

## THERMOGRAVIMETRIC STUDIES OF LIGANDS AND ITS METAL COMPLESES

Dr. Mallikarjun Kote\*

Department of Chemistry, B. V. Bhoomaraddi College of Arts, Science and Commerce  
Bidar-Karnataka.

Article Received on 11 Feb. 2026,  
Article Revised on 03 March 2026,  
Article Published on 16 March 2026,

<https://doi.org/10.5281/zenodo.19046246>

### \*Corresponding Author

Dr. Mallikarjun Kote

Department of Chemistry, B. V.  
Bhoomaraddi College of Arts,  
Science and Commerce Bidar-  
Karnataka.



**How to cite this Article:** Dr. Mallikarjun Kote\*.  
(2026). Thermogravimetric Studies of Ligands  
and Its Metal Complexes. World Journal of  
Pharmaceutical Research, 15(6), 981-986.  
This work is licensed under Creative Commons  
Attribution 4.0 International license.

### ABSTRACT

Thermogravimetric Analysis (TGA) abstract describes using a material's weight change versus temperature/time to analyze its thermal stability, composition (volatiles, fillers, moisture, decomposition products), and degradation kinetics, revealing thermal events like drying, oxidation, or decomposition in controlled atmospheres (inert/oxidative) for applications in polymers, composites, and materials science. The results, often shown with Derivative Thermogravimetric (DTG) curves, help determine product quality, estimate service life, and understand material structure.

### INTRODUCTION

Thermogravimetric analysis (TGA) is a thermal analysis method that measures a sample's mass change over time as its temperature is precisely controlled, revealing physical changes (like water loss, desorption) and chemical reactions (like decomposition, oxidation). A thermo balance, furnace, and controlled atmosphere are used to generate plots of mass vs. temperature or time, helping determine material composition, thermal stability, moisture content, and degradation kinetics for polymers, pharmaceuticals, and other materials.

### Method

A small sample is placed on a sensitive microbalance in a furnace. The temperature is increased (or decreased) following a programmed profile. A controlled gas (like nitrogen or air) can flow over the sample. As the sample undergoes thermal events, its mass change (loss

or gain) is continuously recorded.

### What it Measures & Reveals

**Mass Loss:** Loss of water (moisture), solvents, or decomposition.

**Mass Gain:** Reactions with the surrounding atmosphere, such as oxidation or reduction.

**Physical Phenomena:** Phase transitions, absorption, adsorption, and desorption.

**Chemical Phenomena:** Thermal decomposition, chemisorption, and solid-gas reactions.

### Applications

- **Polymers:** Determine degradation temperature, composition, and additive levels.
- **Materials Science:** Assess thermal stability, purity, and inorganic/organic content.
- **Pharmaceuticals:** Study stability and volatile content.
- **Food Science:** Analyze composition and moisture.

## RESULTS AND DISCUSSION

A graph (TGA curve) plots percentage weight vs. temperature/time, showing distinct steps for different events, according to

