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Standard Terminology Relating to Thermal Analysis and Rheology[1]

This standard is issued under the fixed designation E473; 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 terminology is a compilation of definitions of terms used in ASTM documents relating to thermal analysis and rheology. This terminology includes only those terms for which ASTM either has standards or is contemplating some action. It is not intended to be an all-inclusive listing of terms related to thermal analysis and rheology.

1.2 This terminology specifically supports the single-word form for terms using thermo as a prefix, such as thermoanalytical or thermomagnetometry, while recognizing that for some terms a two-word form can be used, such as thermal analysis. This terminology does not support, nor does it recommend, use of the grammatically incorrect, single-word form using thermal as a prefix, such as, thermalanalytical or thermalmagnetometry.

1.3 A definition is a single sentence with additional information included in a *Discussion* area. It is reviewed every five years.

2. Terminology

adiabatic, *adj*—no heat exchange with the surroundings.

calorimeter, *n*—apparatus for measuring quantities of absorbed or evolved heat.

combined, *adj*—the application of two or more techniques to different samples at the same time.

controlled-rate thermal analysis (*CRTA*), *n*—a family of techniques that monitors the temperature versus time profile needed to maintain a chosen, fixed rate of change of a property of a substance.

DISCUSSION—Compared to controlled-temperature experiments, where the reaction rate tends to increase exponentially and the rate can become limited by heat or mass transfer, CRTA experiments are more likely to involve the chemical reaction as the limiting step. This technique can also improve the resolution of multiple reactions. For example, in controlled rate experiments, power to the furnace is controlled to ensure a fixed rate of mass loss (or gain).

controlled-temperature program, *n*—the temperature history experienced by a sample during the course of a thermal analysis experiment.

DISCUSSION—In contrast to controlled-rate experiments, power to the furnace is controlled to ensure a fixed rate of temperature change for controlled-temperature experiments. The program may include heating or cooling segments in which the temperature is changed at a fixed rate, isothermal segments in which time becomes the explicit independent variable, or any sequence of these individual segments. If the atmosphere (or vacuum) around the sample is changed by some external action (depending on the independent variable only—temperature or time) during the course of the experiment, that too becomes part of the controlled-temperature program.

curve, thermal, *n*—the plot of a dependent parameter against an independent parameter such as temperature or time.

derivative, *adj*—pertaining to the first derivative (mathematical) of any curve with respect to temperature or time.

dielectric analysis (*DEA*), *n*—a technique in which the dielectric constant (permittivity or capacitance) and dielectric loss (conductance) of a substance under oscillating electric field are measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

differential, *adj*—pertaining to a difference in measured or measurable quantities usually between a substance and some reference or standard material.

differential scanning calorimetry (*DSC*), *n*—a technique in which the heat flow difference into a substance and a reference material is measured as a function of temperature while the substance and reference material are subjected to a controlled-temperature program.

DISCUSSION—The record is the differential scanning calorimetric or DSC curve. Two modes, power compensation differential scanning calorimetry, and heat flux differential scanning calorimetry can be distinguished, depending on the method of measurement used.

DISCUSSION—Two conventions exist in thermal analysis. In the physicist's convention, exothermic behavior increases downward on the thermal curve. In the chemist's convention, exothermic behavior increases upward on the thermal curve. Committee E37 takes no position on which convention shall be used. To aid the user, the direction of exothermic (or conversely, endothermic) behavior shall be indicated on each thermal curve.

differential thermal analysis (*DTA*), *n*—a technique in which the temperature difference between the substance and a

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reference material is measured as a function of temperature, while the substance and reference material are subjected to a controlled-temperature program.

DISCUSSION—The term *quantitative differential thermal analysis* covers those uses of DTA where the equipment is designed to produce quantitative results.

dilatometry, *n*—see **thermodilatometry.**

dynamic mechanical analysis (*DMA*), *n*—a technique in which the storage modulus (elastic response) and loss modulus (viscous response) of a substance under oscillatory load is measured as a function of temperature, time, or frequency of oscillation, while the substance is subjected to a controlled-temperature program in a specified atmosphere.

endotherm, *n*—In thermal analysis, the thermal record of a transition where heat is absorbed by the specimen.

evolved gas analysis (*EGA*), *n*—a technique in which the nature or amount, or both, of gas or vapor evolved by a substance is subjected to a controlled-temperature program.

DISCUSSION—Some specific forms of EGA have become established for investigating different aspects of catalysis, such as reduction, oxidation, or desorption. In this context, EGA in a hydrogen atmosphere is known as temperature-programmed reduction (TPR); EGA in an oxygen atmosphere is temperature-programmed oxidation (TPO); and EGA in the absence of decomposition, in an inert atmosphere or vacuum, is temperature-programmed desorption (TPD). For each technique the method used for gas identification and quantification should always be clearly stated.

evolved gas detection (*EGD*), *n*—see **evolved gas analysis.**

extrapolated onset value, *n*—the value of the independent parameter found by extrapolating the dependent parameter baseline prior to the event and a tangent constructed at the inflection point on the leading edge to their intersection.

first-deviation-from baseline, *n*—the value of the independent parameter at which a deflection is first observed from the established dependent parameter baseline prior to the event.

high-pressure (*HP*...), *adj*—a prefix for different thermoanalytical techniques in which the pressure in the apparatus is above ambient.

