

Thermal Analytical Characterization of *Gymnema sylvestre* Using TGA-DTA Technique

**Nirmala Kakade¹, Devidas Gaikwad², Shabnam Sayyad³, Chetankumar Sedani⁴,
Farook Sayyad⁵, Shobha Rupanar⁶, Nikita Bangar⁷, Kamalkishor Maniyar^{8*}**

^{1,2}Assistant Professor, Department of Chemistry, Dadapatil Rajale Art's and Science College, Adinathnagar, Pathardi

³Associate Professor, Department of Computer Engineering, AISSMS College of Engineering, Pune

⁴Professor and Director, P K Technical Campus, Chakan, Pune

⁵Principal and Professor, Department of Mechanical Engineering, Ajeenkya D Y Patil School of Engineering, Lohegaon

⁶Assistant Professor, Department of Engineering Sciences, Ajeenkya D Y Patil School of Engineering, Lohegaon.

⁷Department of Computer Engineering, Dr. D. Y. Patil Institute of Technology, Pimpri, Pune, India

⁸Department of Mechanical Engineering, Dr. D. Y. Patil Institute of Technology, Pimpri, Pune, India

*kkmaniyar2020@gmail.com

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Abstract:

Gymnema sylvestre, a well-known antidiabetic plant, has been extensively studied for its therapeutic potential across various traditional medicine systems. It is widely used to treat a range of ailments in humans. In modern herbal medicine, drug standardization is critical to ensure the quality and purity of herbal drugs. The TGA-DTA (Thermogravimetric Analysis - Differential Thermal Analysis) technique is commonly employed to study the physical and chemical changes of various herbal substances. In this study, the thermal and chemical characteristics of powdered leaves, stems, and roots of *Gymnema sylvestre* were analysed using TGA-DTA methods. TGA (Thermogravimetric Analysis) and DTA (Differential Thermal Analysis) are sophisticated thermal analysis techniques commonly used to examine the thermal properties, stability, and composition of a wide range of materials, including medicinal plants, pharmaceuticals, polymers, and other substances. The TGA and DTA curves were recorded over the temperature range of 35°C to 700°C to examine the decomposition patterns of *Gymnema sylvestre* plant material. In the DTA curve, an endothermic peak at 101°C was observed in all samples, corresponding to the evaporation of water from the surface and pores of the powder. A second weight loss between 350°C and 400°C is attributed to the degradation of cellulose and hemicellulose present in the plant. Further analysis suggests the possibility of lignin degradation occurring between 450°C and 700°C as the temperature is extended. The TGA analysis of the powdered leaves, stems, and roots of *G. sylvestre* provides valuable insights into the stability and composition of this medicinal plant. These results offer supporting data that can be utilized for the identification and standardization of *Gymnema sylvestre* in herbal drug analysis.

Keywords: Thermal (TGA-DTA) analysis, *Gymnema sylvestre* leaves, stem and root.

1. Introduction

Gymnema sylvestre Wild R.Br., belonging to the family Apocynaceae (Subfamily: Asclepiadaceae), is an important herbal medicinal plant in traditional Indian medicine, primarily used for the treatment of diabetes. Known as "Gurmar," which translates to "sugar killer," this plant has been utilized by

Indian healers for nearly 2,000 years as part of the Ayurveda system of medicine. One of the major concerns for modern societies is to deepen our understanding of medicinal plants, herbal-derived products, and herbal extracts⁴. Thermal analysis techniques, such as TGA-DTA, provide an effective method for assessing these properties. TGA-DTA analysis plays a crucial role in the standardization of herbal drugs in photochemistry. These techniques offer both qualitative and quantitative insights into the volatile and non-volatile compounds present in plant materials. Additionally, they help determine the overall composition and thermal stability of plants. Assessing thermal stability is essential for applications in fields like biomedicine and food science.