### Thermogravimetric analysis (TGA)

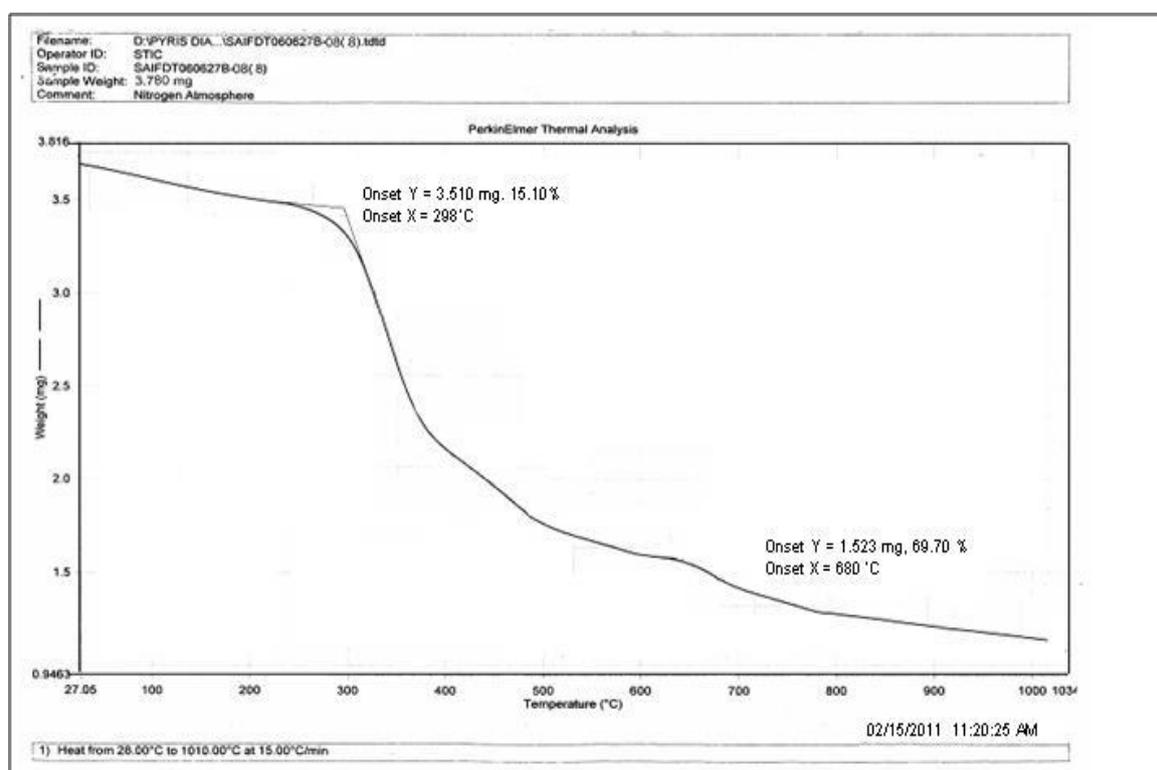
Thermogravimetric measurements taken on Perkin-Elmer thermal analyzer at heating rate  $15^{\circ}\text{C}/\text{minute}$  from  $27^{\circ}\text{C}$  to  $1020^{\circ}\text{C}$ . Thermogram of the complex is shown in figure 3.22.

### Thermogravimetric analysis of the Mn(II) complex of the ligand L<sup>1</sup>

Thermogram of the Mn(II) complex is shown in figure 3.22. The thermogram showed a first inflection point at  $298^{\circ}\text{C}$  with the weight loss of 15.10 %, which amounts for the loss of  $-\text{C}_6\text{H}_{12}$ . This practical weight loss of 15.10 % corresponding to  $-\text{C}_6\text{H}_{12}$  is in agreement with theoretical weight loss of 15.20 %. Continued process of heating resulted in second inflection point at  $680^{\circ}\text{C}$  with the weight loss of 69.70 %. Which amount to loss of  $-\text{C}_{20}\text{H}_{10}\text{N}_6\text{O}_3$  species in the TGA curve. The practical weight loss of 69.70 % of this second stage decomposition is accordance with theoretical weight loss of 70.25 %. The partially decomposed complex is unstable after this temperature ( $>1000^{\circ}\text{C}$ ) and showed a continuous weight loss till  $1020^{\circ}\text{C}$  (as shown in the thermogram), with the loss of rest of the organic matter leaving behind the metal oxide as residue.<sup>[64]</sup> The thermal decomposition of the Mn(II) complex with probable assignments are given in the table 3.11.

**Table 3.11: Thermal decomposition of Mn(II) complex of Schiff's base ligand L<sup>1</sup>.**

| Complex  | Stage | Peak Temp. TG (°C) | Loss of Mass (%) |             | Probable Assignments   |
|--|-------|--------------------|------------------|-------------|--|
|  |       |                    | Practical        | Theoretical |  |
| [Mn(C <sub>26</sub> H <sub>22</sub> N <sub>6</sub> O <sub>4</sub> )] | I     | 298                | 15.10            | 15.20       | C <sub>26</sub> H <sub>22</sub> MnN <sub>6</sub> O <sub>4</sub><br>↓ -C <sub>6</sub> H <sub>12</sub><br>[Mn(C <sub>20</sub> H <sub>10</sub> N <sub>6</sub> O <sub>4</sub> )] |
|  | II    | 680                | 69.70            | 70.25       | ↓ -C <sub>20</sub> H <sub>10</sub> N <sub>6</sub> O <sub>3</sub><br>MnO  |

