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THERMOGRAVIMETRIC ANALYSIS

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Abstract: This article provides information about thermogravimetric analysis, its types, and tests. In short, thermogravimetry is the process of determining the weight of a material as a function of temperature and time. This method is often used to study the thermal properties of a substance in a thermal environment.

Keywords: Thermogravimetric analysis, methods, tests, temperature, material, substance, moisture, and volatility.

Thermogravimetric analysis is an analytical technique used to determine the thermal stability and volatile composition of a material by observing the weight change that occurs when a sample is heated at a constant rate. This analytical method is a type of thermal analysis technique. Thermogravimetric measurements are usually performed as a function of temperature rise at a constant heating rate or as a function of time, taking into account mass loss and temperature constant.

Thermogravimetric analysis is recognized as a powerful method for measuring the thermal stability of materials, including polymers. In this method, the change in the weight of a sample is measured as its temperature increases. The moisture and volatility in the sample are determined by this analysis. The instrument used in these analyses consists mainly of a highly sensitive balance to measure the weight change and a programmable oven to control the heating rate of the sample. The balance is located above the oven and is thermally insulated from the heat. To maximize the accuracy, precision, and accuracy of the balance, the balance must be isolated from thermal effects.

Three different methods are commonly used in thermogravimetric analysis:

- • In dynamic thermogravimetric analysis, the temperature is increased over time as the mass is recorded. This technique allows us to determine how much gas is released at a time and the temperature at which it is generated.
- • In static thermogravimetric analysis, the temperature is kept constant while the mass is measured. This technique is used to gain more information about the degradation that occurs at a given temperature or to obtain information about the waistline of a material. It is used to study its ability to withstand high temperatures.
- • In quasistatic thermogravimetric analysis, the sample is heated through several temperature ranges and is usually held for a certain period of time until the mass stabilizes within these ranges. This technique is ideal for investigating substances that are known to decompose in different ways at different temperatures and for better characterizing their decomposition.

Thermogravimetric analysis data are usually displayed with a graph representing mass as a function of temperature for dynamic thermogravimetric analysis.

Types of TGA

There are three types of thermogravimetry:

Isothermal or static thermogravimetry: In this technique, the weight of a sample is measured as a function of time at a constant temperature.

Quasistatic thermogravimetry: In this technique, the temperature of the sample is increased in successive steps separated by isothermal intervals, during which the mass of the sample reaches a steady state before the next temperature scale is started.

Dynamic thermogravimetry: In this technique, the sample is heated in an environment where the temperature is changed linearly and measured.

Thermogravimetric Analysis (TGA) Tests

In the thermogravimetric analysis (TGA) technique, a test sample is placed in a controlled temperature program in a controlled environment and the mass of the substance is observed as a function of temperature or time. In other words, the thermogravimetric analysis technique is a method in which the weight of a material increases or decreases as the material is heated. In this method, the weight of the sample is measured as the material is heated or cooled in an oven.

A thermogravimetric analyzer consists of a sample pan supported by a precise scale. This pan is placed in an oven and heated or cooled during the experiment. At the same time, the mass of the sample is monitored. A sample purge gas controls the sample environment. This gas can be an inert or reactive gas or can flow through the sample or be emitted from the exhaust gas. A thermogravimetric analyzer uses gravity to obtain very accurate and repeatable measurements. These instruments can measure water loss, solvent loss, plasticizer loss, decarboxylation (removal of carbon dioxide from an amino acid), pyrolysis (combustion in an oxygen-free environment), oxidation, decomposition, percentage of filler, amount of metal catalyst residue, carbon nanotubes remaining, and ash weight fraction. All of these measurement applications are typically performed during the heating process, but there are some tests where data can be obtained after cooling. As can be seen, thermogravimetric analysis (TGA) is an analytical technique used to determine the thermal stability of a material and the proportion of volatile components by observing the weight change that occurs when a sample is heated at a constant rate. Thermogravimetric analysis is a very useful tool for understanding the thermal phenomena associated with nanomaterials and polymer composites when heated at a predetermined heating rate and temperature. Thermogravimetric analysis is a thermal analysis technique that monitors the mass of a sample in a controlled environment oven as a function of time or temperature. The equipment consists of an oven, a microbalance, a temperature controller, and a data acquisition system. The bulk sample is weighed on the microbalance as it is heated or cooled in the oven according to a predetermined schedule. This technique is a low-cost technique, a small sample is sufficient, and it allows for quantitative or qualitative analysis. However, this method is a destructive analysis, and the analysis may not always be accurate due to the presence of volatile components in the sample. Thermogravimetric analysis (TGA) is a technique used to determine the thermal stability, oxidative stability, chemical composition, and water content of biopolymer films. This technique is used as a useful tool to investigate the incorporation of nanoparticles and active compounds into biopolymer films or membranes by monitoring the increase or decrease of thermal degradation

peaks, or by evaluating the fastest or slowest thermal degradation. In summary, thermogravimetry is the process of determining the weight of a material according to a combination of temperature and time. This technique is often used to study the thermal properties of a substance in a thermal environment. The temperature of the oven is raised to 2000 degrees and can analyze a sample weight of up to 1 gram. The oven of the device is designed as a radiant heating chamber. It contains a temperature controller, a precision balance, a gas supply system, and a data analyzer. Approximately 7-8 milligrams of test sample or powder is placed on a precision balance, and the temperature is continuously recorded by an instrument under the basket. Two types of graphs are usually obtained in these analyses:

• Plot of the sample versus temperature (thermogravimetric analysis curve)

• Rate of mass loss due to temperature increase

These curves are also used to obtain other parameters, such as reaction kinetics.

The main standards based on these tests are:

• ASTM E1131 standard developed by the American Society for Testing and Materials (ASTM E1131-08 Standard Test Method for Composition Analysis by Thermogravimetry

• USO 11358-1 standard developed by the International Standards Organization (ISO) and published in our country by the Turkish Standards Institute (TSE) (TS EN ISO 11358-1 Plastics - Thermogravimetry (TG) of Polymers - Part 1: General Principles)

Commonly analyzed materials include polymers, organic materials, adhesives, food products, coatings, prescription drugs, rubber, composites, laminates, petroleum, chemicals, explosive plastics and biological samples.

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