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NOMENCLATURE FOR THERMAL ANALYSIS—IV

(Recommendations 1985)

Prepared for publication by

R. C. MACKENZIE

Department of Chemistry,
The University of Aberdeen, AB9 2UE, Scotland, UK

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Nomenclature for thermal analysis—IV

Abstract - The recommendations update and supplement earlier versions of definitions in the field of thermal analysis. A new system of classification of thermal analytical techniques is outlined. A number of new techniques are defined and classified.

The recommendations in the earlier reports on nomenclature in thermal analysis¹⁻⁸ have been well received and have been accepted by such international and national bodies as ISO⁹, ASTM¹⁰ and AFNOR¹¹. An integrated version of the second and third reports^{2, 3} with some modifications was adopted by IUPAC and published in this journal¹². The unofficial albeit accurate translations that have appeared in several other languages^{3, 13} are welcomed.

It has become evident since the first report¹ was published that the definition of thermal analysis given therein is not entirely satisfactory: moreover, over the years several new techniques have emerged or minor techniques have assumed increasing importance. The recommendations that follow are intended both to supplement and update the earlier versions.

DEFINITION OF THERMAL ANALYSIS

The definition given in the first report has certain shortcomings and is replaced by the following:

Thermal analysis. A group of techniques in which a physical property of a substance "(Note a)" is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

In addition to being more accurate, this definition has the advantage that it can be adapted to define all thermoanalytical techniques by alteration of only a few words in each instance.

It follows from the above definition that some techniques, such as X-ray diffraction or IR spectroscopy, can, when used in a specific manner, yield thermoanalytical information: these special cases are not considered below.

INDIVIDUAL THERMOANALYTICAL TECHNIQUES

Classification

In the light of the new definition some one hundred techniques known to the Committee have been assessed and those previously defined¹, those that have come into prominence in the interim and those showing prospect of future development were classified to bring out interrelationships. The arrangement finally adopted for the defined techniques (Table 1) shows clearly the interrelationships between them and can be readily adapted to incorporate additional physical properties and/or techniques as necessary: various modes of certain techniques can also be distinguished.

Definitions

On the basis of the above definition for Thermal Analysis the techniques listed in Table 1 can be defined as follows.

Thermogravimetry (TG). A technique in which the mass of a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

The record is the thermogravimetric or TG curve; the mass should be plotted on the ordinate decreasing downwards and temperature (T) or time (t) on the abscissa increasing from left to right.

Isobaric mass-change determination. A technique in which the equilibrium mass of a substance at constant partial pressure of the volatile product(s) is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

The record is the isobaric mass-change curve; the mass should be plotted on the ordinate decreasing downwards and temperature on the abscissa increasing from left to right.

Note a: Throughout this report substance is to be understood in the sense of substance and/or its reaction product(s).

TABLE 1. Classification of Thermoanalytical Techniques

Physical Property	Derived technique(s)	Acceptable abbreviation
Mass	Thermogravimetry	TG
	Isobaric mass-change determination	
	Evolved gas detection	EGD
	Evolved gas analysis	EGA
	Emanation thermal analysis	
Temperature	Thermoparticulate analysis	
	Heating-curve determination*	
	Differential thermal analysis	DTA
Enthalpy	Differential scanning calorimetry†	DSC
Dimensions	Thermodilatometry	
Mechanical characteristics	Thermomechanical measurement	
	Dynamic thermomechanical measurement	
Acoustic characteristics	Thermosonimetry	
	Thermoacoustimetry	
Optical characteristics	Thermooptometry	
Electrical characteristics	Thermoelectrometry	
Magnetic characteristics	Thermomagnetometry	

*When the temperature programme is in the cooling mode, this becomes Cooling-curve determination.

†The confusion that has arisen about this term seems best resolved by separating two modes (Power-compensation DSC and Heat-flux DSC) as described in the definition given in the text.