**Figure 3.22: Thermogram of Mn(II) complex of ligand L<sup>1</sup> (HMOHAD).**

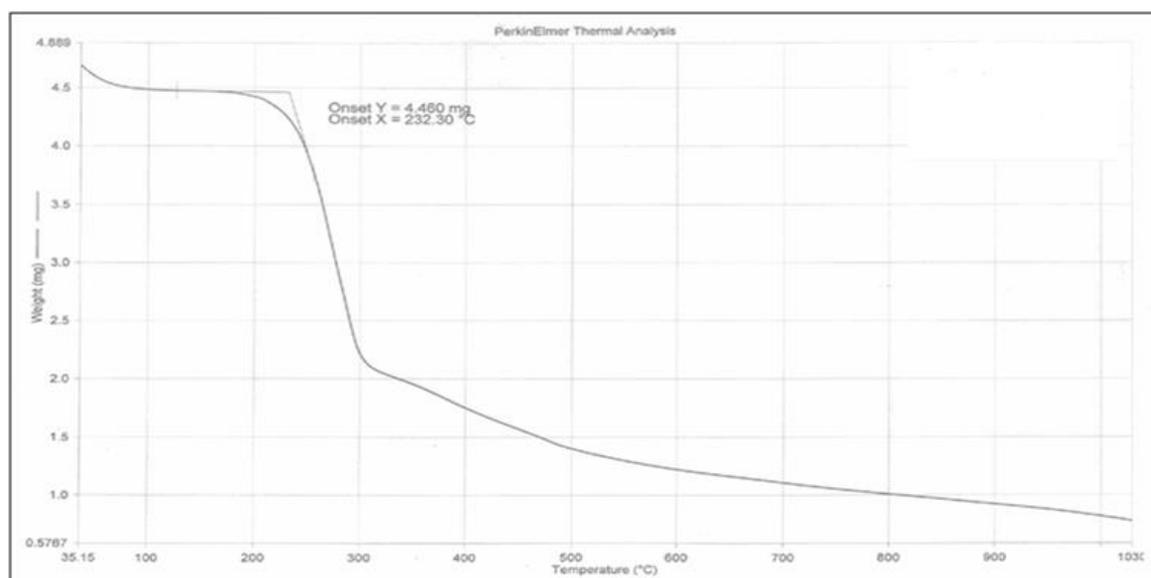
### Thermogravimetric analysis of the Ni(II) complex of the Schiff's base ligand L<sup>5</sup>(HECHCC)

Thermogram of the Ni(II) complex is shown in figure 4.15. The thermogram showed a first inflection point at 232.30 °C with the weight loss of 5.09 %, which amounts for the loss of four methane molecules. This practical weight loss of 5.09 % corresponding to four methane molecules is in agreement with theoretical weight loss of 4.80 %. Continued process of heating resulted in second inflection point at 336 °C with the weight loss of 56.15 %. Which amount to loss of -C<sub>35</sub>H<sub>30</sub>N<sub>4</sub>O<sub>8</sub> species in the TGA curve. The practical weight loss of 56.15 % of this second stage decomposition is accordance with theoretical weight loss of 56.94 %. The partially decomposed complex is unstable after this temperature (>1000 °C) and showed

a continuous weight loss till 1010 °C (as shown in the thermogram), with the loss of rest of the organic matter leaving behind the metal oxide as residue. The thermal decomposition of the Ni(II) complex with probable assignments are given in the table 4.8.

**Table 4.8 Thermal decomposition of Ni(II) complex of Schiff's base ligand L<sup>5</sup>.**

| Complex  | Stage | Peak Temp. TG (°C) | Loss of Mass (%) |             | Probable Assignment   |
|--|-------|--------------------|------------------|-------------|---|
|  |       |                    | Practical        | Theoretical |   |
| [Ni(C <sub>39</sub> H <sub>34</sub> N <sub>4</sub> O <sub>8</sub> )] | -     | -                  | -                | -           | [Ni(C <sub>39</sub> H <sub>34</sub> N <sub>4</sub> O <sub>8</sub> )]                      |
|  | I     | 232.30             | 5.09             | 4.80        | ↓ -4CH <sub>4</sub><br>Ni(C <sub>35</sub> H <sub>30</sub> N <sub>4</sub> O <sub>8</sub> ) |
|  | II    | 336.00             | 56.15            | 56.94       | ↓ -C <sub>35</sub> H <sub>30</sub> N <sub>4</sub> O <sub>8</sub><br>NiO                   |