DISCUSSION—As an example, high-pressure thermogravimetric analysis is designated HPTGA.

isoperibol, *adj*—to maintain constant surroundings.

DISCUSSION—For calorimeters, if only the surroundings are isothermal, the mode of operation is isoperibol. In isoperibol calorimeters, the temperature changes with time, governed by the thermal resistance between the calorimeter and surroundings.

isothermal, *adj*—at constant temperature.

modulated temperature, *adj*—a prefix applied to the technique named to indicate that temperature modulation has been applied to the temperature program.

DISCUSSION—As an example, a DSC experiment carried out with a modulated temperature program would be Modulated Temperature Differential Scanning Calorimetry (MTDSC).

DISCUSSION—Other modulated techniques are possible, such as modulated force TMA.

DISCUSSION—The use of the prefix MT is preferred to TM.

nonreversing, *adj*—in modulated temperature experiments, responding to the value of the temperature or time, or both.

onset point (temperature or time), *n*—the temperature or time at which a deflection is first observed from the established baseline prior to the thermal event.

peak, *n*—that portion of a thermal curve characterized by a deviation from the established baseline, a maximum dependent parameter deflection, and a reestablishment of a baseline not necessarily identical to that before the peak.

peak value, *n*—the value of the independent parameter corresponding to the maximum (or minimum) deflection from the baseline of the dependent parameter curve.

plateau, *n*—a region of little or no change in a graphical representation.

pulse, *n*—a transient step-hold-return variation of a parameter that is normally constant where the intensity and duration are specified.

reversing, *adj*—in modulated temperature experiments, responding to the rate of change of the temperature.

rheometer, *n*—an instrument for measuring rheological properties with a controlled temperature, shear rate, or stress program.

rheometry, *n*—a technique in which viscosity, storage modulus, and loss modulus of a material are measured as a function of temperature, time, shear rate, or stress while the material is subjected to controlled temperature, shear rate, or stress program.

simultaneous, *adj*—the application of two or more techniques to the same sample at the same time.

DISCUSSION—A hyphen is used to separate the abbreviations of the techniques; for example, simultaneous thermogravimetric analysis and differential scanning calorimetry would be TGA-DSC.

stochastic, *adj*—random.

tan δ, *n*—is the dimensionless ratio of energy lost to energy returned during one cycle of a periodic process. Tan δ is normally calculated by dividing the loss component of the property measured by a periodic method by the storage component (for example, tan $\delta = E''/E'$ as used in DMA).

thermal analysis (*TA*), *n*—a group of techniques in which a physical property of a substance is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program.

thermally stimulated current (*TSC*) analysis, *n*—a technique in which the current generated when dipoles change their alignment in a substance is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—The technique can be applied in several ways: for example; the substance can be pre-conditioned by heating and cooling in a nonoscillating electric field to create aligned, frozen dipoles. The substance may then generate a thermally stimulated current during subsequent heating with no field applied.

thermoanalytical, *adj*—of, or pertaining to, thermal analysis.

thermodilatometry, *n*—a technique in which a dimension of a substance under negligible load is measured as a function of temperature while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—Linear thermodilatometry and volume thermodilatometry are distinguished on the basis of the dimension measured.

thermogravimetric analysis (*TGA*), *n*—a technique in which the mass of a substance is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—The record is the thermogravimetric or TG curve.

thermogravimetry (*TG*), *n*—see **thermogravimetric analysis.**

thermomagnetometry, *n*—a family of thermoanalytical techniques in which a magnetic characteristic of a substance is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—Thermogravimetric analysis with a magnetic field acting on the specimen is the most common example.

thermomechanical analysis (*TMA*), *n*—a technique in which the deformation of a substance under nonoscillatory load is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—The load on the substance may be compressive, tensile, flexural, or torsional. When the applied load is too low to cause deformation, TMA measures a dimension of the substance and in this mode is called **thermodilatometry.**

thermomicroscopy, *n*—see **thermoptometry**.

thermoptometry, *n*—a family of techniques in which an optical characteristic of a substance is measured as a function of temperature or time while the substance is subjected to a controlled-temperature program in a specified atmosphere.

DISCUSSION—Measurement of total light, light of specific wavelength(s), refractive index, and luminescence leads, respectively, to *thermophotometry, thermospectrometry, thermorefractometry,* and *thermoluminescence*. Observations under the microscope lead to *thermomicroscopy*.

valley, *n*—a region of minimum values in a graphical representation bordered by higher values.

viscometer, *n*—an instrument for measuring viscosity at fixed temperature, shear rate, or stress.

viscometry, *n*—a technique in which viscosity of a material is measured at fixed temperature, shear rate, or stress.

3. Keywords

3.1 definitions; rheology; terminology; thermal analysis