Fraunhofer IVV

Report

Executive Summary for Final Report of Recycling Study KR/8058/19

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Executive Summary

Products made from pure aluminium are completely recyclable, however the recycling of flexible laminates comprising aluminium and plastics is still very challenging. With regard to sustainability, the European Aluminium Foil Association (EAFA) is interested in innovative technologies enabling a closed loop recycling of flexible packaging made from aluminium and plastics. In this research study, EAFA is supported by the International Aluminium Institute (IAI), the Global Aluminium Foil Roller Initiative (GLAFRI), Constantia Flexibles International and Achenbach Buschhütten.

The Fraunhofer Institute for Process Engineering and Packaging IVV, Freising, has developed the CreaSolv® Process for the recovery of high-quality plastic and/or metals from plastic waste fractions. This variable process can be applied to most thermoplastics and has a very high cleaning potential. The solvent-based CreaSolv® Process belongs to the material recycling techniques, where the polymer molecules remain intact like in mechanical recycling. It utilises the physical dissolution of the polymer and allows the separation of different polymers on a molecular scale by using specific solvent formulations. After the selective dissolution of the first target polymer, additional polymers remain undissolved and are recovered in a second process run. Indissoluble components like aluminium foil, incorporated in film laminates, can be recovered as the last step after removal of every polymer film and laminating adhesive.

The objective of this research study is the separation of flexible laminates, made from aluminium and different polymer films, by utilising the CreaSolv® Process in order to enable a complete recycling of aluminium and plastics fraction. The recyclability of different waste fractions is examined in lab scale tests and on the small pilot plant at Fraunhofer IVV with respect to technical feasibility and economic viability.

This project includes the identification, sorting and recycling for a variety of post-industrial (pi) and post-consumer (pc) packaging wastes, always containing aluminium-polymer laminates. The pi-samples each comprise one type of aluminium laminated film with polymers like PE, PP, PVC, PA and PET as well as paper. The pc-samples always represent a part of the non-ferrous metal (NF-metal) waste fraction, which originates from a German sorting facility (DSD) and also contains other types of waste including food residues. In total, ten different pi-samples and four pc-samples are examined at lab scale (work package 1). With an input mass of 35 kg each, two pc-samples are processed at small technical scale (work package 2). After each separation test is concluded, the mass balance and sample composition is determined. Subsequently, the obtained recycled polymers and residues like aluminium foil are analysed by several methods like melt flow rate (MFR), Fourier-transform infrared spectroscopy (FTIR) and differential scanning calorimetry (DSC) to examine polymer quality and separation capability.

First, the results of manual sorting of NF-metal waste fraction show that aluminium containing waste has a total share of 77% (solid and flexible aluminium; moist and dirtying included). Aluminium flexibles (Al-flexibles) is the target waste fraction in this study and amounts to 21 % of given NF-metal waste fraction. Other waste

fractions identified are ferrous metal (5 %), rigid polymers (7 %) and flexible polymers (4 %). After processing the waste and recovering the aluminium as a dry residue, 32 % of the moist NF-metal waste fraction could be identified as aluminium. Accordingly, moist Al-flexibles have an aluminium content of 27 %.

The results of recycling tests prove that a complete separation of aluminium-polymer laminated films by utilising the CreaSolv® Process is possible. This would enable the recycling of both aluminium film and polymer films. The selective extraction of polymers from multilayer structures is technically feasible for the polyolefins PE and PP as well as PVC, PA and PET, which could be successfully recovered from the pi-samples. The most complex pi-sample is a quadruplex film laminate (PET / Al / PA / PE) with a thin aluminium film of 8 µm. The selective extraction of every laminate could be performed with a clean separation between all three polymers and the aluminium film was virtually free of any remaining organic compounds. The testing of real pc-waste has also delivered promising results with regard to extracting and recovering the polyolefins PE and PP. In the case of Al-flexibles the amount of recovered polyolefins is 35 % and of non-polyolefins 21 %. The Al-residue comes to 32 % and paper and dirtying add up to 10%.

Every recycled polymer was characterised by several analytical methods like MFR, FTIR, DSC and others. Overall, a good quality with very high purity could be obtained, enabling a true closed loop recycling.

The originally intended recycling of aluminium separated from these multilayer laminates is also very promising. Every polymer film and laminating adhesive could be effectively removed from the aluminium film. However, the presence of paper would require an additional process step to the actual CreaSolv® Process, which could be integrated in the cleaning of input material, for example. Especially for pc-waste, the prior removal of carbon containing impurities like paper and food residues is an important step for directly remelting the Al-residue obtained from the CreaSolv® Process.

The baseline scenario for a possible commercial projection covers the pc-waste fractions Al-flexibles and flexible polymers together. This waste stream would be easily accessible by an additional sorting step like air separation and more favourable for the CreaSolv® Process than the NF-metal waste as a whole, which contains significantly less Al-flexibles due to a higher amount of solid aluminium pieces and dirtying. A first projection of an economically viable recycling process for Al-flexibles and flexible polymers is presented for two business case options. In the first option, focus is on the extraction of the polyolefins PE and PP, which generates an Al-residue including the remaining non-polyolefins and paper fibres. A treatment by pyrolysis would be the following process step in order to remove residual organic compounds. The second option focuses on concentrating aluminium for directly remelting it as well as extracting the polyolefins PE and PP. With a plant capacity of 14000 t/a infeed and a total capex of 18 to 21 Mio €, a payback period of 3 to 8 years could be achieved depending on the business case option. In these two options, revenues of 1000 €/t for PE and PP as well as 500 to 1500 €/t for the Al-residue for pyrolysis and direct remelting are assumed.

Signatures

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