**Figure 4.15: Thermogram of Ni(II) complex of ligand L<sup>5</sup>.**

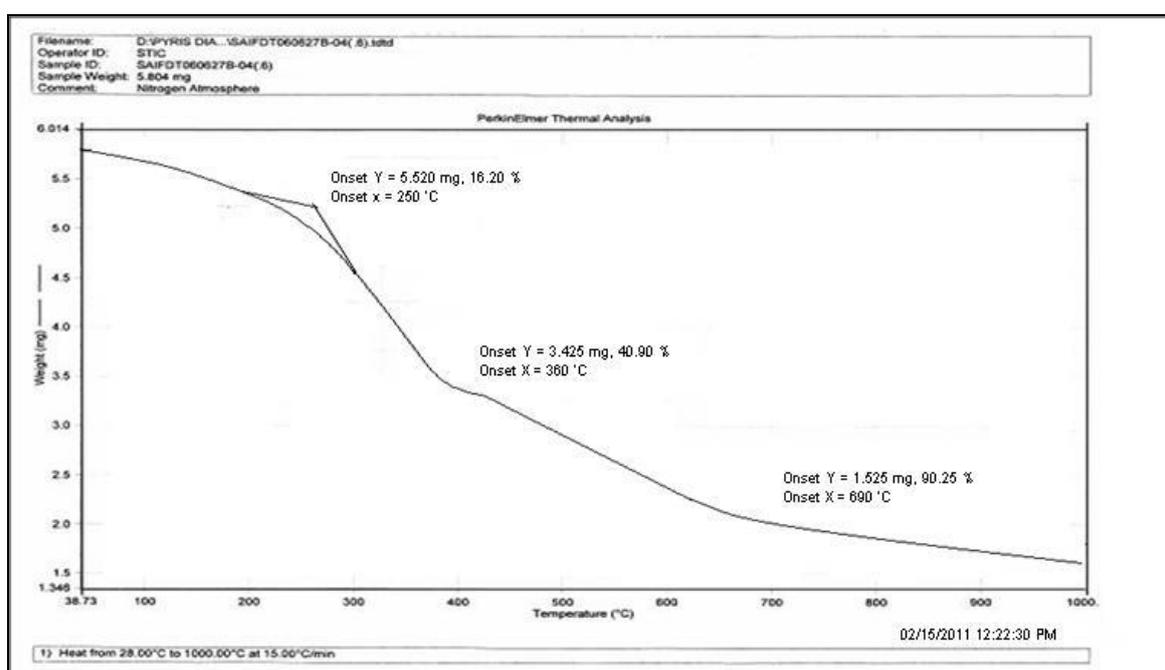
### Thermogravimetric analysis of the Mn(II) complex of the ligand L<sup>8</sup>

The decomposition pattern was concluded, where by the complex decomposed in three stages shown in figure 5.11. The thermogram showed a first inflection point at the temperature 250 °C with the weight loss of 16.20% which accounts for the loss of -C<sub>10</sub>H<sub>8</sub> molecules. This weight loss 16.20 % is in agreement with theoretical weight loss of 16.80 % calculated for removal of -C<sub>10</sub>H<sub>8</sub> molecules, continued process of heating resulted in second inflection point at 360°C with the weight loss of 40.90 %, which amount to loss of -C<sub>12</sub>H<sub>9</sub>O<sub>4</sub> molecule, in the TGA curve. The practical weight loss of 40.90 % of this second stage decomposition is in accordance with theoretical weight loss of 40.38 %. The third inflection point results at 690° C, amount to the loss of 90.25 % corresponding to the loss of -C<sub>12</sub>H<sub>7</sub>N<sub>2</sub>O<sub>2</sub> species is in agreement with the theoretical weight loss of

83.11 %. This partially decomposed complex is unstable after this temperature ( $>1000\text{ }^{\circ}\text{C}$ ) and showed a continuous weight loss with the loss of rest of the organic matter leaving behind the metal oxide as residue. The thermal decomposition of the Mn(II) complex with probable assignments are given in table 5.11.

