



Standard Test Method for Determination of Antioxidants and Erucamide Slip Additives in Polyethylene Using Liquid Chromatography (LC)¹

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1. Scope

1.1 This test method covers a liquid-chromatographic procedure for the separation of some additives currently used in polyethylene. These additives are extracted with either isopropanol (resin densities $< 0.94 \text{ g/cm}^3$) or cyclohexane (resin densities $> 0.94 \text{ g/cm}^3$) prior to liquid-chromatographic separation. The ultraviolet absorbance of the eluting compound(s) is measured and quantitation is performed using external calibration.

1.2 *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.* Specific precautionary statements are given in Section 9.

NOTE 1—There is no equivalent ISO standard.

2. Referenced Documents

2.1 ASTM Standards:

- D 883 Terminology Relating to Plastics²
- D 1600 Terminology for Abbreviated Terms Relating to Plastics²
- D 4697 Guide for Maintaining Test Methods in the User's Laboratory³
- E 131 Terminology Relating to Molecular Spectroscopy⁴
- E 169 Practices for General Techniques of Ultraviolet-Visible, and Near-Infrared Spectrophotometers⁴
- E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near-Infrared Spectrophotometers⁴
- E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁵
- E 1657 Practice for Testing Variable-Wavelength Photometric Detectors Used in Liquid Chromatography⁴

¹ 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 July 10, 2003. Published August 2003.

² *Annual Book of ASTM Standards*, Vol 08.01.

³ *Annual Book of ASTM Standards*, Vol 07.02.

⁴ *Annual Book of ASTM Standards*, Vol 03.06.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 Definitions:

3.1.1 For definitions of plastic terms and detector terminology used in this test method, see Terminologies D 883, D 1600, and E 1657.

3.1.2 For units and symbols used in this test method, refer to Terminology E 131 or IEEE/ASTM SI 10.

3.2 Additives:

3.2.1 *BHEB, Prodox 500*—2,6-di-*t*-butyl-4-ethylphenol or butylated hydroxyethyl benzene, CAS No. 4130-42-1.

3.2.2 *BHT, CAO-3, Noclizer M-17*—2,6-di-*t*-butylcresol or butylated hydroxy toluene, CAS No. 128-37-0.

3.2.3 *Irgafos 168*—Tris(2,4-di-*t*-butylphenyl)-phosphite, CAS No. 31570-04-4.

3.2.3.1 *Oxidized Irgafos 168*—Tris(2,4-di-*t*-butylphenyl)-phosphate.

3.2.4 *Irganox 1010*—Tetrakis[methylene(3,5-di-*t*-butyl-4-hydroxyhydrocinnamate)] methane CAS No. 6683-19-8.

3.2.5 *Irganox 1076*—Octadecyl-3-(3,5-di-*t*-butyl-4-hydroxyphenyl)-propionate, CAS No. 2082-79-3.

3.2.6 *Isonox 129*—2,2'-ethylidene bis(4,6-di-*t*-butylphenol), CAS No. 112-84-5.

3.2.7 *Kemamide-E, Erucamide*—Cis-13-docosenamide, CAS No. 112-84-5.

3.2.8 *TNPP, Weston 399*—Tris(nonylphenyl)phosphite, CAS No. 26523-78-4.

3.2.8.1 *Hydrolyzed TNPP*—Nonylphenol, CAS No. 104-40-5.

3.2.8.2 *Oxidized TNPP*—Tris(nonylphenyl)phosphate, CAS No. 26569-53-9 (available in small quantities from GE Specialty Chemicals as XR2616).

4. Summary of Test Method

4.1 The polyethylene sample is ground to a 1-mm (~20 mesh) or 0.5-mm (~40 mesh) particle size and extracted by refluxing with either isopropanol or cyclohexane.

4.2 The solvent extract is analyzed by liquid chromatography.

4.3 Additive concentrations are determined from external calibration curves using reverse phase chromatography (C-8 or C-18 column) with ultraviolet (UV) detection at wavelengths corresponding to the wavelengths of an absorption apex of each additive (except erucamide which does not have an absorption maximum in the accessible UV region).

5. Significance and Use

5.1 Separation and identification of stabilizers used in the manufacture of polyethylene resins are necessary in order to correlate performance properties with polymer composition. This test method provides a means to determine BHT, BHEB, Isonox 129, erucamide slip, Irgafos 168, Irganox 1010, Irganox 1076 and TNPP levels in polyethylene samples. This test method should be applicable for the determination of other antioxidants such as Ultrinox 626, Ethanox 330, Santanox R, and Topanol CA, but the stability of these during extraction has not been investigated.

