



Designation: **D7823—14 D7823 – 16**

## Standard Test Method for Determination of Low Level, Regulated Phthalates in Poly (Vinyl Chloride) Plastics by Thermal Desorption—Gas Chromatography/Mass Spectrometry<sup>1</sup>

This standard is issued under the fixed designation D7823; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope\*

1.1 This test method provides a procedure to identify and quantify six phthalates by thermal desorption (TD) gas chromatography (GC) mass spectrometry (MS). The phthalates are BBP, DBP, DEHP, DNOP, DINP and DIDP.

NOTE 1—The method can be extended to include other phthalates.

1.2 Within the context of this method, “low level” is defined as 1000 ppm.

1.3 The values in SI units are to be regarded as standard.

1.4 This test method includes references, notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in the tables and figures) shall not be considered as requirements of this method.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 2—There is no known ISO equivalent to this test method standard.

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

[D883 Terminology Relating to Plastics](#)

[D1600 Terminology for Abbreviated Terms Relating to Plastics](#)

[D3465 Test Method for Purity of Monomeric Plasticizers by Gas Chromatography](#)

[D7083 Practice for Determination of Monomeric Plasticizers in Poly \(Vinyl Chloride\) \(PVC\) by Gas Chromatography](#)

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[E355 Practice for Gas Chromatography Terms and Relationships](#)

[E594 Practice for Testing Flame Ionization Detectors Used in Gas or Supercritical Fluid Chromatography](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

[IEEE/ASTM SI-10 Practice for Use of the International System of Units \(SI\), the Modernized Metric System](#)

2.2 *ASTM Adjuncts:*

[Adjunct to D7823 Vinyl Plasticizer Library—Total Ion Chromatograms and Mass Spectra](#)<sup>3</sup>

### 3. Terminology

3.1 *Definitions*—For definition of plastic terms used in this test method, see Terminologies [D883](#) and [D1600](#).

3.2 For units, symbols, and abbreviations used in this test method refer to Practices [E594](#), [E355](#), or [SI10](#).

3.3 *Compounds and Instrumentation:*

3.3.1 (DOA) *Hexanedioic acid, 1,6-bis(2-ethylhexyl) ester* CAS #103-23-1

3.3.2 (DINCH) *1,2-Cyclohexanedicarboxylic acid, dinonyl ester, branched and linear* CAS #474919-59-0

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee [D20](#) on Plastics and is the direct responsibility of Subcommittee [D20.70](#) on Analytical Methods. Current edition approved Aug. 1, 2014; May 1, 2016. Published September 2013; May 2016. Originally approved in 2013. Last previous edition approved in 2013 as [D7823-13](#); [D7823-14](#). DOI: [10.1520/D7823-14](#); [10.1520/D7823-16](#).

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](#), or contact ASTM Customer Service at [service@astm.org](#). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from ASTM International Headquarters. Order Adjunct No. [ADJD7823S-EA](#). Original adjunct produced in 2016.

\*A Summary of Changes section appears at the end of this standard

- 3.3.3 (DBP) 1,2-Benzenedicarboxylic acid, 1,2-di-n-butyl ester CAS #84-74-2
- 3.3.4 (BBP) Benzyl butyl phthalate CAS #85-68-7
- 3.3.5 (DEHP) Bis(2-Ethyhexyl) Phthalate CAS #117-81-7
- 3.3.6 (DNOP) Di(n-octyl) phthalate CAS #117-84-0
- 3.3.7 (DINP) 1,2-Benzenedicarboxylic acid, di-C8-10-branched alkyl esters, C9-rich (Jayflex) CAS #68515-48-0
- 3.3.8 (DINP) 1,2-Benzenedicarboxylic acid, 1,2-diisononyl (Palatinol) CAS #28553-12-0
- 3.3.9 (DIDP) 1,2-Benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich (Jayflex) CAS #68515-49-1
- 3.3.10 (DIDP) 1,2-Benzenedicarboxylic acid, 1,2-diisodecyl CAS #26761-40-0
- 3.3.11 TD Thermal Desorption
- 3.3.12 GC Gas Chromatography
- 3.3.13 GC/MS Gas Chromatography/Mass Spectrometry
- 3.3.14 PVC Poly (Vinyl Chloride)
- 3.3.15 THF GC grade or higher “Tetrahydrofuran”
- 3.3.16 DCM GC grade or higher “Methylene Chloride”
- 3.3.17 EGA-MS Evolved Gas Analysis-mass spectrometry
- 3.3.18 FTIR Fourier Transform Infrared Spectroscopy
- 3.3.19 TIC Total ion chromatogram
- 3.3.20 DQO Data quality objectives