**Table 5.11 Thermal decomposition of Mn(II) complex of the Schiff's base ligand L<sup>8</sup>.**

| Complex   | Stage | Peak temp. TG ( $^{\circ}\text{C}$ ) | Loss of mass (%) |             | Probable assignments  |
|---|-------|--------------------------------------|------------------|-------------|---|
|   |       |                                      | Practical        | Theoretical |   |
| [Mn(C <sub>36</sub> H <sub>28</sub> I <sub>2</sub> N <sub>4</sub> O <sub>8</sub> )] | –     | –                                    | –                | –           | [Mn(C <sub>36</sub> H <sub>28</sub> I <sub>2</sub> N <sub>4</sub> O <sub>8</sub> )  |
|   | I     | 250                                  | 16.20            | 16.80       | ↓ - C <sub>10</sub> H <sub>8</sub><br>[Mn(C <sub>26</sub> H <sub>20</sub> N <sub>4</sub> O <sub>8</sub> )   |
|   | II    | 360                                  | 40.90            | 40.38       | ↓ C <sub>12</sub> H <sub>9</sub> O <sub>4</sub><br>[Mn(C <sub>14</sub> H <sub>11</sub> N <sub>4</sub> O <sub>4</sub> )                            |
|   | III   | 690                                  | 90.25            | 83.11       | ↓ -C <sub>12</sub> H <sub>7</sub> N <sub>2</sub> O <sub>2</sub><br>[Mn(C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> )]<br>↓<br>MnO |



**Figure 5.22: Thermal decomposition of Mn(II) complex of the Schiff's base ligand L<sup>8</sup> (HMCHBA).**

## REFERENCES

1. A. L. El-Ansary, H. M. Abdel-Fattah, N. S. Abdel-Kader, *Spectro. Chem. Act. A.*, 2011; 79: 522.
2. R. Chaudhary, A. Shelly, *J. Chem, Bio, Phy. Sci.*, 2012; 2(1): 1.
3. K. Siddappa, K. Mallikarjun, *J. Appl. Chem.*, 2013; 2(3): 405.
4. K. Siddappa, K. Mallikarjun, P. Chandrakant Reddy, Tukaram Reddy, *J. Chem. Pharm. Res.*, 2011; 3(6): 780.
5. M. Asadi, M. Ghatee, S. Torabi, K. Mohamod, F. Moosavi, *J. Chem. Sci.*, 2010; 122(4): 539.
6. P. Mishra, *Inter. J. Pham. Sci. Rev. Res*, 2010; 2: 2.
7. V. L. Chavan, B. H. Mehta, *Res. J. Chem. Envir*, 2011; 15(2): 58.
8. T. M. A. Ismail, A. A. Saleh, M. A. El, Ghamry, *Spectro. Chem. Act. A.*, 2012; 86: 276.
9. K. Siddappa, K. Mallikarjun, *Der Pharma Chemica.*, 2012; 4(3): 1206.
10. K. Siddappa, K. Mallikarjun, *J. Chem. Bio. Phy. Sci. Sec.*, 2013; 3(4): 2401.
11. K. Siddappa, P. Tukaram Reddy, P. Chandrakant Reddy, M. Mallikarjun, T Mahesh, K. Mallikarjun, *Inter. J. Pure & Appl. Chem.*, 2008; 3(2): 87.
12. K. Siddappa, S. Palled, K. Mallikarjun, *Elix. J. Appl. Chem.*, 2012; 52: 11490.
13. K Siddappa, K. Mallikarjun, *Arch. Appl. Sci. Res.*, 2012; 4(3): 1411.
14. K Siddappa, K. Mallikarjun, *J. Appl. Chem.*, 2013; 2(3): 405.
15. M. M. Woolfson, "An Introduction to X-ray Crystallography" Cambridge University Press, Cambridge, 1980; 125.
16. S. Chandra, U. Kumar, *Spectro. Chem. Act. Part A.*, 2005; 61(2): 219.
17. K Siddappa, K. Mallikarjun, *J. Appl. Chem.*, 2013; 2(3): 405.
18. H. S. Peiser, H. P. Rookshy , A. J. C. Wilson, "X-ray Diffraction by Polycrystalline Material", Institute of Physics, London, 1956.
19. K. S. Patel, J. C. Patel, H. R. Dholariya, K. D. Patel., *Spectro. Chem. Act. Part A*, 2012; 468.
20. K. Siddappa, K. Mallikarjun, *Int. J. Chem. Pharm. Sci.*, 2013; 1(8): 433.
21. K. Siddappa, Tukaram Reddy, P. Chandrakant Reddy, M. Mallikarjun, K. Mallikarjun, *Mat. Sci. Res. Ind.*, 2008; 5: 131.