PET-G as a PET contaminant

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Introduction

Currently, PET recycling companies are increasingly confronted with a new type of contaminant such as PET-G, which was introduced as an alternative to PVC. The group of copolymers referred to as "PET-G" is extensive and contains more than 60 modifications. These differ in the molar ratios of the individual components of the copolymer, which fundamentally affect the physical properties. The final products are commonly referred to as "PET". PET-G is therefore often perceived as another type of PET.

Although PET and PET-G are physiochemically similar, the most crucial is the difference in their melting point. In some countries, PET-G has therefore been excluded from recycling category 1 (PET) and classified in category 7 (other plastics). Opponents of this reclassification argue that it is sufficient to adjust the sensitivity of sorting devices with NIR detectors.

In our analysis several dozen samples, which the recycler identified as contaminants, were examined in order to detect the presence of PET-G. Because the standard for PET-G is not available, 2 products for 3D printing were used, declared by the manufacturer as "PET-G".

Methods

Thermal properties were measured by differential scanning calorimetry (DSC) with a TA Instrument DSC 2500.

FTIR-ATR spectra were measured using the attenuated total reflection method with a Bruker ALPHA II.

Samples

PET standard - ES 303015 GoodFellow (sheet, amorphous, transparent)
PET-G samples for 3D printing - declared by the manufacturer as PET-G
Contaminants - several dozen samples declared by the recycler as a PET contaminants

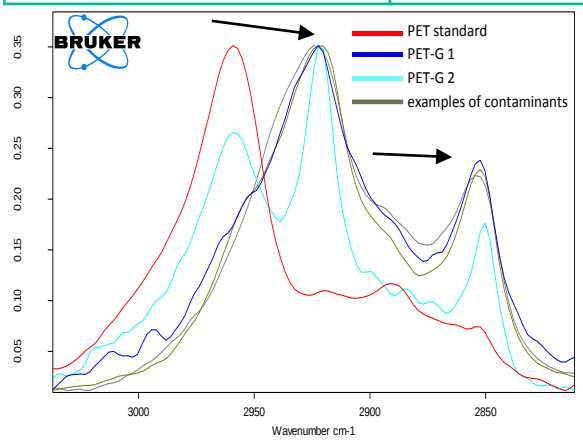
Results and discussion

DSC

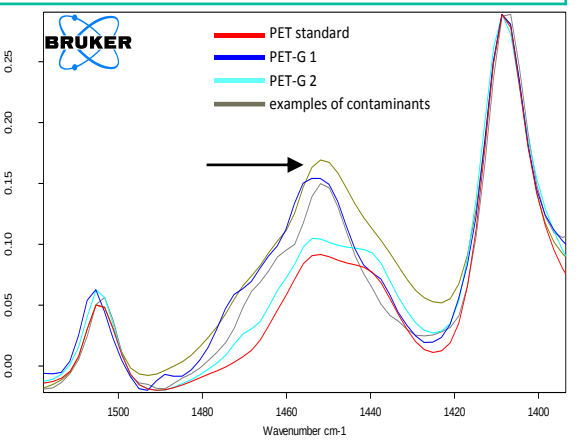
Samples	Glass transition T_g	Melting temeprature T_m
PET standard	81°C	260°C
PET-G 1	–	79°C
PET-G 2	80°C	253°C
contaminants of recycled PET	Vary, but less than 200°C	

Different thermophysical properties were confirmed by DSC.
PET-G 2 corresponds with the PET standard.
On the contrary, PET-G 1 and contaminants show significantly different thermal properties.

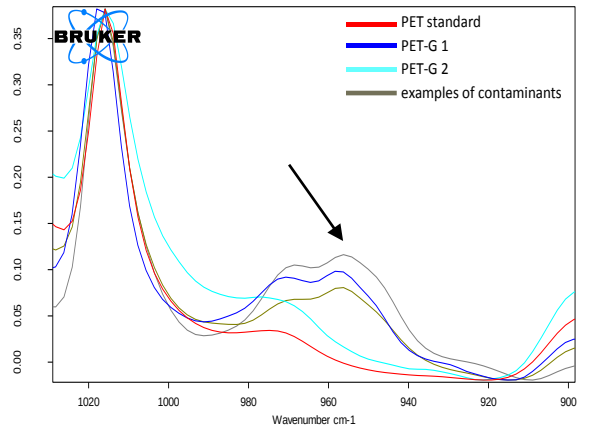
FTIR-ATR



Peak 2960 and 2910 cm^{-1} due to the presence of methyl groups in PET-G moves to 2925 cm^{-1} and 2855 cm^{-1}.[1)]



Peaks 1460-1430 cm^{-1} – ethylene glycol segments bending and wagging vibrational modes. In PET-G peak 1450 cm^{-1} is sharp. [2)]



Peak 957 cm^{-1} - the C–H stretching of cyclohexylene ring was observed in spectrum of PET-G.[1)]

The agreement of whole spectra of all samples exceeds 95% according to algorithm provided by Bruker.
Identification is possible only due to a few characteristic peaks of the spectrum (2960, 2910, 2855, 1450 and 957 cm^{-1}).
PET-G 2 differ from the PET standard only in peaks 2910 and 2855 cm^{-1}. PET-G 1 differ in all five peaks.
14,55 % of groups of the total amount of contaminants analyzed corresponds to this type and can be identified as "PET-G".

Conclusions

It was confirmed that PET-G 2 has very similar thermophysical properties as the PET standard. This type of "PET-G" is therefore indistinguishable from the PET standard and can be recycled together with PET. PET-G 1, also referred as "PET-G", has significantly different thermophysical properties and therefore it can not be recycled together with PET. Thus, it was confirmed that materials with the same labeling differ significantly, especially in the possibility to recycling together with PET.

Also 14.55% of the analyzed contaminants of PET correspond in their properties to PET-G 1. These groups are most common contaminants in recycled PET. Thus PET-G is indeed a significant contaminant of recycled PET. This also suggests that some products labeled as „PET" may, in fact, be made of PET-G. But due to their labeling, recyclers do not identify these products as contaminants.

Identification of PET-G is possible only due to a few characteristic peaks of FTIR spectrum. But FTIR analysis is more sensitive than industrial NIR detectors. Thus, it is unlikely that PET-G can be separated from PET by simply adjusting the sensitivity of the NIR detectors.

Based on these findings the reclassification of PET-G into category 7 (other plastic) could be legit.

The aim of this paper was to point out the problems connected with PET-G. Therefore, debate about use, labeling, identification and reclassification of PET-G products should be opened.

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1) Paszkiewicz, Sandra et al. 2017. "Synthesis and Characterization of Poly(Ethylene Terephthalate-: Co -1,4-Cyclohexanedimethylene Terephtlatate)- Block -Poly(Tetramethylene Oxide) Copolymers." RSC Advances 7(66): 41745–54.
2) Chen, Ziyu, J. N. Hay, and M. J. Jenkins. 2012. "FTIR Spectroscopic Analysis of Poly(Ethylene Terephthalate) on Crystallization." European Polymer Journal 48(9): 1586–1610.