Plastics for tree shelters: characterization of polypropylene tube residues after up to 20 years in the reforestation area

J. Martínez Urreaga[1,2], F.R. Beltrán [1,2], G. Gaspar[1], J. A. Oliet Palá[3], M.U. de la Orden[2,4]*

[1]Dpto. Ing. Química Industrial y Medio Ambiente, Universidad Politécnica de Madrid, E.T.S.I. Industriales, Madrid, 28006, Spain.
[2]Grupo de Investigación: Polímeros, Caracterización y Aplicaciones (POLCA).
[3]E.T.S. de Ingeniería de Montes, Forestal y del Medio Natural, Universidad Politécnica de Madrid
[4]Dpto. de Química Orgánica I, Universidad Complutense de Madrid, Facultad de Óptica y Optometría, Madrid, 28037, Spain.

*e-mail: f.beltran@upm.es

Introduction

- Plastic tube shelters (**Fig. 1**) play a very important role in the survivability of young plants in agricultural and reforestation environments [1].
- They are manufactured mainly from **polyolefins such as polyethylene (PE) and polypropylene (PP)**.
- The management of the tubes, once they have fulfilled their function is concerning from an environmental point of view.
- **Unmanaged dumping could lead to important environmental problems**, but the collection of the residues could be difficult and expensive
- Nevertheless, EC is promoting the adoption of a **circular economy approach**, which includes the **recycling of plastic materials** [2].

Fig 1. *Example of utilization of plastic tube shelters*

The main aim of this work is to **analyze the degradation and contamination of polypropylene tube shelters during service life**, in order to adequately choose an alternative for the management of the generated plastic waste

Materials and methods

Plastic tube shelters were recovered from different reforestation processes in central Spain. Tubes with 5, 10 and 20 years of service life (**Fig. 2**) were analyzed by means of Fourier-transform infrared spectroscopy (FTIR) and differential scanning calorimetry (DSC).

Fig 1. From left to right: new, 5 years, 10 years and 20 years old tube shelters

Acknowledgements

Authors would like to acknowledge the support of MINECO-Spain (project CTM2017-88989-P), European Union's Horizon 2020 research and innovation program under grant agreement No. 860407 BIO-PLASTICS EUROPE and Universidad Politécnica de Madrid (project UPM RP 160543006).

References

[1] Puértolas J. et al., 2010. *Is light the key factor for success of tube shelters in forest restoration plantings under Mediterranean climates?*. Forest Ecol. Manag. 260, 610-617

[2] European Commission, 2018. A European strategy for plastics in a Circular Economy. http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN (accessed June 2021).

[3] Rjeb A., et al., 2000. *IR Spectroscopy Study of Polypropylene Natural Aging*. J. Appl. Pol. Sci., 77, 1742-1748

[4] Niemczyk A. et al., 2019, Accelerated laboratory weathering of polypropylene composites filled with synthetic silicon-based compounds. Polym. Deg. Stab., 161, 30-38

Results and discussion

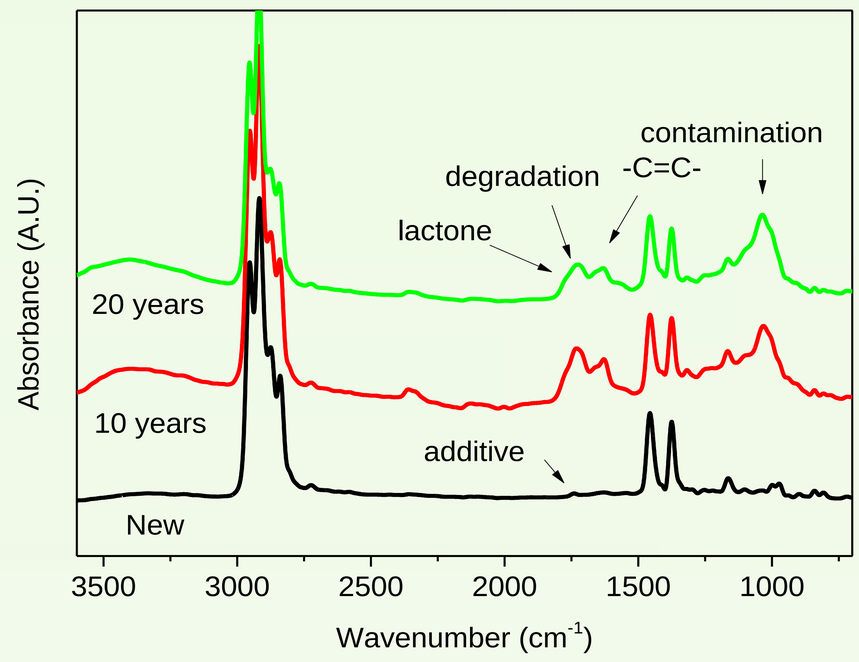

Fig 3. *FTIR-ATR spectra of the new, 10 years and 20 years old tubes*

- The band centered at **1036 cm^{-1}** can be attributed to the silicates of the soil, indicating the **contamination of the used tubes**.
- The bands between **1600 and 1800 cm^{-1}** correspond to the C=C. C=O and lactone groups. These indicate the **thermoxidative degradation of PP**.
- The band **above 3000 cm^{-1}** is attributed to the formation of hydroperoxydes, another product of **the degradation of PP** [3].

