Charge and heat transport in halogen-free flame retarded polypropylene compounds

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Polypropylene (PP) is rising as an alternative polymer for the manufacture of cable protection conduits, replacing traditional PVC pipes. However, PP needs to be flame retarded in order to comply with the current stringent EU safety regulations regarding halogen content, smoke density and corrosiveness of released gases (EN50642, EN61034-2, EN60754-2). Herein, three flame retarded (FR) PP formulations (FR1-FR3) were developed by the incorporation of commercial FR additives into PP, by means of melt-compounding. A high impact strength heterophasic co-polymer (Repsol ISPLEN PB131N5E) was selected as reference PP. The additives used comprised: ammonium polyphosphate, a polymeric triazine derivative (PPM triazine HF) and a N-alkoxy hindered amine resulting in halogen-free formulations FR1 and FR2. The loading level for FR1 and FR2 additives in PP was 25 and 20 wt% respectively. For the low-halogen formulation FR3 (Br<1500 ppm) a mixture of aluminum hypophosphite (AHP) and a phosphorous-bromine salt was used with a low loading level of FR3 (only 2 wt%). All compounds were found to comply with the aforementioned European standards [1].

The focus of this work lies on the investigation of the effects of the additives on the molecular mobility of the compounds and in the corresponding dielectric and thermal conduction properties by employing Broadband Dielectric Spectroscopy, Thermally Stimulated Depolarization Currents and Thermal Conductivity measurements. Our results show that the compounds with relatively high content of additives (FR1 and FR2) exhibit enhanced molecular mobility, which is related to the glass transition of PP, and remarkable charge transport properties due to the high conductivity of the additives. Interestingly, the enhanced charge transport properties are not accompanied by an increased heat transfer capability in the compounds: all compounds are characterized by smaller values of thermal conductivity than neat PP. These findings are discussed in terms of heat transfer mechanisms in the polymeric matrix and alterations in the semi-crystalline morphology of the compounds.

Acknowledgments *This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (Project code: T2EDK-01466).*

[1] Porfyris, A.D. et. al. *Halogen-Free Flame Retarded PP Compounds designated for cable protection conduits.* AMI Fire Resistance in Plastics, 30 November – 2 December 2021, Düsseldorf, Germany.

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