NOTE 3—DINP and DIDP, when used in various PVC formulations are technical mixtures. Take care, when preparing the phthalate calibration standard to use the technical grade. Here is specific information on DINP and DIDP. For more information, please refer to [Appendix X3](#).  
 Jayflex DIDP: 1,2-Benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich: CAS# 68515-49-1.  
 Jayflex DINP: 1,2-Benzenedicarboxylic acid, di-C8-10-branched alkyl esters, C9-rich: CAS# 68515- 48-0.

#### 4. Summary of Test Method

4.1 200 mg of the PVC sample are dissolved in 10 mL of THF. 10 µL of the THF solution are analyzed using TD-GC/MS. Phthalates are identified by their retention times and their mass spectra. Quantification is based on the area of a designated quant ion (SIM or full scan)—see [Table 1](#). Standard addition is the calibration method.

NOTE 4—Standard addition calibration will negate matrix interference. It also takes into account the overall performance of the instrumentation at the time the samples are analyzed.

#### 5. Significance and Use

5.1 Identification and quantitation of phthalates: DBP, BBP, DEHP, DNOP, DINP, and DIDP are required for regulated articles. Regulations include: EU—Directive 2005/84/EC, US—Consumer Product Safety Improvement Act of 2008—section 108, Japan—Health, Labor and Welfare Ministry guideline No.336 (2010). This test method provides a procedure to identify and quantify regulated phthalates in PVC.

5.2 Other techniques successfully used to separate and identify phthalates in PVC include GC/MS, HPLC/UV, HPLC/MS, FTIR, and GC/FID (flame ionization detector).

#### 6. Interferences

6.1 Retention times for GC are dependent on several variables and it is possible to have two or more components with identical retention times. The analyst shall take the necessary steps to insure that adequate separation of the plasticizer components is achieved and or the ions used to monitor for a target phthalate are free of interference. This includes, but is not limited to changing the selectivity of the chromatographic column. Calibration by standard addition offers the advantage of minimizing interferences.

6.2 When using a TD-GC/MS method, care must be taken to ensure that the sample cups are inert and clean. Any and all solvents used to prepare standards and sample solutions must be free of contamination.

**TABLE 1 Ions and Ion Ratios Used to Identify Each Phthalate**

	DBP	BBP	DEHP	DNOP	DINP	DIDP
Quant ion	223	206	279	279	293	307
Confirm ion 1	149	149	149	149	149	149
Area ratio (±10%) (Quant/Confirm 1)	<0.04	<0.23	<0.08	<0.06	<0.20	<0.12
Confirm ion 2	167	167	167	167	167	167

6.3 The presence or absence of each phthalate is based upon three criteria: (1) the relative retention time of the peak (2) the presence or absence of the quant ion and the two confirming ions and (3) the ratio of the quant and the confirming ion one must satisfy the established guideline (see **Table 1**).

6.4 Calculating the phthalate concentrations using the areas of compound specific ions and standard addition significantly reduces interference from non-target compounds.

## 7. Apparatus

7.1 Gas chromatograph/mass spectrometer capable of operating in the 75 to 350°C range.

NOTE 5—Optional but recommended: Vent-free GC/MS Adapter. This facilitates the rapid conversion between detailed analysis and evolved gas analysis.

