"The Study on Thermodynamic Parameters and Fungiudal Activity of 3,4,5-Trimethoxybenzaldehyde Thiosemicarbazone"

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Abstract

The thermodynamic parameters of 3,4,5-trimethoxybenzaldehyde thiosemicarbazone have been calculated and discussed at different temperatures. The fungicidal activity of the molecule has also been studied. The fungal growth was measured in terms of colony diameter (mm). The antifungal effect has been recorded at different concentrations against *Rhizopus (Rh)*, *Aspergillus flavus (As)*, *Aspergillus nidulence (An)*, *Aspergillus niger (Af)*, *and Alternaria alternata (Aa)*. A correlation between physical parameters and biological activity has also been established.

Key-words: 3, 4, 5- Trimethoxybenzaldehyde, thermodynamic parameters; thiosemicarbazone; fungicidal activity.

Introduction

The hydrazone, semicarbazone and thiosemicarbazone of benzaldehyde and their respective derivatives are of great importance because of their bio-activity against tuberculosis, leprosy, mental disorder and certain kinds of tumors[1-5] and also these acting as herbicides, insecticides and antidiabetic agents. Benzaldehyde is the simplest aromatic aldehyde, and the substitution of various functional group in the benzene nucleus changes its bioactivity markedly[6, 7].

The present study deals with the evaluation of the thermodynamic parameters of 3,4,5-trimethoxybenzaldehyde thiosemicarbazone (here after referred to as 3,4,5- TMBTS), and examination of fungicidal activity. The data obtained on both the studies have also been analyzed and correlated.

Objective of the Study

It is proposed to calculate the thermodynamic parameters *viz.* enthalpy function $(H^o–E^o_o)/T$, free energy function $(F^o–E^o_o)/T$, entropy (S^o) and heat capacity (C^0_p) at absolute temperature, and to examine the fungicidal effect of the 3,4,5-**t**rimethoxybenzaldehyde thiosemicarbazone, at varying concentrations, and also to correlate the results then obtained.

METHODOLOGY

Thermodynamic Parameters

Thermodynamic parameters *viz*. heat capacity (C^0_p) enthalpy function $(H^o–E^o_o)/T$, entropy (S^o) and free energy function $(F^o–E^o_o)/T$ of 3,4,5-TMBTS have been computed using the standard expressions[8,9], considering Y- axis perpendicular to the molecular plane and Z-axis as passing through the para positions.

The thermodynamic parameters have been calculated at different temperatures between 200-1500 K using (3n-6) fundamental frequencies for the molecule and assuming rigid rotor harmonic oscillator approximation. The calculations were for 1 mole of an ideal gas at 1 atmospheric pressure. The symmetry number for over-all rotation has been taken as 2 and internal rotation as 2.

Fungicidal Activity

The antifungal activity of 3,4,5-TMBTS has been evaluated at different concentrations (0.01-0.05%) against *Rhizopus, Aspergillus flavus, Aspergillus nidulence, Aspergillus niger and Alternaria alternata* (here after referred to as *Rh, Af, An, As and Aa* respectively) by growth method[10].

The fungal growth was measured in terms of colony diameter in mm. The diameter of 20 colonies was measured from each Petri dish. The average diameter from three replicates gave the average diameter of fungal growth.
The % inhibition was then calculated as follows:

$$\text{Percentage inhibition} = (C - T)/C \times 100$$

where C and T are the average diameters of fungus colony in control and treated sets respectively.

RESULTS AND DISCUSSION

The structural formula of 3,4,5- TMBTS is shown in **Figure 1.**

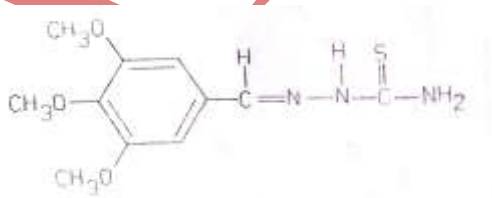

Figure 1

Thermodynamic Parameters

The computation data of thermodynamic parameters viz. enthalpy function $(H^o–E^o_o)/T$, free energy function
$(F^o–E^o_o)/T$, entropy (S^o) and heat capacity (C^0_p) with absolute temperature carried out statistically by using computer programming are given in T**able 1,** and the variation of enthalpy function and free energy function with absolute temperature is shown in **Figures 2 and 3** and that of heat capacity and entropy is shown in **Figures 4 and 5** is agreement with the trend reported in the literature [11-14].

