European PET Bottle Platform

Accelerated Impact Quick Test

(AI-QT)

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1. Introduction

This Quick test describes the Accelerated Impact Test (AIQT), which evaluates the long-term recycling performance of PET packaging innovations. The AIQT simulates multiple recycling loops by subjecting PET pellets to controlled thermal and oxidative conditions, followed by extrusion. The Quick test provides instructions for sample preparation, equipment setup, test execution, data collection, and result interpretation.

2. Scope

The AIQT is used to assess the effect of (PET resin, labels, adhesives, additives, coatings, etc.) on PET quality during repeated recycling. It targets to measure changes in intrinsic viscosity (IV), color (L*, a*, b*, YI), and potential non-intentionally added substances (NIAS). Results guide circularity assessments and compliance with EPBP criteria.

3. Safety & PPE

The AIQT involves high temperatures and potential exposure to fumes. Ensure the following safety measures:

- Perform work in a well-ventilated area or fume hood.
- Use PPE: lab coat, safety glasses/face shield, heat-resistant gloves, protective footwear.
- Follow local regulations for handling, storing, and disposing of test residues.
- Ensure fire safety equipment is available near heating systems.

4. Apparatus & Equipment

- Fluidized bed system capable of maintaining 175–230 °C.
- Extruder (single-screw preferred) with defined residence time control (e.g., 100–125 s).
- Oven for drying pellets (extrusion if pellets are crystalline).
- Pelletizer (strand cutting system).
- Balance (±0.0001 g).
- Spectrophotometer for color (L*, a*, b*, YI).
- IV measurement equipment.

5. Concentration of substance

Additives, contaminants or resins of a special type tend to accumulate in the rPET resin used in multiple cycles and therefore the testing concentration of a substance in innovative bottles must not only consider the maximum intended use concentration of the substance (c0) but also the substance amount that represents the equilibrium concentration of the substance in the rPET stream due to circular PET use (c~).

The equilibrium concentration of the substance depends on the market penetration of the bottles containing the innovative substance and the amount of mechanically recycled PET that is used in a closed loop (%rPET) versus the addition of fresh PET (%vPET). Fresh PET is either virgin PET or PET from chemical recycling with the ability to remove the added substance.

For accumulation calculations a long-term maximum share of closed loop mechanical recycling of 75% is used.

The equilibrium concentration of the substance also depends on the point of introduction of an added substance. Three characteristic cases can be distinguished:

1. A substance added to the fresh PET only. An example would be a substance that is added in the PET manufacturing process. The equilibrium concentration in the rPET stream is:

   c~ = c0 * market penetration

2. A substance added to the recycled PET only. An example would be a substance that is added during the recycling process. The equilibrium concentration in the rPET stream is:

   C~ = c0 * rPET/vPET share * market penetration.

   for 75%/25% rPET/vPET share = 3 * c0 * market penetration

3. A substance added to the recycled PET and the fresh PET. An example would be an additive that is added during preform manufacturing. The equilibrium concentration in the rPET stream is

   c~ = c0 * (1 + rPET/vPET share) * market penetration.

   for 75%/25% rPET/vPET share = 4 * c0 * market penetration

The above cases can be described by one equation as follows:

c~ = c0 * (1 + a) * market penetration

whereas:

a = 0 when the substance is added only to the virgin PET

a = rPET/vPET share - 1 (at 75% rPET: a = 2) when the substance is added only to recycled PET

a = rPET/vPET share (at 75% rPET: a = 3) when the substance is added to recycled and virgin PET

Dilution according to market penetration is already considered by mixing the innovation material with the control resin. The test concentration must be increased accordingly. This simplifies the test concentration to:

ctest = c0 * (1 + a)

Based on the above formula the test concentration may be higher than the maximum intended use concentration. Preparing the sample at this concentration requires different strategies:

For any components inside the PET body (like additives) by directly applying the test concentration when preparing the test sample.

