Tube shelters from agricultural plastic waste: an example of circular economy

J. Martínez Urreaga[1,2], F.R. Beltrán[1,2], J. Acosta[2,3], T. Aguinaco[2,3], C. Fonseca[2,3], A. Ochoa[2,3], J. A. Oliet Palá[4], M.U. de la Orden[2,5],

[1]Dpto. Ingeniería Química Industrial y del Medio Ambiente, E.T.S.I. Industriales, Universidad Politécnica de Madrid, José Gutiérrez Abascal, 2, 28006-Madrid, Spain.
[2]Grupo de Investigación: Polímeros, Caracterización y Aplicaciones (POLCA).
[3] E.T.S. de Ingeniería y Diseño Industrial, Universidad Politécnica de Madrid
[4]E.T.S. de Ingeniería de Montes, Forestal y del Medio Natural, Universidad Politécnica de Madrid
[5]Dpto. de Química Orgánica I, Universidad Complutense de Madrid, Facultad de Óptica y Optometría, Madrid,
Keywords: agricultural plastic waste, mechanical recycling, circular economy, tube shelters.
Presenting author email: joaquin.martinez@upm.es

The promotion of the circular economy (CE) is one of the keys of European policy for the coming years. The demanding objectives set by the European Union in the field of CE represent a formidable challenge for the entire society, and especially for companies and research centers.

The production of plastics and the fate of waste plastics play a main role in achieving the objectives of the CE policy. The production of plastics is growing continuously, consuming a significant amount of resources, most of which come from non-renewable sources. Although the amounts of plastic residues sent to mechanical recycling and energy recovery increase every year, even today an important fraction of the residues is not properly valorized, which generates important environmental problems, in addition to the loss of raw materials.

A life cycle assessment based on a real-world case study has shown that mechanical recycling, which is fully compliant to the proposals of the circular economy, is the best alternative for many plastic residues (Gu et al., 2017). However, the high costs of recycling post-consumer plastics, as well as the limited performance of some recycled products, limit the economic viability of mechanical recycling of plastic waste.

Agriculture consumes 5% of all plastics produced (Rentizelas et al., 2018), so the destination of agricultural plastics waste is very important in CE policies. In order to increase the mechanical recycling of the agricultural plastics, it is necessary to optimize the economy of the recycling process, improving the properties of recycled plastics and developing viable markets for the final materials. In previous works, the use of agricultural plastic waste to obtain ecocomposites with good performance was studied (González Sánchez et al., 2014; Martínez Urreaga et al., 2015).

The present research work addresses the study of another application for recycled plastics obtained from agricultural plastics waste, specifically the manufacture of tube shelters (Fig. 1) to protect young trees in forest restoration and other plants, such as vines. These tube shelters play an important role in the survival and growth of young specimens, because they protect them from predators and control the amount of light reaching the plant, as well as temperature and relative humidity (Oliet et al., 2005; Puértolas et al., 2010).

Fig. 1. Pellets of the plastics used (left). An example of tube shelter (right).

In order to evaluate the suitability of recycled plastics, optical and mechanical properties of different mixtures of virgin low-density polyethylene (LDPE) and recycled agricultural plastic were measured and compared to those of the virgin plastic. Befesa Plásticos (Spain) kindly supplied the recycled plastic, which was obtained by mechanical recycling of greenhouse covers and other agricultural films used in the south of Spain. The main component of the recycled plastic was LDPE, with minor amounts of ethylene-vinyl acetate (EVA) copolymer, impurities and additives. Sheets of the different materials were subjected to accelerated aging and characterized using tensile tests, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA) and

Fourier transform infrared spectroscopy (FTIR). Optical properties were measured using UV-Vis spectroscopy and standard colorimetry.

Results and discussion

Fig.2 shows the effects of the recycled agricultural plastic and the accelerated aging on the mechanical and optical properties of the materials used in the tube shelters. The addition of 90 wt % of recycled plastic reduces only slightly the maximum elongation of the plastic. In general, blends that contain recycled plastic show mechanical performance similar to that of virgin plastic.