Evolved gas detection (EGD). A technique in which the evolution of gas from a substance is detected as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Evolved gas analysis (EGA). A technique in which the nature and/or amount of volatile product(s) released by a substance are/is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme. The method of analysis should always be clearly stated.

Emanation thermal analysis. A technique in which the release of radio-active emanation from a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Thermoparticulate analysis. A technique in which the release of particulate matter from a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Heating-curve determination. A technique in which the temperature of a substance is measured as a function of the programmed temperature whilst the substance is subjected to a controlled temperature programme in the heating mode. Sample temperature should be plotted on the ordinate increasing upwards and programmed temperature or time on the abscissa increasing from left to right.

Two derivative curves, heating-rate curves (for dT/dt against T or t) and inverse heating-rate curves (for dt/dT against T or t), can be obtained.

Differential thermal analysis (DTA). A technique in which the temperature difference between a substance and a reference material is measured as a function of temperature whilst the substance and reference material are subjected to a controlled temperature programme.

The record is the differential thermal or DTA curve; the temperature difference (T) should be plotted on the ordinate with endothermic reactions downwards and temperature or time on the abscissa increasing from left to right.

The term quantitative differential thermal analysis (quantitative DTA) covers those uses of DTA where the equipment is designed to produce quantitative results in terms of energy and/or any other physical parameter.

Differential scanning calorimetry (DSC). A technique in which the difference in energy inputs into a substance and a reference material is measured as a function of temperature whilst the substance and reference material are subjected to a controlled temperature programme.

Two modes, power-compensation differential scanning calorimetry (power-compensation DSC) and heat-flux differential scanning calorimetry (heat-flux DSC) "(Note b)", can be distinguished depending on the method of measurement used.

Note b: A system with multiple sensors (e.g. a Calvet-type arrangement) or with a controlled heat leak (Boersma-type arrangement) would be heat-flux DSC, whereas systems without these or equivalent arrangements would be quantitative DTA.

Thermodilatometry. A technique in which a dimension of a substance under negligible load is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

The record is the thermodilatometric curve; the dimension should be plotted on the ordinate increasing upwards and temperature or time on the abscissa increasing from left to right.

Linear thermodilatometry and volume thermodilatometry are distinguished on the basis of the dimensions measured.

Thermomechanical measurement. A technique in which the deformation of a substance under non-oscillatory load is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

The mode, as determined by the type of stress applied (compression, tension, flexure or torsion), should always be stated.

Dynamic thermomechanical measurement. A technique in which the dynamic modulus and/or damping of a substance under oscillatory load is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Torsional braid measurement is a particular case of dynamic thermomechanometry in which the material is supported on a braid.

Thermosonometry. A technique in which the sound emitted by a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Thermoacoustimetry. A technique in which the characteristics of imposed acoustic waves are measured as a function of temperature after passing through a substance whilst the substance is subjected to a controlled temperature programme.

Thermoptometry. A technique in which an optical characteristic of a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

Measurement of total light, light of specific wavelength(s), refractive index and luminescence lead to thermophotometry, thermospectrometry, thermorefractometry and thermoluminescence, respectively; observation under the microscope leads to thermomicroscopy. Other terms may have to be added.

Thermoelectrometry. A technique in which an electrical characteristic of a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

The most common measurements are of resistance, conductance or capacitance.

Thermomagnetometry. A technique in which a magnetic characteristic of a substance is measured as a function of temperature whilst the substance is subjected to a controlled temperature programme.

CONCLUSION

Development of any subject involves change, and older concepts have to be modified as new ideas emerge. In effect, therefore, this report updates and amplifies the first report, presenting a logical classification scheme that can be enlarged as required. It should be noted that only the definitions of those techniques discussed in the first report¹ are modified: the names, with the exception of thermodilatometry for dilatometry, remain. Similarly, the guide-lines enunciated in the first report and in the policy document¹⁴ have been followed in proposing names for techniques considered here for the first time.

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