16

Thermal Methods

16.1. INTRODUCTION

The term thermal methods or thermal methods of analysis includes those analytical techniques in which some physical parameter of the system is determined and/or recorded as a function of temperature. In thermal methods changes in physical and for chemical properties of a substance are measured as a function of temperature. Methods that involve changes in weight or changes in energy come within this definition.

The different thermal analytical techniques are included in Table 16.1.

TABLE 16.1
Some thermal Analytical Methods

Name of the Method	*Abbreviation of the Method*	*Parameter Measured*	*Instrument Employed*	*Drawning of the Curve*
1. Thermogravimetry	TG	Mass	Thermobalance	Mass vs temperature or time
2. Derivative thermo–gravimetry	DTG	*dm/dt*	Thermobalance	*dm/dt* vs temperature
3. Differential thermal analysis	DTA	ΔT	DTA Apparatus	ΔT vs temperature
4. Differential scanning calorimetry	DSC	*d*H/*dt*	Calorimeter	*d*H/*dt* vs temperature
5. Dynamic reflectance spectroscopy	DRS	Reflectance	Speectrophoto–meter	% reflectance vs temperature
6. Electrical conductivity	EC	Current (I) or Resistance (R)	Electrometer	I or R vs temperature

It is important to note that a single thermal analytical method does not provide complete information of a system. Sometimes it is required to collect the information from other thermal methods also.

15.2. DIFFERENTIAL THERMAL ANALYSIS (DTA)

Introduction : It is an analytical method for recording the difference in temperature (ΔT) between a substance and an inert reference material as a function of temperature or time. Any transformation which is charcterised by a change in specific heat or an enthaply of transition can be detected by DTA (including melting, vaporisation, chemical reactions, crystal transitions and glass transitions).

In differential thermal analysis both the test sample and an inert reference material (usually α-alumina) undergo a controlled heating or cooling programme. There is a zero temperature difference between the sample and the reference material when the sample does not undergo any chemical or physical change. If any reaction takes place, then a temperature difference (ΔT) will occur between the sample and the reference material. Thus in an endothermic change (*e.g.*, when the sample melts or is dehydrated) the sample temperature is lower than that of the reference material.

In differential thermal analysis a plot is made of ΔT against temperature or time. A typical DTA curve is shown in Fig. 16.1.

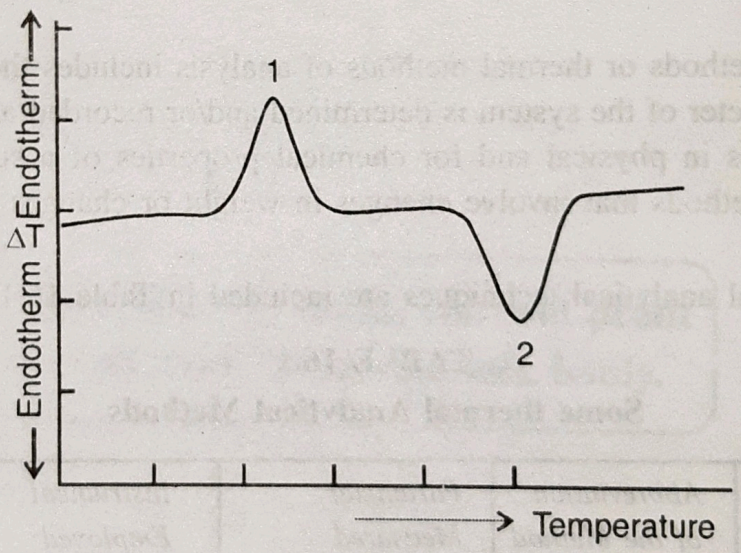

Fig. 16.1. DTA curve

In the above Fig. 16.1 :

1. Is an exothermic peak and
2. Is an endothermic peak.

Both the shape and size of the peaks can give a lot of information about the nature of the test sample. Sharp endothermic peaks often signify changes in crystallanity or fusion processes, where as broad endotherms arise from dehydration reactions. Physical changes usually result in endothermic curves while chemical reactions (particularly those of oxidative nature) are exothermic.

15.3. INSTRUMENTATION

A schematic diagram of a differential thermal analyser is given in Fig. 16.2.

The heart of the analyser is a heating block provided with a power supply and controller that allows its temperature to be increased linearly at selected rates. The block contains an identical pair of cavities for the sample and a reference substance, and the whole unit is set in an oven to provide control of the pressure and chemical constitution of the atmosphere surrounding the sample.

In real operation, the sample is placed in one cavity and a reference material in the other. The reference material is selected to be thermally inert over the intended temperature range of the study, and is often glass beads, ∝ alumina, or an empty sample holder. A thermocouple is placed directly in contact with the sample and another in contact with the reference. As the temperature of the block is raised, the temperature of the sample and reference follow. They are not at exactly the same temperature as the block, but lag behind it by an amount determined by the heat capacity of the sample and the thermal conductivity of the interface between the sample and the block. There is a zero temperature difference between the sample and reference material when the former does not undergo any chemical or physical change. However, if any reaction takes place, then a temperature difference ΔT will occur between the sample and the reference material.

