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NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 46019.1-2025

Plastics - Identification of recycled plastics - Part 1: Poly(ethylene terephthalate) (PET) materials

塑料 再生塑料成分鉴别 第1部分：聚对苯二甲酸乙二醇酯（PET）材料

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1 Scope

This document describes a method for identifying post-consumer mechanically recycled PET plastic materials and virgin PET plastic materials by determining the volatile components of poly(ethylene terephthalate) (PET) materials using headspace gas chromatography-mass spectrometry and constructing a prediction model based on the random forest algorithm.

This document is applicable to the identification of flake recycled PET plastic materials obtained from post-consumer PET packaging bottles by crushing, screening, sorting and washing, or pelletized recycled PET plastic materials manufactured from recycled PET bottle flakes through processes such as melt extrusion and pelletizing.

This document does not apply to the identification of recycled PET plastic materials obtained through chemical recycling.

Note. It may also be used as a reference for the identification of recycled PET plastic materials obtained through the mechanical recycling of other types of post-consumer PET products.

2 Normative references

GB/T 2035

GB/T 30102

GB/T 40006.1

GB/T 41867

GB/T 45090

3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in GB/T 2035, GB/T 30102, GB/T 40006.1, GB/T 45090 and GB/T 41867, apply.

3.1 post-consumer plastic

Plastic generated by end users that has fulfilled its intended purpose or can no longer be used (including plastic returned from the distribution chain).

[Source. GB/T 30102-2024, 3.3, modified]

3.2 chemical recycling

Process in which the chemical structure of plastic waste is altered through reactions such as pyrolysis, gasification or depolymerization, excluding energy recovery and incineration, thereby generating new monomers or raw materials.

Note. This includes adding recycled polymers directly to the virgin polymer polymerization reaction system, and preparing new materials containing recycled components through partial depolymerization and repolymerization processes.

[Source. GB/T 45090-2024, 3.4, modified]

3.3 random forest model

A machine learning method that performs classification or regression by constructing multiple decision trees and aggregating their predictions.

3.4 gini impurity

Measure of the purity of a dataset, representing the probability that two samples randomly selected from the dataset belong to different categories.

Note. The smaller the gini impurity, the higher the purity of the dataset.

3.5 grid search

Systematic hyperparameter optimization method that determines the optimal combination of hyperparameters by training models and evaluating their performance for each combination within a predefined hyperparameter search space.

3.6 receiver operating characteristic curve; ROC

Performance evaluation method in which the false positive rate and the true positive rate are calculated at different classification thresholds and their relationship is plotted as a curve to assess the ability of a classification model to distinguish between positive and negative samples.

Note. The area under the receiver operating characteristic curve (ROC-AUC) can be used as a quantitative indicator of the overall discriminative ability of the model. The closer the value is to 1, the better the performance.

3.7 precision

Proportion of samples predicted as positive by a model that are actually positive.

3.8 recall

Proportion of actual positive samples that are correctly identified as positive by a model.

4 Principle

PET materials may introduce or lose various volatile components throughout its life cycle (including use, disposal, and mechanical recycling), resulting in differences in the volatile components between recycled and virgin PET. Therefore, headspace gas chromatography-mass spectrometry (HSGC-MS) can be used to analyze the compositional characteristics of volatile components in a sufficient number of virgin and recycled PET samples with clearly defined sources, screening for marker volatile components. A random forest model can then be constructed and validated based on their quantifier ion peak areas. For the sample to be tested, use the same analytical method to determine its marker volatile components, and input the quantifier ion peak area data into the aforementioned model to provide a probability prediction value for recycled PET, which can be used for the identification of recycled PET.

Note. The procedure for identifying virgin PET and recycled PET is detailed in

5.1 Sample collection

To ensure the stability and applicability of the model, collect a sufficient number of representative virgin PET and recycled PET samples for model construction. There shall be

no fewer than 75 batches of virgin PET and recycled PET samples, covering different sources, manufacturing techniques, and manufacturers. To avoid imbalanced sample distribution, the proportion of either category (virgin PET or recycled PET) in all samples shall not exceed 60%.

5.2.1.1 Standards

5.2.1.1.1 Mixed standard solution of n-alkanes (C7-C28, a total of 22 kinds), with n- hexane as the solvent; the mass concentration of each substance shall be 1 000 μg/mL.

5.2.1.1.2 D8-naphthalene (CAS No.. 1146-65-2), purity >= 99.5% (mass fraction).

5.2.1.2 Reagents

5.2.1.2.1 Absolute ethanol. chromatographic pure.

5.2.1.2.2 Liquid nitrogen. purity 99.999% (volume fraction).

5.2.2.1 Headspace gas chromatography-mass spectrometry system. equipped with an

EI source, operating temperature of the headspace sampler not lower than 200 °C.

5.2.2.2 Headspace bottle. 20 mL, provided with aluminum cap and PTFE silicone

rubber gasket.

5.2.2.3 Dewar flask. equipped with a sealing cap.

5.2.2.4 High-speed rotary crusher. rotation speed not less than 10 000 r/min, equipped

with a screen with an aperture not greater than 0.5 mm.

5.2.2.5 Analytical balance. sensitivity 0.01 mg.

5.2.2.6 Analytical balance. sensitivity 0.1 mg.

5.2.3.1 D8-naphthalene stock solution (1 000 μg/mL)

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