Table 1 The Thermodynamic Parameters with Temperature 3, 4, 5- TMBTS

Temperature (K)	Enthalpy	Free energy	Heat	Entropy

	function $(H^o–E^o_o)/T$	function $(F^o-E^o_o)/T$	capacity (C^op)	(S^o)
200	3.31	51.72	13.64	61.03
300	11.77	54.17	21.77	66.14
400	15.56	56.53	30.17	72.09
500	19.25	58.09	37.62	77.34
600	22.84	59.38	43.87	82.22
700	26.23	60.46	49.05	86.69
800	29.26	61.41	53.41	90.77
900	32.24	62.25	57.10	94.99
1000	34.89	63.01	60.27	97.89
1100	37.33	63.69	62.99	101.02
1200	39.57	64.32	65.35	103.88
1300	41.63	64.89	67.39	106.52
1400	43.54	65.43	69.18	108.11
1500	45.29	65.93	69.73	108.23

The variation of enthalpy function and free energy function with absolute temperature is shown in **Figures 2 and 3** and that of heat capacity and entropy is shown in **Figures 4 and 5**

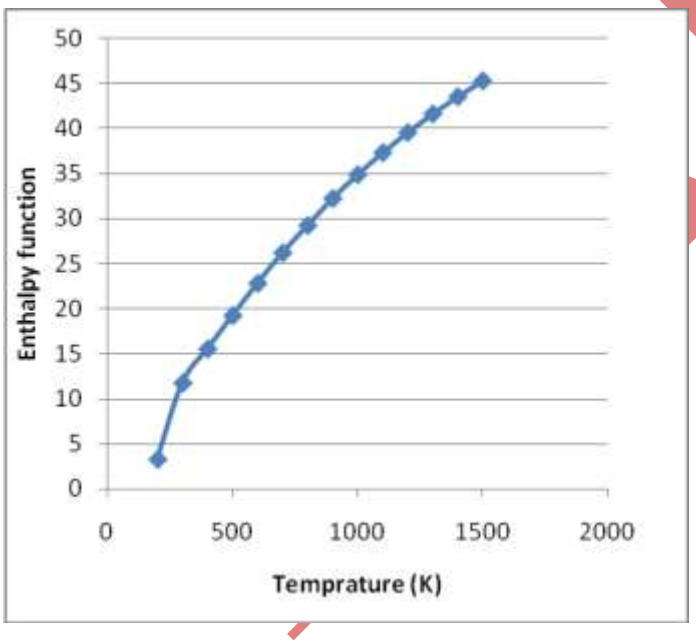

Figure 2

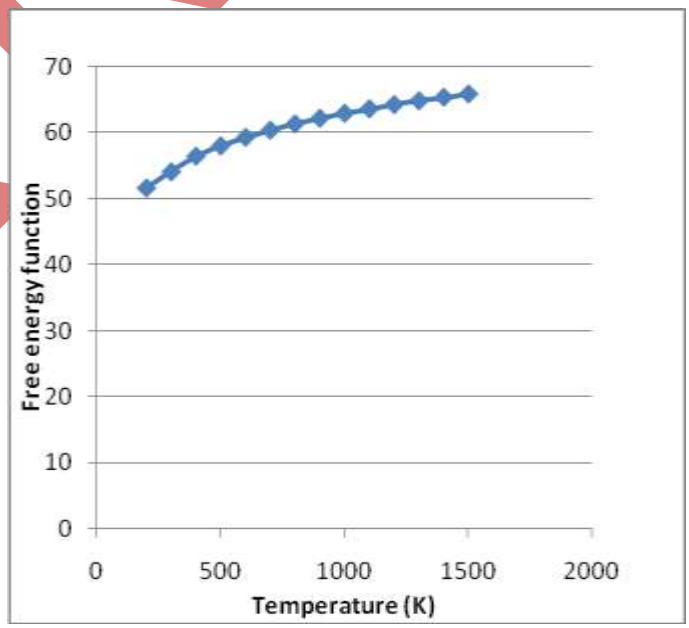

Figure 3

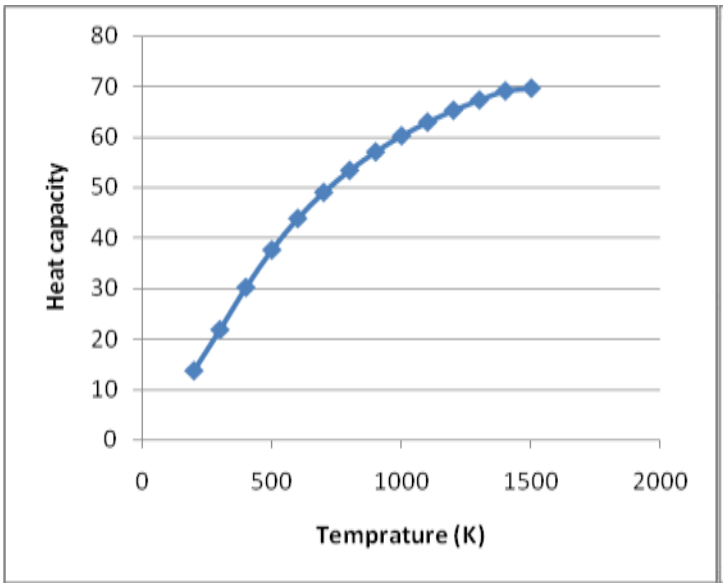

Figure 4

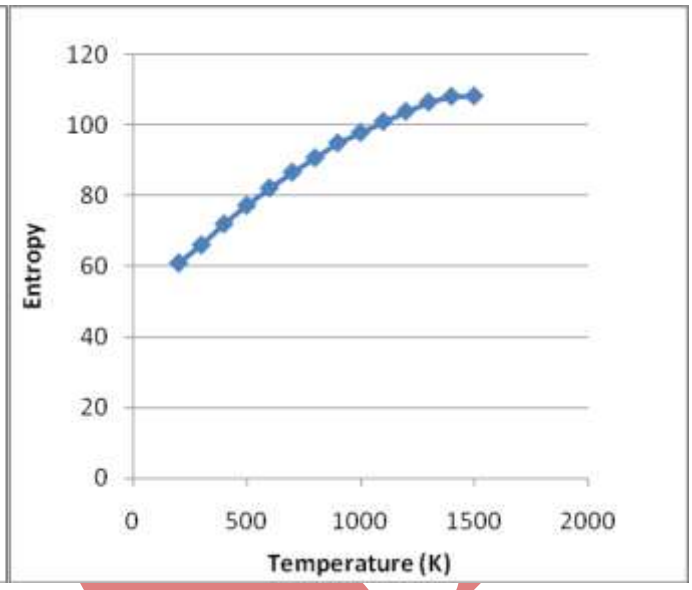

Figure 5

The principal moment of inertia were found to be 146.93, 236.08 and 383.01 x 10^{-39} gm cm^2 in 3,4,5-TMBTS.

Fungicidal Activity