TGA-DTA is a powerful tool used to evaluate the stability and decomposition temperatures of materials under controlled temperature conditions⁴. While initially developed for analysing polymers and ceramics, TGA-DTA techniques have since been adapted for a wide range of materials, including those of biological origin. TGA is commonly employed to assess the thermal stability of organic substances, such as pharmaceuticals and polymers, and to determine drying conditions and moisture content^{6,7}. It can also be used to quantify specific components in a sample by measuring the characteristic mass loss associated with their degradation. Recent research has shown that not only the leaves of *Gymnema sylvestre*, but also its stems and roots, possess medicinal properties and could potentially be used as herbal drugs.

2. Materials And methods

2.1 Collection and Authentication of plant material:

A bulk quantity of 5 kg of *Gymnema sylvestre* plant material was collected from Mulashi, Pune, for research purposes. The plant was authenticated by the Botanical Survey of India (BSI), Pune, and a specimen has been deposited at the AHMA Herbarium at BSI with the voucher number SVS-1/783.

2.2 Preparation of Sample for TGA-DTA analysis:

The leaves, stem, and root of *G. sylvestre* were carefully separated and thoroughly washed with water to remove soil, foreign particles, and any surface contamination. The plant materials were then allowed to air dry at room temperature. Once dried, the materials were cut into small pieces and ground into a fine powder using a grinder. Each powdered sample was sieved through 0.5 mm mesh sieve. The three plant samples were stored in airtight containers to maintain their quality before further analysis, as shown in Figure 1. Prior to analysis, each sample was weighed and placed in the TGA device to begin the experiment. A 7.0 mg portion of each powdered sample was used for the TGA-DTA studies.

2.3 Instrumental Parameter

TGA-DTA analysis was performed using a Perkin STA 8000 thermal analysis system. The temperature was gradually increased from 35°C to 700°C at a heating rate of 10°C/min, with a suitable cooling attachment and a Pt-Pt/Rh thermocouple sensor. For the analysis, a sample weight of 20.00 mg was used for each of the plant material samples.

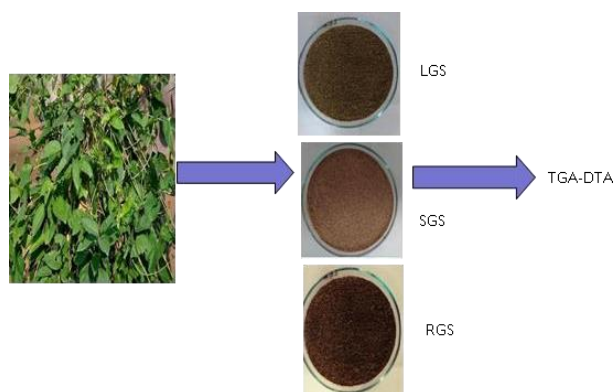


Figure 1: Powdered sample of Leaves, stem and Root of *G. sylvestre*.

3. Results and Discussion

The results of the Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA) for the leaves, stem, and root of *G. sylvestre* are presented in Figures 2, 3 and 4 respectively. The thermal behaviour of the dried powdered plant material was monitored using TGA, with the curves representing the mass loss (TG) as a function of temperature, as well as the first derivative of the TG curve (DTG) with respect to temperature. In the DTA curves, all samples exhibit an endothermic peak at 101°C, which is attributed to dehydration or the loss of water molecules from the surface and pores of the powder. The graph shows a second weight loss occurring between 350°C and 400°C in all samples, which is likely due to the degradation of cellulose and hemicellulose. Further heating between 450°C and 700°C leads to the degradation of lignin compounds in *G. sylvestre*.