5.2 The additive extraction procedure is made effective by the relatively low solubility of the polymer sample in solvents generally used for liquid chromatographic analysis. In this method, isopropanol and cyclohexane were chosen because of their excellent extraction efficiencies as well as for safety reasons. Other solvents including ethylacetate, isobutanol, chloroform and methylene chloride can also be used.

5.3 Methods other than refluxing that have been used to remove additives from the polymer matrix include microwave, ultrasonic, and supercritical fluid extractions. For the separation of the extracted additives, SFC and GC have been used successfully for several of the additives.

5.4 Under optimum conditions, the lowest level of detection for an antioxidant is approximately 2 ppm.

6. Interferences

6.1 Any material eluting at or near the same retention time as the additive can cause erroneous results. This includes degradation products of the additives.

6.2 A major source of interferences can be from solvent impurities. For this reason, the solvents should be examined by HPLC using the same analysis conditions as for the samples (see Section 12).

6.3 The grinding process may cause a low bias. For example, some erucamide slip is known to be lost to the grinder surface and excessive grinding may cause degradation of the antioxidants.

7. Apparatus

7.1 *Liquid Chromatograph*, equipped with a multiple wavelength (see Practices E 169 and E 275) or photodiode array ultraviolet detector, heated column compartment, and gradient elution capabilities. The liquid chromatograph should be equipped with a means for a 10- μ L injection such as a sample loop.

7.2 *Chromatographic Column*, C-8 or C-18 reverse phase, 5- μ m particle size, 15 cm by 4.6 mm or equivalent, capable of separating the additives and their degradation products.

7.3 *Data Acquisition/Handling System*, providing the means for determining chromatographic peak areas and for handling

and reporting data. This is best accomplished using a computer with appropriate software.

7.4 *Mill—Cutting Mill (Wiley) or Centrifugal Grinding Mill (Brinkmann)*, equipped with 1-mm (~20 mesh) and 0.5-mm (~40 mesh) screens.

7.5 *Reflux Extraction Apparatus*, consisting of a condenser, (24/40 ground-glass joint), a round-bottom 125-mL flask having a 24/40 ground-glass joint, and a heating mantle.

7.6 *Boiling Chips*.

7.7 *Filter System*, (PTFE), for non-aqueous solutions (pore size of 0.22 μ m).

7.8 *Analytical Balance*, capable of weighing to ± 0.0001 g.

7.9 *Top Loading Balance*, capable of weighing to ± 0.01 g.

8. Reagents and Materials

8.1 *Solvents*:

8.1.1 *Isopropanol*—HPLC grade, spectro-quality or chromatography quality reagent.

8.1.2 *Cyclohexane*—HPLC grade, spectro-quality or chromatography quality reagent.

8.1.3 *Water*—HPLC, or UV quality reagent, degassed by sparging with high-purity helium or by filtration under vacuum.

8.1.4 *Acetonitrile*—HPLC, spectro-quality or chromatography quality reagent (a reagent whose UV cutoff is about 190 nm).

8.2 *Additives*:

8.2.1 High purity additives and degradation products (see 3.2).

9. Precautions

9.1 Isopropanol and cyclohexane are flammable. This extraction procedure should be carried out in a fume hood.

10. Preparation of Solutions

10.1 *Polymer Samples*:

10.1.1 Grind the sample to a particle size of 1 mm, that is, ~20 mesh (density < 0.94 g/cm³) or 0.5 mm, that is, ~40 mesh (density > 0.94 g/cm³).

NOTE 2—Unless sample amount is limited, grind a minimum of 10 g. It is important to minimize the time of grinding to prevent any thermal degradation of the additives in the polymer. Some erucamide is known to be lost during grinding.

NOTE 3—A cutting-type mill is needed for film samples. Because of its higher efficiency, a centrifugal-type mill is recommended for pellet samples.

10.1.2 Weigh, to the nearest 0.01 g, approximately 5 g of the sample, that is, W_{sample} , into a pre-weighed (to the nearest 0.01 g) 125-mL flat-bottom flask containing boiling chips, that is, W_{flask} . Add approximately 50.0 mL of isopropanol or cyclohexane and boil for a minimum of 2 h.

NOTE 4—Isopropanol is used as the extraction solvent for densities of less than 0.94 g/cm³ and cyclohexane for densities higher than 0.94 g/cm³.

10.1.3 Cool the solution to room temperature by raising the flask from the heating mantle while still attached to the condenser.

10.1.4 Weigh the cooled flask to the nearest 0.01 g, that is, $W_{(flask + sol)}$.