The antifungal data of 3,4,5-TMBTS is appended in **Table 2,** and the fungal growth data at varying concentrations (0.010 - 0.050 %) are shown in **Figure 6.** The correlation between thermodynamic parameters and biological data for the compound 3,4,5-TMBTS is shown in **Table 3.**

At low concentration (0.010%), the percentage inhibition was 9.89% on *Rh*, 24.15% on *Af*, 16.25% on *Aa*, 15.23% on *An* and 10.52% on *As* for 3,4,5- TMBTS. At 0.015% concentration, the inhibitory effect was maximum on *Af* being 28.50% while minimum effect was on *Rh* being 12.75%. At 0.020%, 0.025% and 0.030% concentrations the inhibitory effect was 16.25%,18.25%, 22.00% on Rh, 32.75%, 37.00%, 41.50% on Af, 25.75%, 30.00%, 34.50% on *Aa*, 25.50%,30.75%, 35.75% on *An* and 20.75%, 25.50%, 30.50% on *As* in the compounds 3,4,5-TMBTS. At 0.035% concentration effect is maximum on *Af* and minimum on *Rh*. At 0.040% concentration the percentage inhibition was found to be 28.50% on *Rh*, 49.75% on *Af*, 43.50% on *Aa*, 46.25% on *An* and 40.25% on *As.* At 0.045% and 0.050% the inhibitory effect is maximum on *Af* being 54.00% and 58.63% and effect is minimum on *Rh* being 32.75% and 36.28%.

