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Thermal characterization of solid wastes

D. Prabhakarachary

Department of Physical Sciences, Kakatiya Institute of Technology and Science, Hasanparthy, Warangal-506 015, Andhra Pradesh, **INDIA**

Email: dpcnkd@gmail.com

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ABSTRACT

Nowadays biodegrable residential and market solid waste increasing enormously around globe. The maintenance of generated Wastage in Indian cities is essential as public health concern. Present study focused on residential and market biodegrable solid waste of two major cities in India. The thermal analysis data reveals that 9mg of biodegradable residential and market waste produces calorific value of 3713 and 4206 cal/g respectively. The thermal conductivities of residential and market wastes were 0.00868 and 0.0153 (Cal/cm/s/^{0}C).The experimental data from table ***(1)*** *shows the volatile content and C/N ration of both residential and market waste. The residential and market solid waste contain mainly a high compostable and low combustible matter (paper, plastic, leather, rubber and wood). The metal content is less than 1%, fine earth ashes are high partly due to the presence of sewage sludge and silts. Only the biodegradable mass was considered to be a source of energy whereas the other groups were considered for material winning. Generally, the waste, which has thermal conductivity, would produce more energy on combustion. Thermal conductivity of market waste is higher than that of residential waste. The calorific value obtained from residential waste is comparatively less than that of market waste. Thermogravimetry and differential thermal analysis were recorded for a few representative solid waste samples in order to known the effect of temperature on the mass stability of the solid wastes, volatility, phase transition if any, and the corresponding heat changes. The DTA/TG/DTG curves were recorded for a selected set of samples from Hyderabad and Warangal municipalities in aerial environment.*

Keywords: Residential solid waste, Market solid waste, calorific value, Thermal analysis.

INTRODUCTION

In the last one decade majority of countries have been focusing on maintenance of solid wastes generating in daily life. The term ‘waste’ implies that it is of no concern and is of no use to anyone. It is the term now used internationally to describe non-liquid wastes from Residential, trade, commercial, industrial and from the public services [1-4]. Only the biodegradable mass was considered to be a source of energy whereas the other groups were considered for material winning. Thermal conductivity and calorific value are the very important thermal properties of the wastes [5]. It does not need a specific mentioning that residential and market wastes are rich in organic content and hence in fuel value. However, the presence of inorganic materials such as soil, dust, metal pieces, etc. render the bulk of the solid waste low firing capacity [6-10]. Most of the heat generated by the combustion of organic content of the solid waste is fast absorbed by the highly thermal conducting inorganic contents. Hence, they require a high diffused and protracted activation energy scene [11].

MATERIALS AND METHODS

The thermal characterizations were carried out on TA Instrument Q10 for DSC, Q50 for TGA and DTA. Universal analysis 2000, Version 4.2 E package used for data analysis. The sample preparations were done on Al crucibles. The heat flow is 10 ^{0}C min^{-1}. Thermogravimetric, Differential thermal analysis (DTA) and Differential scanning calorimetric studies were recorded for a few representative solid waste samples in order to know the effect of temperature on the mass stability of the solid wastes, volatility, phase transitions, if any, and the corresponding heat changes.

RESULTS AND DISCUSSION

In figures 1 to 4**,** are shown some of the TGA curves recorded for a selected set of samples. The TGA of pure charcoal was taken as a reference. The TGA curves were found to be irreversible. In the inert atmosphere the weight of the solid wastes falls gradually from 60 ^{0}C to 120 ^{0}C and remains uniform then on till even up to 1000 ^{0}C. Loss of some of the adsorbed gases, gases that are produced in course of putrification and moisture is the reason for this steady but uniform fall in the mass. The mass rises marginally when chlorine gas is introduced. This is attributed to the adsorption of chlorine gas into the interstices and surfaces of the solid wastes. The adsorption of chlorine gas has observed to be decreasing with increasing temperature as indicated from the decreased mass gain upon administering chlorine gas at increasing temperatures. This is an expected surface phenomenon on the lines of Henry's laws.

Table 1: Characteristics of solid wastes

Parameter	**Residential Waste**	**Market Waste**
Wet Density (Tons m^{-3})	0.421	0.334
Dry Density (Tons m^{-3})	0.218	0.173
Volatile Matter (%)	45.65	60.80
Carbon (%)	31.85	18.34
Hydrogen (%)	4.10	3.25
Nitrogen (%)	1.4	0.37
Oxygen (%)	17.83	14.34
C / N Ratio	22.75	49.56
Calorific Value (cal./g)	3713	4206
Thermal Conductivity(Cal/cm/s/^{0}C)	0.00868	0.0153

In the chlorine environment, there is a mass raise in the temperature range of 250 to 500^{0}C. Subsequently the mass gain is marginal. The raise in mass is attributed to the formation of non-volatile halides of the metal and other halogen table moieties such as unsaturated organic sites. As expected, pure charcoal does not show any mass changes in the temperature range, investigated. In ambient aerial or oxygen environment, the TGA is similar to that observed in the inert atmosphere. However, the formation of some Non-Volatile oxides is less efficient than the formation of volatile oxides in the temperature region 300-900 ^{0}C, hence, there is a net fall in the weight with increasing temperature. The TGA curves were found to be irreversible.