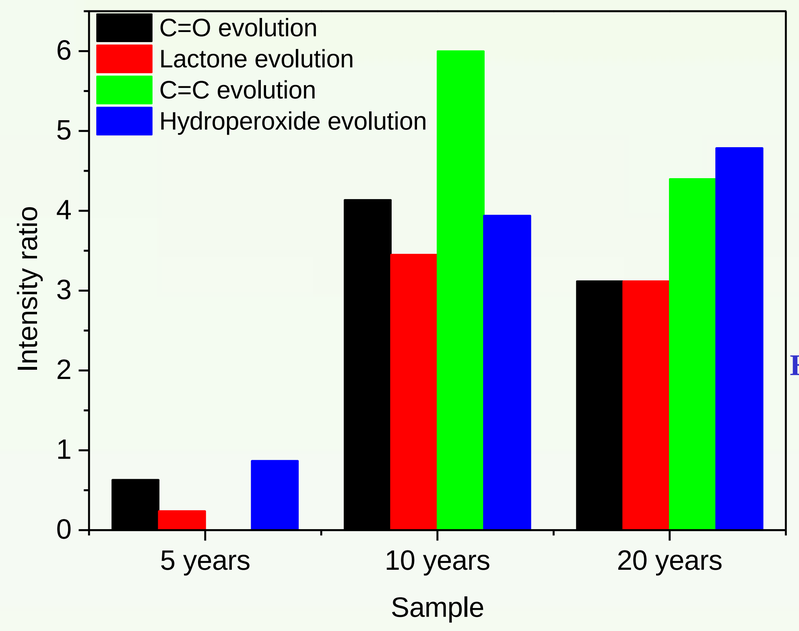

Fig 4. *Evolution of FTIR-ATR bands*

- All degradation products increase during service life. However, after 20 years hydroperoxides have more relevance
- DSC first heating scans (Fig. 5) show that **after 20 years a second melting peak** at lower temperature appears, due to less perfect crystals. This is a consequence of the presence of shorter polymer chains, **due to degradation** processes [4].

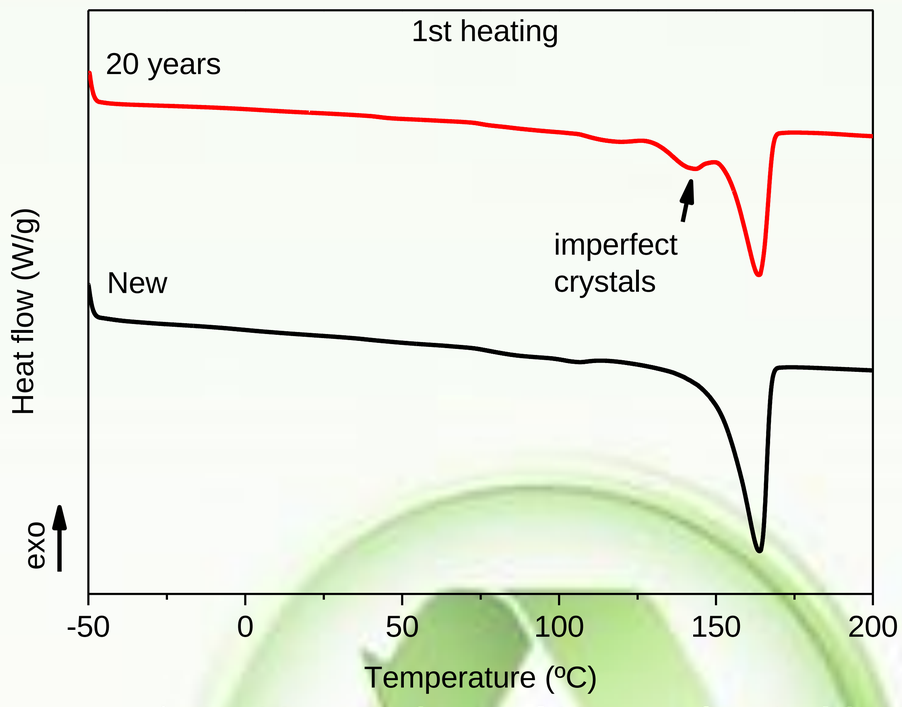

Fig 4. *DSC traces after 0 and 20 years of service life*

Conclusions

- **Both FTIR spectra and DSC results show severe degradation signs in tubes with 10 years or more of service life, which negatively affects the recyclability of PP tubes.**
- **However, tubes show only a very moderate degradation after 5 years of service life.**