7.2 Thermal desorption unit capable of heating the sample from 100 to 350°C at 20°C/min.

7.3 Inert, reusable or disposable sample containers or cups.

7.4 GC capillary column: 5 % diphenyl-95 % poly (dimethylsiloxane) stainless steel, 30 m by 0.25 mm ID with a 0.25 µm film thickness, or equivalent.

7.5 Integrator or data handling system, capable of measuring peak areas and retention times to four significant figures.

7.6 Analytical balance, capable of weighing to ±0.000001 g (1 µg). If using a balance capable of weighing to ±0.00001 g (10 µg), weight used in the sample and standard preparation must be scaled accordingly in order to ensure that the data are accurate to three significant figures.

7.7 Pressure regulators, for all required gas cylinders.

7.8 Flow meter, or other means of measuring gas flow rates ±0.1 mL/min.

## 8. Reagents and Materials

8.1 Helium carrier gas, chromatographic grade.

8.2 Methylene chloride (DCM) or n-hexane for preparing the phthalate standard solution (Solution #1, **10.2**), spectral quality or chromatographic grade.

8.3 Tetrahydrofuran (THF), or a solvent suitable for preparing the PVC sample (Solution #2, **10.3**), spectral quality or chromatographic grade.

8.4 Standards of the appropriate phthalates for use when constructing an external calibration curve or preparing Solution #3 (**10.4**) used for standard addition. See **Note 3**.

## 9. Safety and Precautions

9.1 Use THF and methylene chloride in a well-ventilated space.

## 10. Preparation of the Analytical Samples (based upon using a 1 µg balance) Weights must be scaled up if using a 10-µg balance.

10.1 Three solutions must be prepared: (1) a stock solution of the target phthalate standards, (2) a solution of the sample and (3) the sample solution spiked with the standard stock solution.

10.2 *Solution #1*—Prepare a stock standard solution of the phthalates by dissolving 0.30 mg of each phthalate in 10 mL of methylene chloride (0.30 mg/10 mL). N-hexane has also been used with success. See **Fig. 1** for a typical chromatogram.

10.3 *Solution #2*—Dissolve 200 mg of the sample in 10 mL THF (200 mg/10 mL). Shake (or sonicate) the solution for five minutes—see **Note 6**. The solution is likely to range from clear to slightly cloudy. Place 10 µL of the sample solution in a clean sample cup. Evaporate the solvent; the sample is ready to analyze. See **Figs. 2 and 3** for example chromatograms.

NOTE 6—A critical step in the accurate determination of phthalates is sample homogeneity. This is discussed in more detail in **Appendix X2**.

NOTE 7—It is possible that the solution will contain inorganic material. Studies have shown that the presence of insoluble inorganic material will not affect either the accuracy or precision of the phthalate determination.

10.4 *Solution #3*—Place 10 µL of the sample solution (#2) into a clean sample cup. Add 10 µL of the phthalate standard solution (#1). Evaporate the solvent.

NOTE 8—To expedite the evaporation process, pass a steady stream of a high purity inert gas using clean, (plasticizer- and additive-free) tubing over the sample cup.

## 11. Procedure

11.1 Establish that the analytical system contains concentrations of phthalate contamination that are lower than the background contamination acceptable to the project specific Data Quality Objectives by analyzing 10 µL of THF.

