Towards improved circularity of polyolefin-based packaging

End report

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Project Number ISPT	CP-50-02
Project Title + Acronym	Towards improved circularity of polyolefin-based packaging
Secretary (penvoerder)	ISPT
Name Program Director	Ronald Korstanje
Name project leader	Ronald Korstanje
Project start	1 May 2020
Project original end date	31 April 2022
Project final end date	31 Oktober 2022

KPI	**Description**
1. TRL at closing, Main category	Industrial research
2. TRL at closing, Detail category	Industrial research
3. Project success	2. The project has been completed satisfactorily, but the content of the milestones has changed;
4. Follow up	Bijv. vervolgonderzoek, ontwikkeling prototype, marktintroductie, etc.
5. Number of Realized peer-reviewed publications	3
6. Number of Expected peer-reviewed publications	8
7. Number of Realized non-peer-reviewed publications realized	1
8. Number of patents	0
9. Number of granted licenses	0
10. Number of prototypes	1
11. Number of demonstrators	0
12. Number of spin-offs/ spin-outs	0
13. Number of new or improved products / processes or services introduced	0
14. Impact	This project has made clear that, when using pyrolysis or gasification is possible to get improvements on CO_2 emissions from the plastic va chain that was examined (PMD as part of post-consumer plastic was compared to the current practice of waste management (incineration) Next to that it has been found that pyrolysis together with gasification could play a complementary role in processing mixed plastic waste (DKR350) in such a way that a relevant part of the output from these processes can be used for conversion into polymers. This would resu in improved circularity from DKR350. This project also made clear tha there are multiple (technological) routes that can be followed and implemented to improve the composition of feedstock for (thermochemical) recycling through improvement of sorting technique and procedures, improving the overall circularity of a plastic value cha

Public summary

Objective and set-up of the project

There are plenty of technologies for the recycling of plastics that are being developed. However, development to and implementation on an industrial scale often presents significant challenges. In this collaboration, we focused on the development of technologies as well as new methodologies that are needed to close the complex recycling loop for (mixed) polyolefin based plastics.

The aim of the project was to improve the understanding of the feedstock-process-output relationship of polyolefin rich feedstocks using pyrolysis and gasification as processing techniques. The feedstock was derived from post-consumer based packaging waste (PMD).
This project involved parties from the whole value chain; from polymer production via collection and sorting to recycling and end-use. This way the circular process could be effectively addressed which is important as this enabled to focus on the logistic and technological challenges in connection to each other.

Various sorting and washing protocols were used to deliver feedstocks with different compositions to the gasification and pyrolysis processing units. Also sorting tests including newly designed plastic products were set up to understand the influence of newly designed products on composition of feedstock and processing. Next to that new characterisation techniques for sorting black plastics, which is a problem with standard NIR sorting, were developed and evaluated and new algorithms to support better sorting were developed. Pyrolysis and gasification trials were executed at lab as well as pilot scale, testing with different types of feedstocks and using different process settings.
An environmental sustainability analysis, consisting of stakeholder interviews, life cycle assessments and circularity assessment were developed and executed.

Results

The focus was to carry out a detailed chemical and physical analysis of polyolefin based plastics from post-consumer waste streams and use these streams for pyrolysis and gasification. During the project we focused on Dutch post-consumer waste streams.

The project has resulted in the publication of unique results in relation to pyrolysis and gasification of various types of mixed plastic waste and gave a much better understanding of the feedstock-process-output relationship for pyrolysis and gasification, related to mixed polyolefin rich plastic waste streams. The project has demonstrated that the use of DKR350 as a direct feedstock for thermal (non-catalytic) pyrolysis is challenging, delivering an output pyrolysis oil which cannot be easily used in large volume fractions by the petrochemical industry as feed for steam crackers, due to the contaminants present. However, a sorting protocol using standard equipment but unconventional order on a DKR350 stream can lead to a stream with a higher polyolefin content, which may be better suitable for standard pyrolysis. The residue of this sorting process is suitable for gasification. These results are new findings that were previously not publicly known. The project demonstrated that pyrolysis and gasification can support each other in processing complex mixed plastic waste streams (DKR 350) resulting in an optimization of the total output that can be used as feedstock for the production of circular polymers.

As a result of the project new sorting protocols as well as washing protocols have been developed. These will be input for new research projects as well as potential input for standardization of new protocols.
The development of a prototype set-up of DUV RAMAN characterisation for the detection of black plastics resulted in a sorting option with future potential. The development of new algorithms to support better, more accurate sorting, delivered promising results and good potential for future application.

The environmental sustainability analysis of the demonstrated process shows that pyrolysis of DKR-350 offers the potential to reduce the overall GHG emissions compared to the current waste management of DKR-350 . The investigated extra sorting step has the potential to further reduce the overall environmental impacts. Despite the COVID-19 related difficulties in face-to-face contact there was good interaction and exchange of information among the consortium partners. This has led to better understanding of the role each partner can play in moving from a linear value chain towards a circular value chain. The project has also led to the understanding that specific developments, like new packaging designs or new sorting options, can bring improvements to the recycled content quality.