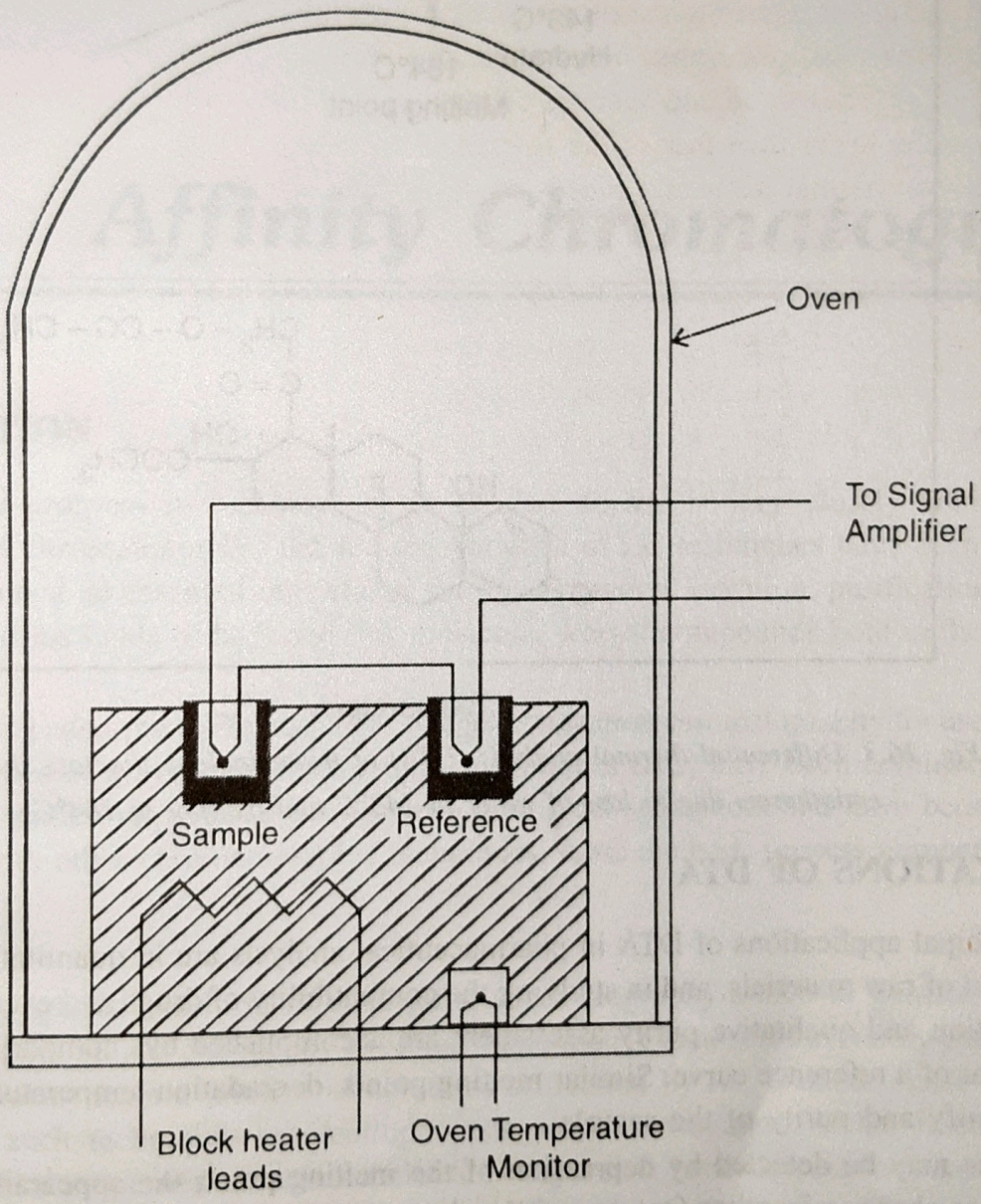

Fig. 16.2. Differential thermal analyzer.

The following Fig. 16.3 is the DTA curve obtained in the differential thermal analysis of triamcinolone diacetate. Only a melt and later decomposition (endotherms) are seen in this thermogram.

Sample sizes for DTA range form 0.1 to 10 mg. Heating rates betwen 10 and 20°C/min are common in pharmaceutical studies. The sample should be finely divided to provide good thermal contact with the block and the thermocouple.

In DTA curve, exotherms noted during heating are usually due to chemical reactions or crystallisation. Endotherms correspond to fusion, solid-solid transitions, desolvation and volatilisation. Physical changes give fairly sharp peaks in the DTA curve, while chemical reactions produce broad peaks.