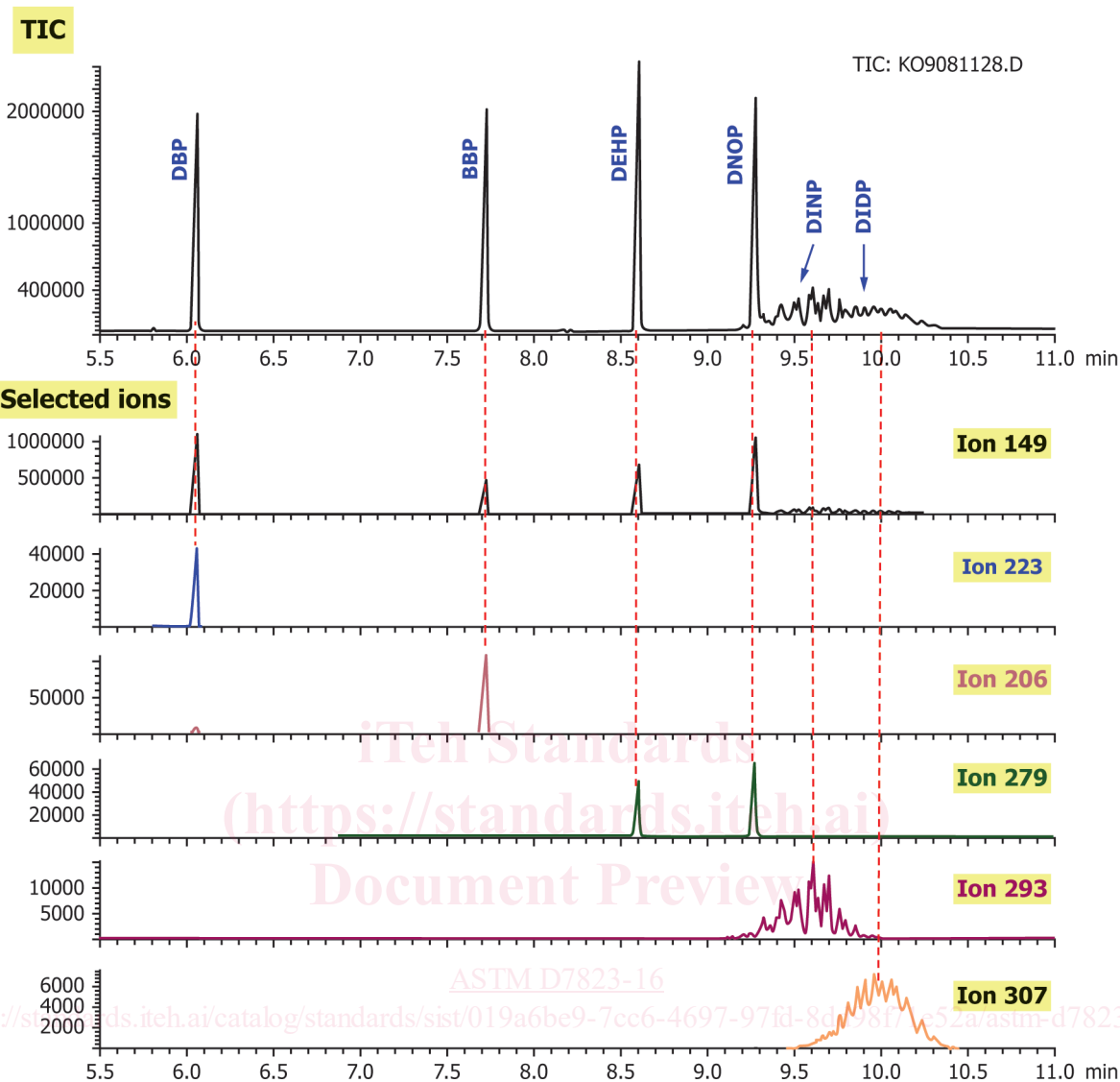


FIG. 1 Solution #1—Phthalates Standard Mixture (see 10.2)

11.2 Establish the relative retention time and mass spectrum of each phthalate using Solution #1—10.2: The following conditions were used to obtain the example chromatograms shown in Figs. 1-4:

