The effect of pigments on thermal properties of high-density polyethylene (HDPE) and polyethylene terephthalate (PET)

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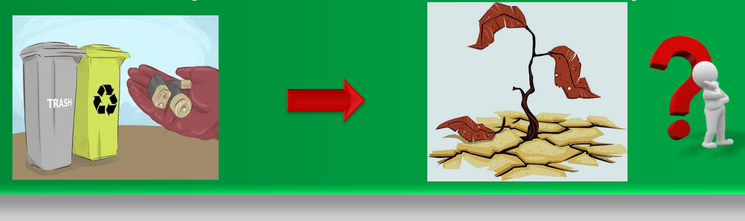
Introduction

High-density polyethylene (HDPE) and polyethylene terephthalate (PET) are widely used in packaging materials. Due to their chemical inertness, good mechanical and physical characteristics, these materials are suitable for packaging material of food, cosmetics, pharmaceuticals, etc. As everyday consumables are most often packed in HDPE foil or PET bottles, these materials give a high percentage of municipal plastic waste [1,2]. The most significant examples of usage in the region of Vojvodina are thin HDPE bags for the package of consumables and PET bottles for water, soft-drink, milk and some dairy products.

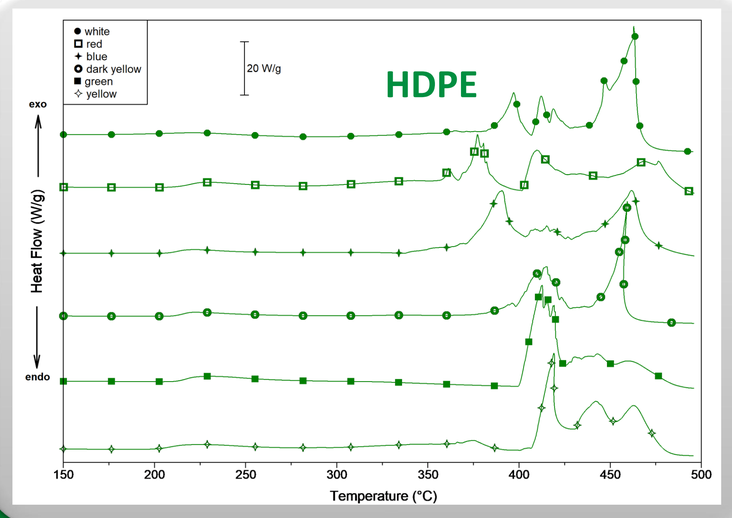
To reduce the amount of plastic waste, following environment protection tendencies, in the last few years stores charge for HDPE bags. Unfortunately, this regulative did not change their use significantly and a huge amount of bags ends up as environmental pollutants. The situation with PET bottles is similar. These items cannot be reused for packing, but maybe recycled. There are several solutions for municipal plastic waste recycling. By melting and molding of selected plastic waste, new products can be prepared. The thermal degradation of plastic materials into simple hydrocarbons is an alternative way for gasoline production. Unfortunately, the conversion of plastics into gasoline is expensive. These materials may also be incinerated as trash, but due to CO_2 release, it increases the greenhouse effect.



Experimental work -Thermal Analysis-

The diferently coloured HDPE bag and PET bootle samples were analyzed by simultaneous thermogravimetry-differntial scanning calorimetry (TG-DSC). The data were collected using TA Instruments SDT Q600 thermal analyzer. The decomposition was followed from room temperature to 600 °C at 5 °C min^{-1} heating rate in air (flow rate = 100 cm^3min^{-1}). Sample holder/reference: alumina crucible/empty alumina crucible. Sample mass 2-5 mg.

