This function was utilized to identify PLA within the streams and successfully eject it from the mixed plastics fraction.10

8. RELEVANT STANDARDS FOR RECYCLING

- EN 15342 Plastics - Recycled Plastics
  Characterization of polystyrene (PS) recyclates
- EN 15343 Plastics - Recycled Plastics
  Plastics recycling traceability and assessment of conformity and recycled content
- EN 15344 Plastics - Recycled Plastics
  Characterisation of Polyethylene (PE) recyclates
- EN 15345 Plastics - Recycled Plastics
  Characterisation of Polypropylene (PP) recyclates
- EN 15346 Plastics - Recycled plastics
  Characterisation of poly(vinyl chloride) (PVC) recyclates
- EN 15347 Plastics - Recycled Plastics
  Characterisation of plastics wastes
- EN 15348 Plastics - Recycled plastics
  Characterization of polyethylene terephthalate (PET) recyclates
- EN 13432 Packaging
  Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging

---