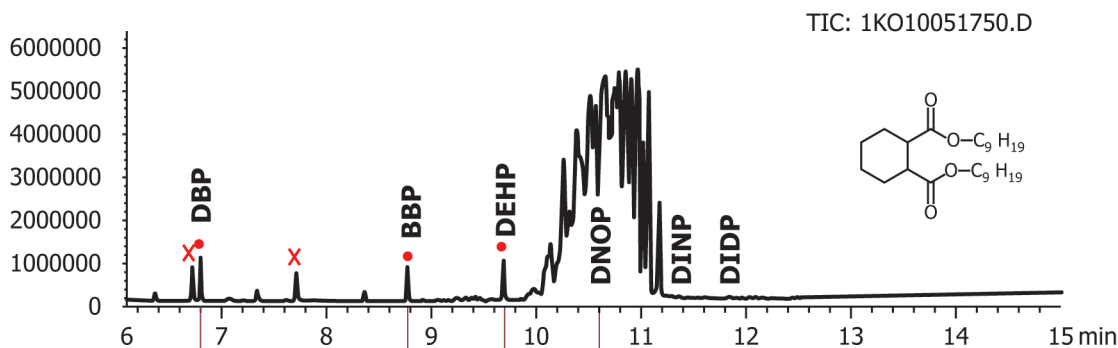
TD temperature:	Thermal Desorption (TD)-GC/MS Analysis
Py interface:	100 - 20°C/min - 320°C (5 min hold)
GC injector :	320°C (Auto mode),
GC oven:	300°C
Solvent delay:	80 (1 min hold) to 200°C (at 50°C/min) to 320°C (15°C/min, 2 min hold)
Column:	6 min
Column He flow:	UA-5 (5 % Diphenyl-95 % dimethyl polysiloxane) 30 m by 0.25 mm i.d, 0.25 µm film) or equivalent
Mass range:	1.2 mL/min, Split ratio: 1/20
Scan speed:	29-600 m/z,
Threshold:	2.57 scans/sec,
MSD Transfer Line Temp.:	50
Ion Source (EI) temp.:	300°C
	230°C

11.2.1 Confirm the TD zone using Evolved Gas Analysis (EGA)-MS. The total ion chromatogram of the sample (Solution #2, 10.3) needs to be similar to that presented in Appendix X1.

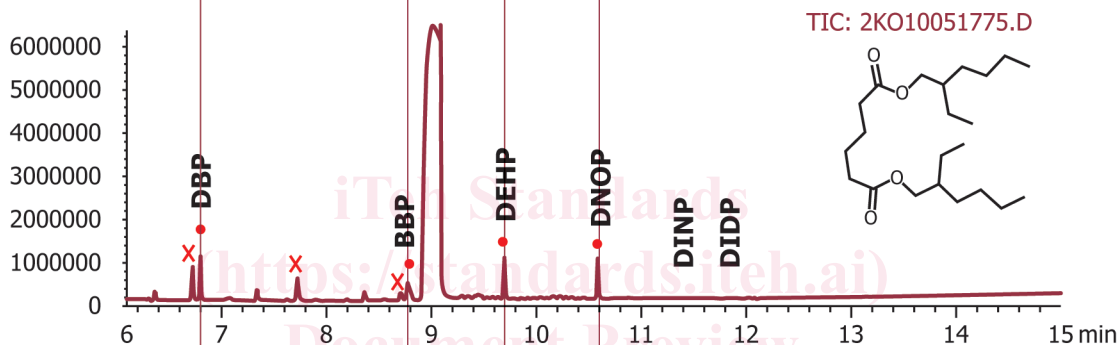
11.3 Analyze the sample (Solution #2, 10.3) using the conditions outlined in 11.2. Typical chromatograms are shown in Figs. 2 and 3. The precision of the TD method is shown in Fig. 3.