The experimental data of antifungal activity shows that the fungal growth was inhibited in all the cases with the addition of 3,4,5-TMBTS. Up to an optimum value the percentage inhibition was directly proportional to the concentration of the compound. In all the cases the fungitoxicity is higher at high concentration than that at low concentration.

It is clear from the above observation that the compound is fungitoxic against all the five fungi at all the concentrations. Thus, the compound 3,4,5-TMBTS can serve as a commercial fungicide

Table.2 The antifungal data of 3,4,5- TMBTS

Concentration (%)		***Rhizopus (Rh)***	***Aspergillus niger (Af)***	***Alternaria alternate (Aa)***	***Aspergillus nidulence (An)***	***Aspergillus flavus (As)***
Control		4.65	3.85	4.35	4.82	5.05
MIC		0.151	0.097	0.099	0.099	0.107
0.010	D	4.19	2.92	3.64	4.09	4.52
	I	9.89	24.15	16.25	15.23	10.52
0.015	D	4.06	2.75	3.42	3.84	4.26
	I	12.75	28.50	21.50	20.25	15.50
0.020	D	3.89	2.59	3.23	3.59	4.00
	I	16.25	32.75	25.75	25.50	20.75
0.025	D	3.80	2.43	3.05	3.34	3.76
	I	18.25	37.00	30.00	30.75	25.50
0.030	D	3.63	2.52	2.85	3.09	3.51
	I	22.00	41.50	34.50	35.75	30.50
0.035	D	3.46	2.09	2.65	2.84	3.26
	I	25.50	45.50	39.00	41.00	35.50
0.040	D	3.33	1.94	2.46	2.59	3.02
	I	28.50	49.75	43.50	46.25	40.25
0.045	D	3.13	1.77	2.27	2.30	2.75
	I	32.75	54.00	47.75	52.25	45.50
0.050	D	2.96	1.59	2.07	2.12	2.49
	I	36.28	58.63	52.50	56.32	50.62

where D= Diameter of fungus colony , I= Percentage inhibition, MIC= Maximum inhibition concentration.

The fungal growth data at varying concentrations (0.010-0.050 %) are shown in **Figure 6.**