Results and discussion

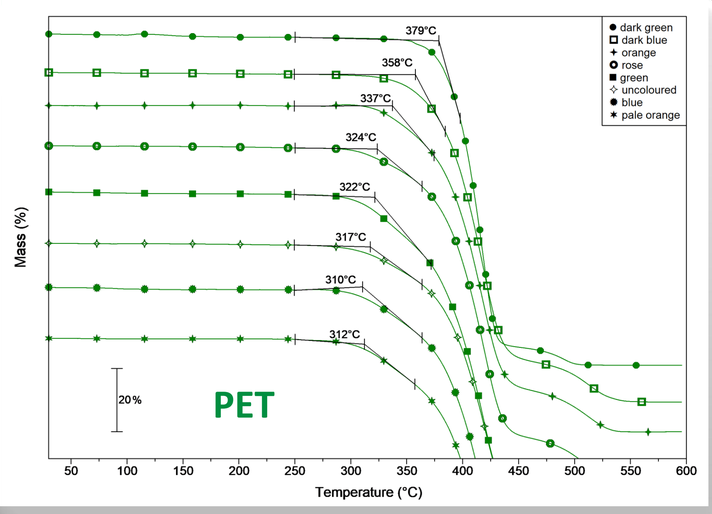


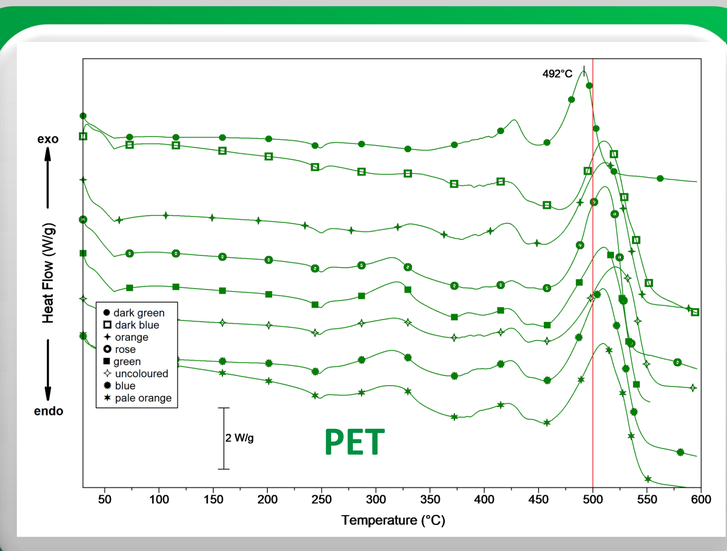
HDPE

Pigment content of the HDPE bags does not affect significantly the melting point of the samples, nor the thermal decomposition onset temperature. The coloured samples' decomposition starts only at a few degrees higher temperatures than the uncoloured foils. Comparing the yellow and dark yellow HDPE bags, the thermal stability of that with higher pigment content is a few degrees higher. The decomposition course of the differently coloured HDPE samples is different above ~300 °C. These differences may be caused by different thickness of foil, different packaging into the crucible, different age of the bags, etc. The released heat during burning in air atmosphere, determined by DSC is also similar ranging from ~8100 to ~11000 J/g.

PET

By thermogravimetric analysis was found that a higher pigment content and intensive coloring of PET bottles increases the thermal stability of PET. Namely, samples with less intensive colors (lover pigment content) begin to decompose somewhat above 300 ˚C (~303 - ~326 ˚C), but the samples of high pigment content at about 65 ˚C higher temperatures. Interestingly these intensively colored samples release the least energy during burning. The samples of the same but less intensive colors release about 1.5 to 2 times more energy. The pigments slightly affect the DSC peak maxima of PET burning (right figure) and lower its temperature a few degrees.





Conclusion

In this work, the effect of the coloring of HDPE and PET on the thermal stability, the decomposition mechanism, and the energy release in air atmosphere was studied by means of simultaneous thermogravimetric and differential scanning calorimetric measurements. It was found that pigments added into HDPE and PET do not affect their thermal properties significantly, except for the dark green and dark blue PET bottles. These samples had higher thermal stability and showed a lower energy release while burning than the samples with no color or with other colors.

References

[1] Singh et al. A TG-FTIR investigation on the co-pyrolysis of the waste HDPE, PP, PS and PET under high heating conditions, Journal of the Energy Institute, 93 (2020() 1020-1030.

[2] Kim et al. Biological Valorization of Poly(ethylene terephthalate) Monomers for Upcycling Waste PET, ACS Sustainable Chem. Eng. 7 (2019) 19396-19406.

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