11.4 Peak identifications are based on relative retention data, full scan extracted ion chromatograms of both the quant and confirming ions and the ion area ratios as indicated in Table 1. Phthalate quantitation is based upon the peak areas of the quant

PVC-DINCH



PVC-DOA



PVC-Mesamoll II

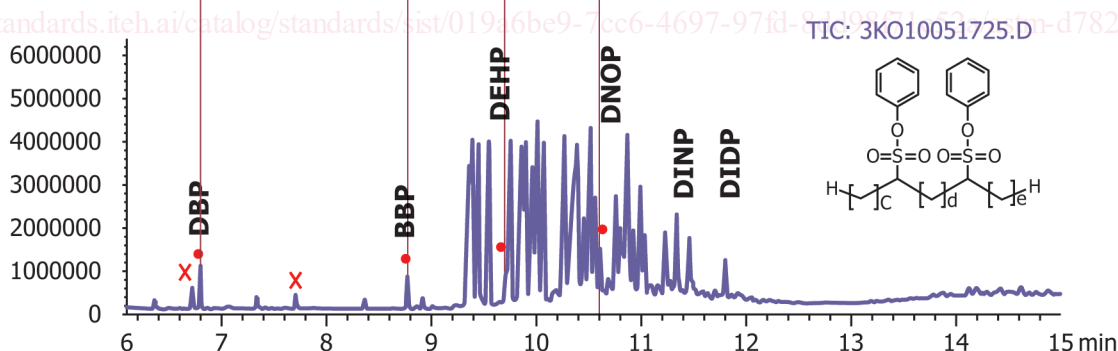


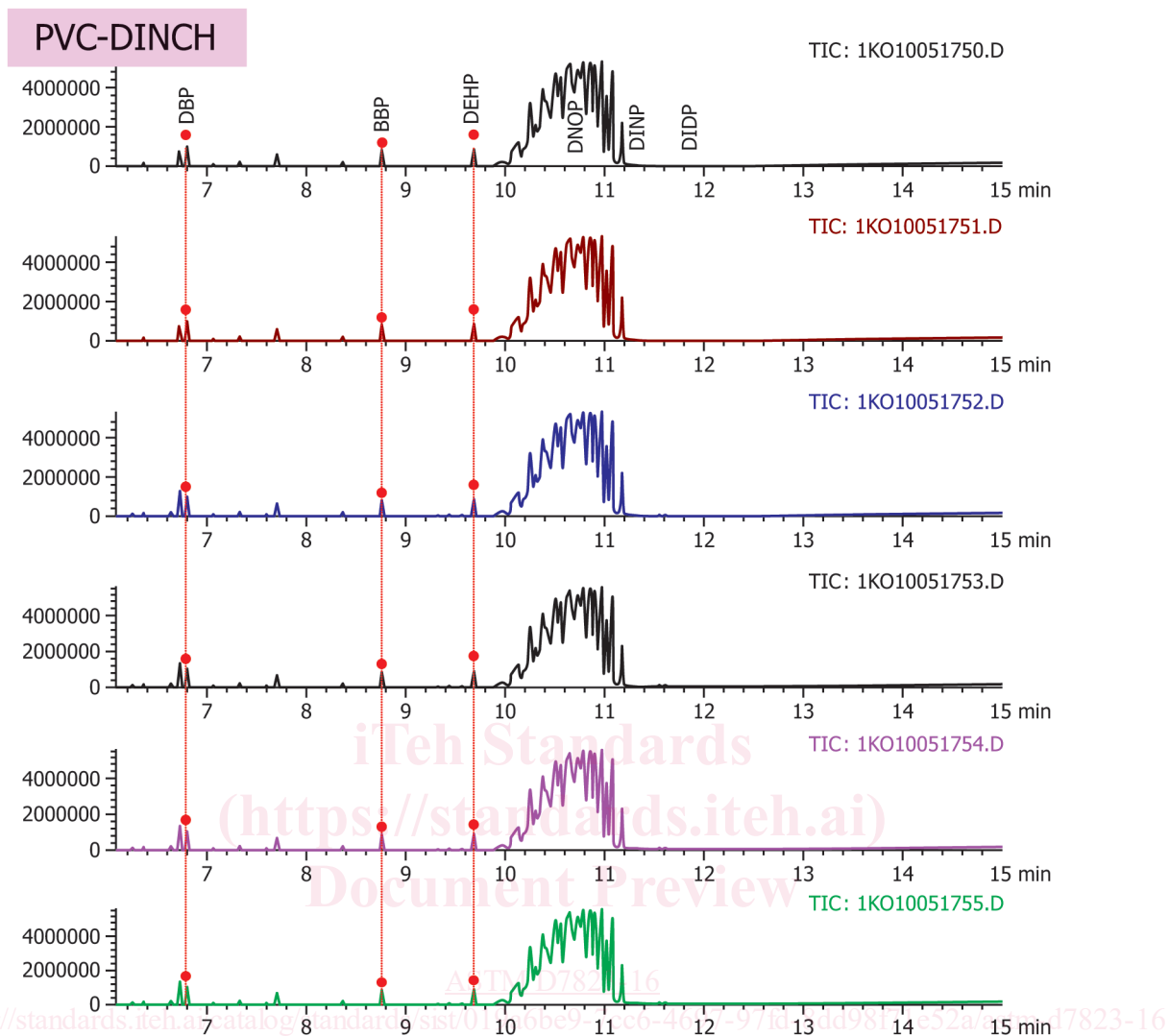
FIG. 2 Solution #2—Chromatograms (TIC) of PVC with Three Different Plasticizers, TD-GC/MS Analysis (see 10.3 and 11.3)

