



Standard Method for Estimating Kinetic Parameters by Differential Scanning Calorimeter Using the Borchardt and Daniels Method¹

This standard is issued under the fixed designation E 2041; 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 reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes the determination of the kinetic parameters of activation energy, Arrhenius pre-exponential factor, and reaction order using the Borchardt and Daniels² treatment of data obtained by differential scanning calorimetry. This test method is applicable to the temperature range from 170 to 870 K (–100 to 600°C).

1.2 This treatment is applicable only to smooth exothermic reactions with no shoulders, discontinuous changes, or shifts in baseline. It is applicable only to reactions with reaction order $n \leq 2$. It is not applicable to autocatalyzed reactions and, therefore, is not applicable to the determination of kinetic parameters for most thermoset curing reactions or to crystallization reactions.

1.3 Electronic instrumentation or automated data analysis systems or treatments equivalent to this test method may be used.

NOTE 1—The user is advised that all electronic data treatment may not be equivalent. It is the responsibility of the user of such electronic data treatment to verify applicability to this test method.

1.4 SI values are the standard.

1.5 This test method is similar, but not equivalent to, ISO Method 11357, Part 5, which contains provisions for additional information not supplied by this test method.

1.6 *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.*

2. Referenced Documents

2.1 ASTM Standards:

E 473 Terminology Relating to Thermal Analysis³

¹ This test method is under the jurisdiction of ASTM Committee E37 on Thermal Measurements and the direct responsibility of Subcommittee E37.01 on Test Methods and Recommended Practices.

Current edition approved Oct. 1, 2003. Published November 2003. Originally approved in 1999. Last previous edition approved in 2001 as E 2041 – 01.

² Borchardt, H.J., Daniels, F., *J. Amer. Chem. Soc.* Vol 79, pp.41–46 (1957).

³ *Annual Book of ASTM Standards*, Vol 14.02.

E 537 Test Method for Assessing the Thermal Stability of Chemicals by Methods of Differential Thermal Analysis³

E 698 Test Method for Arrhenius Kinetic Constants for Thermally Unstable Materials³

E 967 Practice for Temperature Calibration of Differential Scanning Calorimeters and Differential Thermal Analyzers³

E 968 Practice for Heat Flow Calibration of Differential Scanning Calorimeters³

E 1142 Terminology Relating to Thermophysical Properties³

E 1145 Terminology Relating to Hazardous Properties of Chemicals³

E 1641 Test Method for Decomposition Kinetics by Thermogravimetry³

E 1970 Practice for Statistical Treatment of Thermoanalytical Data³

2.2 ISO Standards:

ISO 11357 Part 5: Determination of Temperature and/or Time of Reaction and Reaction Kinetics⁴

3. Terminology

3.1 *Definitions*—Specific technical terms used in this test method are defined in Terminologies E 473, E 1142 and E 1445.

4. Summary of Test Method

4.1 A test specimen is heated at a linear rate in a differential scanning calorimeter or other suitable calorimeter through a region of exothermic reaction behavior. The rate of heat evolution, developed by a chemical reaction, is proportional to the rate of reaction. Integration of the heat flow as a function of time yields the total heat of a reaction.

4.2 The Borchardt and Daniels² data treatment is used to derive the kinetic parameters of activation energy, Arrhenius pre-exponential factor, and reaction order from the heat flow and total heat of reaction information obtained in 4.1 (see Section 5).

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