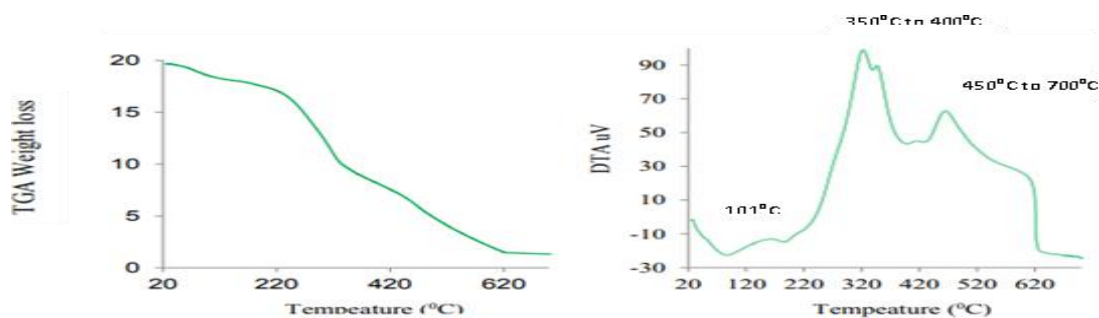


Figure 2. TGA-DTA curves of *G. sylvestre* leaves

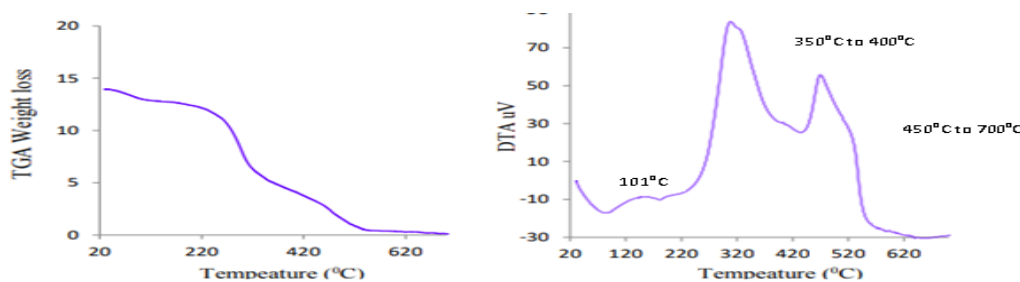
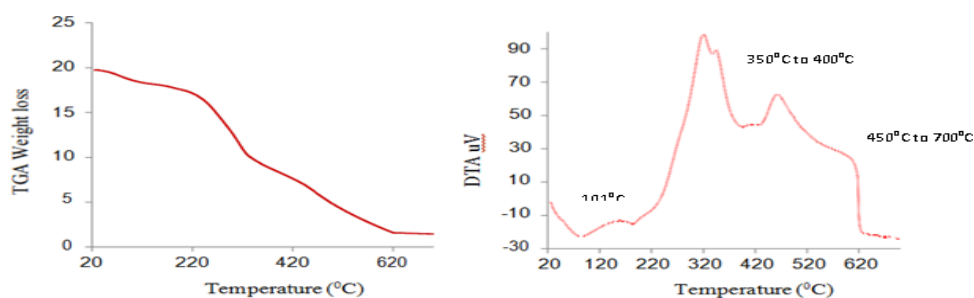


Figure 3. TGA-DTA curves of *G. sylvestre* stem powder

Figure 4. TGA-DTA curves of *G. sylvestre* root powder

4. Conclusions

Thermal analysis is a powerful technique for studying the thermal stability and chemical composition of medicinal plants. The TGA and DTA curves of *G. sylvestre* plant material reveal its decomposition pattern in the temperature range of 35°C to 700°C. An endothermic peak observed at 101°C in all samples corresponds to the evaporation of moisture from the surface and pores of the powder. The second weight loss, occurring between 350°C and 400°C, is attributed to the breakdown of cellulose and hemicellulose in the plant. The DTA curve further indicates that lignin degradation occurs between 450°C and 700°C. TGA analysis of the powdered leaves, stems, and roots of *G. sylvestre* provides valuable information about the plant's stability and composition. The TGA-DTA data can be used for the authentication and standardization of *G. sylvestre* as an herbal drug. TGA and DTA are crucial techniques for assessing the composition and quality of medicinal plants like *Gymnema sylvestre*. These methods enable the monitoring of degradation patterns in essential plant components such as cellulose, hemicellulose, and lignin, offering important insights into the plant's thermal stability. They also help determine moisture content, a key factor in evaluating the plant's shelf life and overall quality. Additionally, TGA and DTA play a vital role in the authentication of plant materials, providing essential data for the standardization of herbal drug formulations and ensuring consistent potency and quality in their medicinal use.

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