For any components adhering to the PET body (like labels) by spiking to the required factor based on the residual contents after washing. This means that the residual content of the innovative substance after washing must be measured (see Mass Balance below) and depending on the required factor additional innovative substance will have to be added. For evaluations at or below 25% test concentration the accumulation can be considered by multiplying the test concentration by (1 + a)

6. Samples & Preconditioning

Samples must be representative of the PET packaging innovation under evaluation.
Requirements:

- Use the same PET resin for reference and innovation following EPBP recommended resins (clear, no additives, high L*-value)
- Use only amorphous pellets for testing
  if pellets are crystalline or if samples are provided in different form (e.g. flakes) drying, extrusion and palletization are required. Extrude under controlled, residence time (in the range of 150 seconds) at approx. 285°C.
- Pellet size: 16 mg ± 2 mg (2.5–3 mm length).

Retain a part of the amorphous PET pellets as sample 0h.

7. Test Procedure

1. Crystallize amorphous pellets in a fluid bed at 175 °C for 20 min.
   Alternatively crystallization can be performed in an oven. Pellets must be separated to individual pellets thereafter.
   → Report any unusual behavior such as fumes, foaming or extensive sticking
2. Heat the fluidized bed under air to the SSP temperature which is required to hold introduced PET pellets at a product temperature of 210 °C.
   Alternative to a fluidized bed a fixed bed reactor with purge gas flow of preheated air can be used. It is important that the actual product temperature inside the reactor is maintained at 210°C.
   As a further alternative a tumble dryer can be used. Conditions must be set to allow frequent air ingress. It is important that the actual product temperature inside the reactor is maintained at 210°C.

3. Put crystallized pellets in fluidized bed under air. Check if PET pellets reach 210°C product temperature within 15 minutes. Extend treatment time if longer heat-up is used.
4. Maintain 210°C product temperature for 2h to represent 2 recycling loops.
5. Maintain 210°C product temperature for 5h to represent 5 recycling loops.
   Steps 4 and 5 can be done by introducing sufficient PET pellets to the fluidized bed for both samples. Take a first half after 2h and continue for 3h to obtain the final sample after 5h
   → Report any unusual behavior such as fumes or extensive sticking
6. Remove pellets from fluid bed and extrude under controlled, extended residence time (in the range of 300 seconds) at approx. 285°C. Pellets can be transferred hot or cooled in a moisture free environment and extruded without pre-drying.
7. Collect amorphous extruded pellets and label samples as sample 2h and 5h

8. Measurements

- Color (L*, a*, b*, YI) on pellets in reflectance mode with Konica Minolta CM-5 Spectrophotometer (or equivalent) according to standard DIN 5033 (25 measurements
  per sample). Calculate delta b* and delta YI between 2h to 0h and 5h to 0h.
- Intrinsic viscosity (IV) by standard solvent method.
  Alternatively a calibrated rheology method may be used.
- NIAS screening using chromatographic methods.

9. Results & Data Tables

Record results in structured tables. Example:

treatment	L*	a*	b*	delta b* 0 to X	YI	delta YI 0 to X	IV (dl/g)
0h				-		-	
2h							
5h							

10. Photographic Checklist

Photographs should be taken of relevant samples, process equipment and any unusual observations:

- Original sample
- Amorphous pellets before AIQT (Loop 0).
- Extruder and extrudate strand.
- Fluidized bed or alternative SSP setup.
- Pelletized Loop 2 and Loop 5 samples.
- Any visual defects or unusual appearances.

11. Acceptance Criteria

Acceptance criteria will have to be developed over time. The first guideline is given below.
L values must be above 50 (better >55) to obtain meaningful color readings. (If samples with low L* value must be qualified, re-crystallization and color measurements on crystallin samples may provide some information.)

- 2h AIT delta b* (innovation – reference) must be below 2.
- 5h AIT delta b* (innovation – reference) must be below 4 respectively.
- If any sample shows a L value below 60, the YI values need to be calculated.
- 2h AIT delta YI (innovation – reference) must be below or 6.
- 5h AIT delta YI (innovation – reference) must be below 11.

NIAS: No increase >20% compared to reference; no exceedance of regulatory limits.

12. Reporting Template

The test report must include:
- Title, lab, operator, date, location.
- Sample description and preparation details.
- Test parameters (temperature, duration, residence time).
- Results (color, IV, NIAS, processing observations).
- Photos (with captions).
- Interpretation vs acceptance criteria.
- Conclusion and recommendations.
- Signature & approval date.