ions listed in Table 1. The assumption being made is that the sole source of the quant ion at a predetermined retention time is the phthalate. Use the peak area of the quant ion can be used to accurately determine the amount of the phthalate.

11.5 If using selected ion monitoring (SIM), peak identification is based solely on the presence or absence of the quant ion and the two confirming ions at a predetermined retention time. Quantitation is based on the area of the quant ion.

11.6 When DINP and DIDP are both present in a sample or standard, use m/z 127 as a qualifying ion for DINP and m/z 289 for DIDP. This is because DINP and DIDP partially co-elute and both produce m/z 149 and 167. If 149 qualifier ion ratios are set when DINP and DIDP are at equal concentrations, then any samples with different ratios will produce substantially different 149/167 ratios, potentially leading to a false negative.

NOTE 9—A typical total ion chromatogram obtained using the conditions specified in 11.2 is shown in Fig. 1. Because the absolute retention times are



No	File name	DBP	BBP	DEHP	DNOP	DINP	DIDP
		m/z=223	m/z=206	m/z=279	m/z=279	m/z=293	m/z=307
1	KO 10051750	243.840	505.044	328.756	332.096	489.945	616.594
2	KO 10051751	242.452	517.461	340.418	321.613	497.762	633.184
3	KO 10051752	240.288	517.972	354.329	331.371	507.979	657.815
4	KO 10051753	246.959	528.137	349.345	327.968	505.853	646.300
5	KO 10051754	238.760	515.500	345.159	336.845	504.904	656.879
6	KO 10051755	246.510	521.102	343.431	333.874	503.383	653.434
<b>Averaged peak area</b>		243.135	517.536	343.573	330.628	501.638	644.034
<b>SD</b>		3293.118547	7556.303832	8729.726158	5296.045748	6684.847213	16242.41879
<b>RSD (%)</b>		<b>1.35</b>	<b>1.46</b>	<b>2.54</b>	<b>1.60</b>	<b>1.33</b>	<b>2.52</b>

FIG. 3 Solution #2—Reproducibility of PVC-DINCH (n=6) (see 10.3 and 11.3)

dependent upon the entirety of the GC system; relative retention times can be used to identify each phthalate. The choice of the base phthalate is left to the laboratory.

11.7 Quantitation is done using standard addition. Analyze Solution #3. A typical total ion chromatogram is shown in Fig. 4. Analytical precision is presented in the table at the bottom of Fig. 4. Standard addition is very useful when it is difficult to eliminate interferences from the sample matrix. This is often the case when analyzing PVC where DINCH, Mesamoll or both are present.