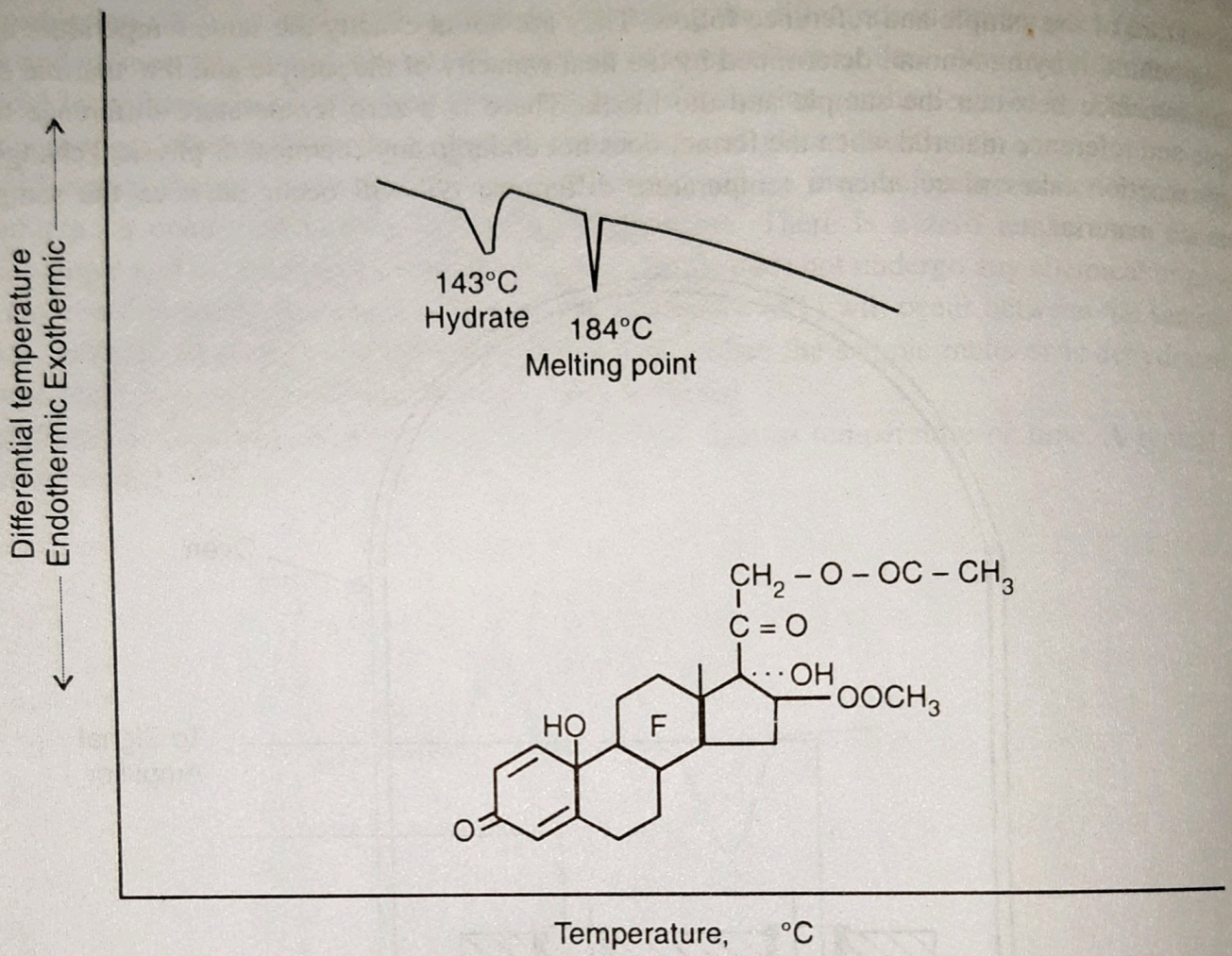

Fig. 16.3. Differential thermal analysis (DTA) of triamcinolone diactate showing endotherms due to loss of water at 143°C and melting at 184°C.

16.4. APPLICATIONS OF DTA

The Principal applications of DTA in pharmaceutical analysis are in quantitative identification and purity assessment of raw materials, and in studying the compatibility of drugs and excipients in formulation work. Identification and qualitative purity assessment are accomplished by comparing the DTA curve of the sample to that of a reference curve. Similar melting points, degradation temperatures and other features support the identify and purity of the sample.

Impurities may be detected by depression of the melting point, the appearance of transitions due to the impurity or changes in other features of the thermogram.

It is a useful technique to identify substances which are difficult to characterise by other common chemical or physical text. For example, waxes can be characterised by DTA.

DTA has also been used to obtain phase diagrams for sulfa traizole-urea solid dispersions, and for griseofulvin succinic acid solid dispersions. Both of these studies were directed to find means of formulating the drug that would enchance their dissolution and absorption rates.