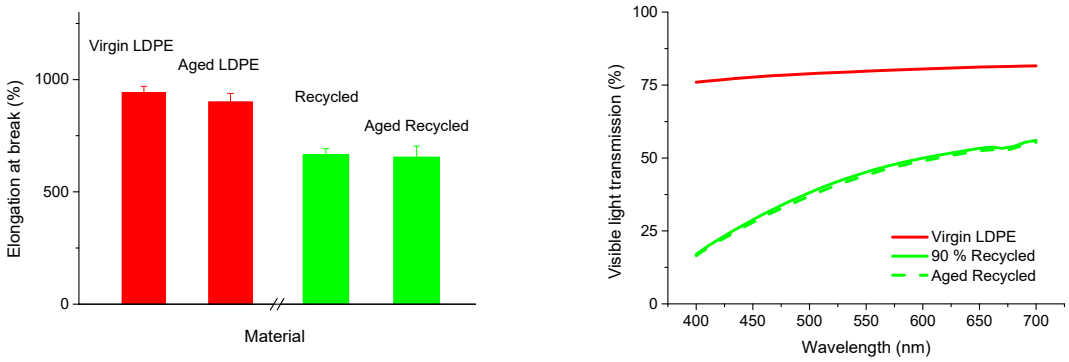

Fig. 2. Elongation at break (left) and visible light transmission (right) of the virgin plastic (red) and the blend with 90 wt % of recycled agricultural plastic (green).

Regarding the optical properties, the mixtures present lower transmission of visible light, because the degradation and the impurities present in the recycled agricultural plastic make it darker than the virgin. The transmission depends on the content of recycled plastic. This fact can be useful, since it is known that the transmission of light influences the growth of the species and that the optimal value of the transmission depends on the species and the climate in which it develops (Puértolas et al., 2010). Fig. 2 also shows that both the blend and the virgin plastic retain their properties during the accelerated aging process.

The above results reveal that recycled agricultural plastics can be used in the manufacture of tube shelters, since the blends with virgin plastic show good optical and mechanical properties.

Acknowledgements

The authors would like to acknowledge the financial support of MINECO-Spain (project CTM2017-88989-P) and Universidad Politécnica de Madrid (project UPM RP 160543006).

References

González-Sánchez, C., Martínez-Aguirre, A., Pérez-García, B., Martínez Urreaga, J., de la Orden, M.U., Fonseca-Valero, C., 2014. Use of residual agricultural plastics and cellulose fibers for obtaining sustainable eco-composites prevents waste generation. J. Clean. Prod. 83, 228-237

Gu, F., Guo, J., Zhang, W., Summers, P.A., Hall, P., 2017. From waste plastics to industrial raw materials: A life cycle assessment of mechanical plastic recycling practice based on a real-world case study. Sci. Total Environ. 601-602, 1192-1207

Martínez-Urreaga, J., González-Sánchez, C., Martínez-Aguirre, A., Fonseca-Valero, C., Acosta, J., de la Orden, M.U., 2015. Sustainable eco-composites obtained from agricultural and urban waste plastic blends and residual cellulose fibers. J. Clean. Prod. 108, 377-84

Oliet, J.A., Planelles, R., Artero, F., Jacobs, D.F., 2005. Nursery fertilization and tree shelters affect long-term field response of Acacia salicina Lindl. planted in Mediterranean semiarid conditions. Forest Ecol. Manag. 215, 339-351

Puértolas, J., Oliet, J.A., Jacobs, D.F., Benito, L.F., Peñuelas, J.L., 2010. Is light the key factor for success of tube shelters in forest restoration plantings under Mediterranean climates? Forest Ecol. Manag. 260, 610-617

Rentizelas, A., Shpakova, A., Masek, O., 2018. Designing an optimised supply network for sustainable conversion of waste agricultural plastics into higher value products. J. Clean. Prod. 189, 683-700