ISGC 2022

N°1035 / PC

TOPIC(s) : Waste and side streams valorization / Alternative technologies

A first approach on the characterization of recycled PP and PS coming from the plastic mix fraction of municipal solid waste.

AUTHORS

Gabriel BLÁZQUEZ / UNIVERSITY OF GRANADA, DEPARMENT OF CHEMICAL ENGINEERING. FACULTY OF SCIENCES, GRANADA

Mónica CALERO / UNIVERSITY OF GRANADA, DEPARTMENT OF CHEMICAL ENGINEERING. FACULTY OF SCIENCES, GRANADA

Mª Ángeles MARTÍN-LARA / UNIVERSITY OF GRANADA, DEPARTMENT OF CHEMICAL ENGINEERING. FACULTY OF SCIENCES, GRANADA

José Antonio RODRÍGUEZ-LIÉBANA / ANDALTEC TECHNOLOGICAL CENTER, R&D DEPARTMENT - MATERIALS, MARTOS, JAÉN

Francisco Javier NAVAS-MARTOS / ANDALTEC TECHNOLOGICAL CENTER, R&D DEPARTMENT - MATERIALS, MARTOS, JAÉN

Antonio PEÑAS-SANJUAN / ANDALTEC TECHNOLOGICAL CENTER, R&D DEPARTMENT - MATERIALS, MARTOS, JAÉN

PURPOSE OF THE ABSTRACT

Plastics recycling is an important factor in the transition towards a green and circular European market. With recycling, Europe can decouple its dependency on natural resources and work towards a more sustainable, autonomous economy. Key aspects of this transition are technology innovations, design of recyclable and durable products, increased separate collection, quality sorting and the optimized recycling processes.

In this work different types of plastics found in mixed plastic waste flow from the non-selective collected municipal solid waste (MSW) were characterized in order to determine their processability through different technologies (injection, extrusion and thermoforming) for its applicability in various sectors. Specifically, the characterization of polypropylene (PP) (food and non-food grade), rigid polystyrene (PS) (High Impact Polystyrene, HIPS and General Purpose Polystyrene, GPPS) and foamed PS (Expanded Polystyrene, EPS and Extruded Polystyrene, XPS) from the MSW mixed plastic fraction was carried out.

Once the test pieces and pellets of each material were obtained, their main mechanical, thermal and physical-chemical properties were determined. The conditions for each test were determined according to the type of polymer and the corresponding regulations (ISO standards).

Table 1 shows the results of the mechanical properties of the tested materials. Non-food grade PP generally has better mechanical properties than PP waste from food grade, with its Young's modulus being more than 1.5 times higher and its impact strength more than double. Regarding PS, better mechanical properties were obtained for the processing of foamed waste (EPS and XPS) with respect to HIPS and GPPS. This may be due to the presence of bubbles inside the HIPS and GPPS or the presence of foreign particles such as aluminium from other containers.

Regarding the thermal properties, the heat deflection temperature (HDT) and the VICAT softening temperature have been determined. The HDT data obtained falls within what is expected for each specific type of polymer, ranging between 85-120 ºC for PP depending on whether it is a copolymer or homopolymer, and in the range 75-100 ºC for PS. The results of the VICAT test vary greatly depending on the rate of heating and the load applied to the sample. As above and for the conditions used in this study (50 ºC/h, 50 N), the values fall within the expected range without large variations for each type of polymer.

Other properties determined were the flow rate, glass transition temperature (Tg), melting temperature (Tm),

melting enthalpy and degree of crystallinity. Regarding the melt index, values of 17.1, 19.4, 8.8, 11.3, 13.8 and 8.2 g/10 min are obtained for food grade PP, non-food grade PP, HIPS, GPPS, EPS and XPS, respectively in the different test conditions, with no significant differences for the materials according to the type of polymer. Regarding temperatures, Figure 1 shows the DSC curves of the materials obtained. For food grade PP and non-food grade PP, Tm values of 163.4 and 162.3 ºC respectively were obtained, thus confirming that the wastes are composed of PP, which has been further corroborated by infrared spectroscopy. In addition, a small endothermic peak appears in the non-food grade PP curve at 125 ºC, indicative of the presence of PE residues. The melting enthalpies for these materials were 88 and 70 J/g, which leads to crystallinity degrees of 43 and 34% for recycled food grade PP and non-food grade PP wastes, respectively. On the other hand, for PS materials, the only observable event in the DSC curves is the Tg, thus confirming the amorphous nature of these materials. As occurred with PP, the DSC curves of recycled PS revealed the presence of traces of other polymers except for that material obtained after processing of EPS wastes.

Acknowledgements

This project has received funds from the European Union LIFE Programme, under Grant Agreement LIFE18 ENV/ES/000045 (LIFEPLASMIX).

FIGURES

Material	Young's modulus (MPa)	Tensile strength (MPa)	Flexural modulus (MPa)	Impact strength (kJ/m²)	Shore D Hardness
Food grade PP	1228 (32)	25.8 (0.4)	1000 (20)	30 (4)	67.6 (0.3)
Non-food grade PP	1934 (111)	23.1 (0.2)	820 (20)	70 (13)	63.3 (0.1)
HIPS	2711 (324)	24.1 (1.0)	2010 (30)	7.1 (0.8)	77.7 (0.3)
GPPS	2642 (183)	23.0 (0.2)	1940 (20)	7.1 (1.1)	77.0 (0.5)
EPS	3457 (104)	53.0 (0.6)	2760 (30)	12.5 (1.4)	82.4 (0.5)
XPS	3233 (165)	50.7 (0.6)	2750 (20)	9.7 (0.9)	81.2 (0.7)

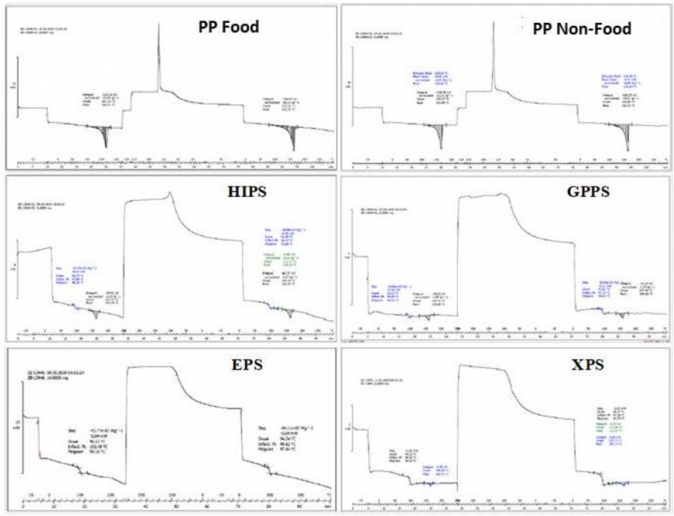

FIGURE 1
Mechanical properties of the tested materials. Values in parentheses indicate the standard deviation

FIGURE 2
DSC curves of all tested materials

KEYWORDS
Mechanical recycling | Municipal solid waste | Plastic waste | Polymers characterization

BIBLIOGRAPHY