

## 3: Differential Thermal Analysis

### Learning Objectives

After completing this chapter, you should be able to:

- Explain the principle and working of a differential thermal analyser.
- Draw and interpret DTA thermogram.
- Compare and contrast TG and DTA results.
- Explain the applications of DTA and simultaneous TG-DTA analysis.

When a molecule undergoes a physical or chemical transition, heat is either absorbed or liberated. Two thermal methods, DTA and DSC are particularly useful for investigating these physical and chemical changes.

### 3.1 Principle and Instrumentation:

In DTA, difference in temperature between the sample and an inert reference ( $\Delta T$ ) is measured as the sample and the reference are heated or cooled in a controlled manner.

$$\Delta T = T_S - T_R \quad (3.1)$$

with  $T_S$  as the temperature of sample and  $T_R$  is temperature of reference which is thermally stable.

Please go through the *Chemlibre* link to understand the principle and working of DTA.



[https://chem.libretexts.org/Bookshelves/Analytical\\_Chemistry/Instrumental\\_Analysis\\_\(LibreTexts\)/31%3A\\_Thermal\\_Methods/31.02%3A\\_Differential\\_Thermal\\_Analysis](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_(LibreTexts)/31%3A_Thermal_Methods/31.02%3A_Differential_Thermal_Analysis)

**Instrumentation and working:** A typical DTA set up is shown in the figure given below.

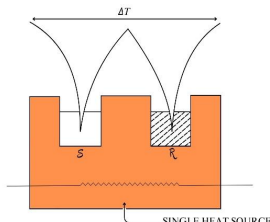


Figure 3.1 DTA set up

In differential thermal analysis (DTA), the difference in temperature between the sample and a thermally inert reference material is measured as a function of temperature (usually the sample temperature). Any transition that the sample undergoes results in the liberation or absorption of energy by the sample with a corresponding deviation of its temperature from that of the reference. A plot of the differential temperature,  $\Delta T$ , versus the programmed temperature,  $T$ , indicates the transition temperature(s) and whether the transition is exothermic or endothermic. DTA and thermogravimetric analyses (measurement of the change in weight as a function of temperature) are often run simultaneously on a single sample.

### 3.2 DTA curve and its interpretation

$$\Delta T = T_S - T_R \quad (3.2)$$

$T_S$  = temperature of sample

$T_R$  = temperature of thermally stable reference

A typical DTA curve is represented below

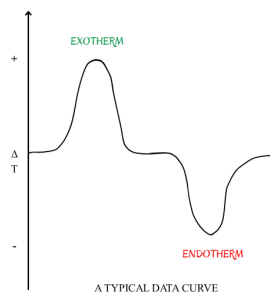


Figure 3.2 DTA curve

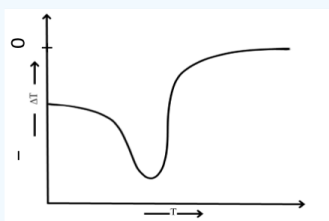


### Brain Teaser:

Can you suggest why we adopt  $\Delta T > 0$  for exothermic and  $\Delta T < 0$  for endothermic transition?

### ? Activity 3.1

The following figure represents thermal investigation. Fill in the blanks by choosing the correct option. (James & Tonge, 2008)



The record shown is that of a \_\_\_\_\_ experiment since the \_\_\_\_\_ plot  $\Delta T$  which is a \_\_\_\_\_ temperature. The \_\_\_\_\_ direction of the peak indicates that a \_\_\_\_\_ reaction has occurred. This in turn implies that the corresponding \_\_\_\_\_ change  $\Delta H$  must have been \_\_\_\_\_ ie the value of enthalpy \_\_\_\_\_ the thermal effect was \_\_\_\_\_ than its value \_\_\_\_\_. This means that the sample \_\_\_\_\_ heat during the reaction. Furthermore, there is evidence of a change \_\_\_\_\_ in the temperature is increased beyond the thermal transition. This is shown by the \_\_\_\_\_ of the just beyond the end.

### Answer

#### Select from the following list

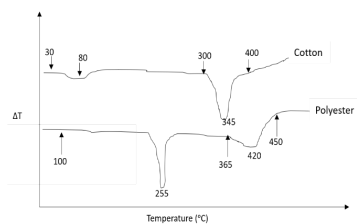
[upward/downward, free energy/heat capacity, greater/less, DTG/DTA, base-line/background, derivative/differential, took in/gave out, negative/positive, enthalpy/entropy, before/after/during, exothermic/endothermic/isothermal, abscissa/ordinate, distortion/displacement.]



### Activity 3.2: (James & Tonge, 2008)

During the Falklands campaign in 1982 many naval personnel suffered serious burns. In 1985 the Admiralty decreed that all men on active service in Navy should be issued cotton uniforms instead of polyester ones which had been issued in 1982. Does the thermal data suggest a reason for the decision? Justify your answer.

[Hint: Cotton decomposes at 345 °C whereas polyester melts at 255 °C and decomposes at 420 °C]



### 3.3 Comparison with TGA

	TGA	DTA
1	It measures change (loss or gain) in weight as the sample is subjected to controlled heating program	It is a technique in which the difference in temperature between the sample and an inert reference material, is measured as a function of temperature
2	It will detect only those physical and chemical transitions which are accompanied by change in weight.	It can detect all physical and chemical transitions.
3	This does not require an inert reference.	This requires an inert reference material.
4	It is a quantitative method	It is a semi-qualitative method.
5	This technique is generally used to study decomposition reactions.	This technique is used to study phase transitions

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