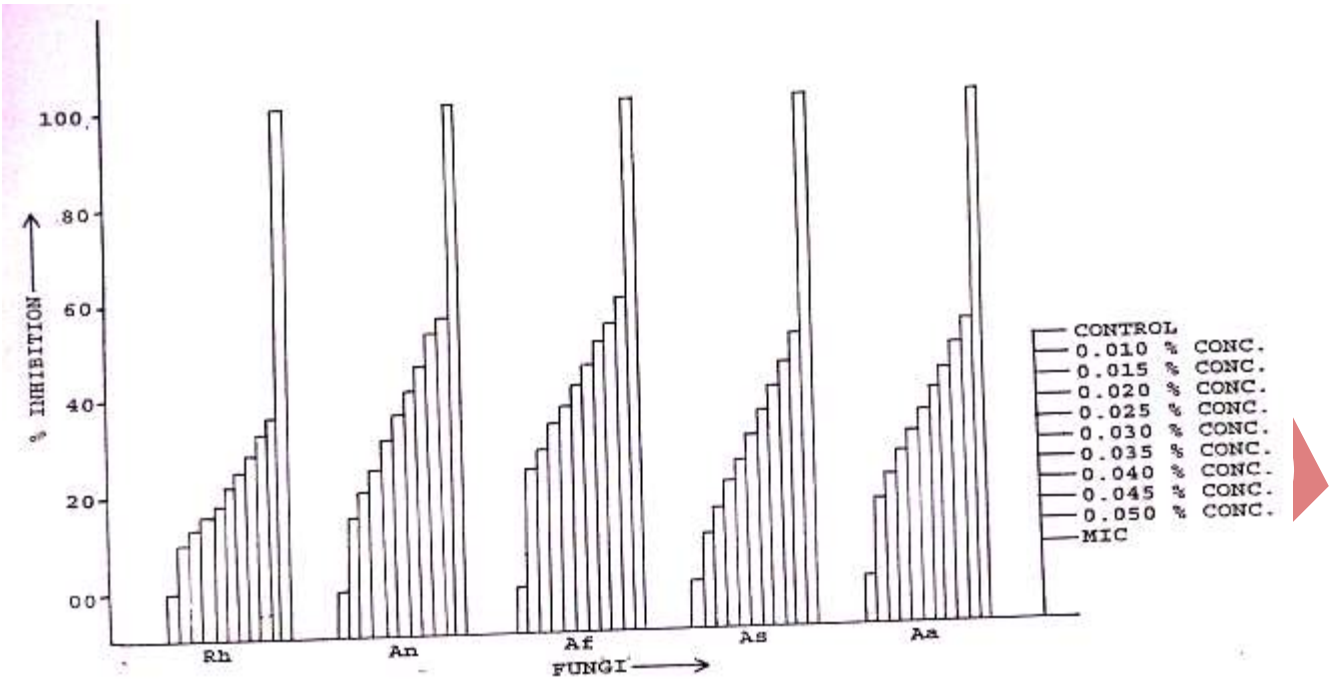

Figure.6

Table 3: Correlation between Thermodynamic parameters and antifungal data

Temp. (°C)	Antifungal data (% Inhibition)															Thermodynamic Parameters			
	Rh			*An*			*Af*			*As*			*Aa*			$(H^o - E^o)/T$	$(F^o - E^o)/T$	$(C^o p)$	(S^o)
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c				
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**11.70**	**54.14**	**21.48**	**65.92**
25	5.10	11.89	17.14	7.99	16.34	33.98	13.03	20.68	34.63	5.82	14.91	27.13	7.16	16.03	29.38	**11.73**	**54.16**	**21.69**	**66.02**
27	7.91	17.13	31.19	13.01	30.76	50.12	22.65	35.93	51.38	8.31	26.48	43.81	12.43	30.10	46.30	11.77	54.18	21.77	66.14
29	8.30	18.04	32.21	13.42	31.74	51.34	22.89	37.01	52.87	8.73	27.27	45.22	13.15	31.01	47.50	11.82	54.21	21.92	66.28
31	8.72	19.01	33.23	13.96	**32.72**	52.54	23.16	38.13	54.18	9.18	28.09	46.63	13.86	31.90	48.72	11.88	54.26	22.15	66.44
33	9.15	19.99	34.26	14.54	33.77	53.86	23.48	39.31	55.59	9.79	28.87	47.94	14.73	32.79	49.98	11.92	54.29	22.32	66.54
35	9.58	21.01	35.27	14.88	34.76	55.01	23.86	40.42	57.18	10.09	29.63	49.25	15.50	33.62	51.09	12.01	54.32	22.56	66.68
37	9.89	22.00	36.28	15.23	35.75	56.32	24.15	41.50	58.63	10.52	30.50	50.62	16.25	34.50	52.50	**12.07**	**54.38**	**22.77**	**66.83**
39	5.93	13.16	21.39	9.28	21.01	33.86	15.00	25.08	35.98	6.66	18.91	31.07	9.82	21.09	32.05	**12.14**	**54.46**	**23.00**	**66.99**
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.23	54.56	23.28	67.21

Effect of Temperature on Thermodynamic Parameters and Fungicidal Activity

It is clear from **Table.3** that the antifungal effect of the test compound 3,4,5- TMBTS at 22^0 C is zero at all the concentrations (0.01 - 0.05%). When the temperature exceeds 22^0 C the antifungal activity as well as thermodynamic parameters is increasing. As the concentration of 3,4,5-TMBTS increases, upto a critical value the inhibitory effect increases however the thermodynamic parameters remain unchanged for being independent of the concentration of the compound. This trend has been found to continue up to a temperature 37^0 C for all fungi and all thermodynamic parameters for 3,4,5-TMBTS.

When the temperature increases beyond 37^0C, the antifungal effect decreases whereas the thermodynamic parameters still increase. At 39^0C and the lowest concentration (0.01%) of the compound the inhibitory effect is found to be 5.93% on *Rh*, 9.28% on *An*, 15.00% on *Af*, 6.66% on *As*, and 9.82% on *Aa*.. The thermodynamic parameters found to increase gradually with increasing temperature. The trend remains the same at higher concentrations (0.03 % and 0.05 %).

Conclusion

It is evident from the above study that the screened compound is fungitoxic against the all five fungi at all experimental concentrations. As the compound shows significant effect on all the five fungi, it can be suggested as a commercial fungicide. It is further concluded that the antifungal effect increases up to a certain limit with a slight increment in the thermodynamic parameters. After a certain limit the fungicidal toxicity decreases and at a particular temperature its value reduces to zero. The thermodynamic parameters follow the same trend, *i.e.* increase continuously.

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