Table 2: Thermal data of the Residential wastes

Sample	**TGA**			**DTG**		**DTA**	
	Start (^{0}C)	**End (^{0}C)**	**Cumulative weight change(%)**	**Tempe-rature (^{0}C)**	**Rate of weight change (^{0}C)**	**Tempe-rature (^{0}C)**	**Relative heat (µv)**
Hyderabad Residential Waste							
Event 1	96.0	112.5	-7.12	290.4	5.44	307.8	25.4
Event 2	112.5	227.5	-11.07	451.3	12.52	457.7	94.7
Event 3	227.5	349.0	-44.93	--	--	--	--
Event 4	349.0	461.9	-64.65	--	--	--	--
Event 5	461.9	516.2	-69.15	--	--	--	--
Warangal Residential Waste							
Event 1	95.0	134.2	-10.16	66.9	1.54	73.4	-3.5
Event 2	134.2	338.2	-53.95	286.1	11.10	299.1	36.2
Event 3	338.2	432.1	-76.68	412.0	12.99	336.0	32.5
Event 4	432.1	485.7	-85.76	434.0	6.79	422.9	102.1
Event 5	485.7	787.4	-88.24	--	--	444.5	97.8

Table 3: Thermal data of the market wastes

Sample	**TGA**			**DTG**		**DTA**	
	Start (^{0}C)	**End (^{0}C)**	**Cumulative weight change(%)**	**Tempe-rature (^{0}C)**	**Rate of weight change (^{0}C)**	**Tempe-rature (^{0}C)**	**Relative heat (µv)**
Hyderabad Market Waste							
Event 1	95.0	112.5	-8.53	101.0	1.75	102.00	-4.9
Event 2	112.5	221.1	-14.29	281.70	4.25	312.10	19.5
Event 3	221.1	353.4	-49.15	447.00	10.56	455.40	89.6
Event 4	353.4	461.9	-69.94	--	--	468.40	56.1
Event 5	461.9	511.8	-81.07	--	--	--	--
Warangal Market Waste							
Event 1	95.0	136.3	-10.56	66.9	1.61	303.5	31.4
Event 2	136.3	368.6	-54.40	283.9	6.85	446.7	90.6
Event 3	368.6	516.2	-83.49	436.2	10.74	461.9	86.5
Event 4	516.2	856.8	-87.88	594.7	2.31	470.5	61.4
Event 5	--	--	--	--	--	596.6	23.4

In ambient aerial or oxygen environment, the TGA is similar to that observed in the inert atmosphere. However, the formation of some Non-Volatile oxides is less efficient than the formation of volatile oxides in the temperature region 300-900 ^{0}C, hence; there is a net fall in the weight with increasing temperature. The TGA curves were found to be irreversible. The differential thermal analysis (DTA) also gave some interesting results. In figures 1-4, are shown the DTA/TG/DTG curves of a residential and a market solid wastes each from Hyderabad and Warangal municipalities in aerial environment the corresponding data included in tables **(2)** and **(3)**

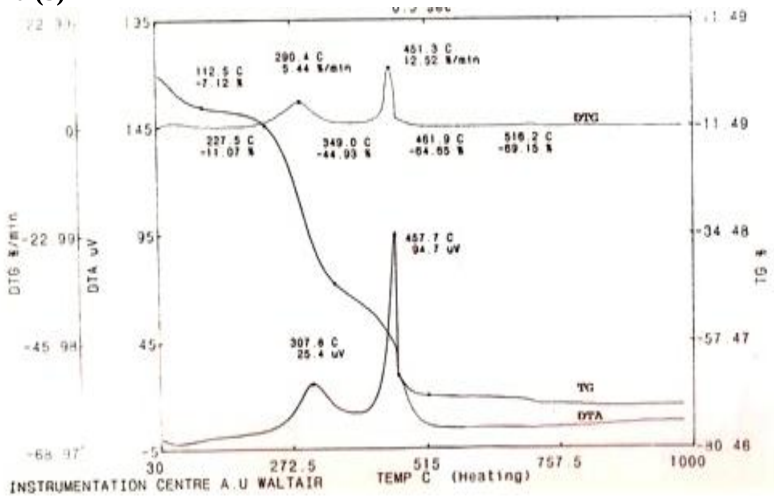

Figure 1: Thermogravimetric, Differential Thermal and DSC analysis of Hyderabad Residential solid waste.

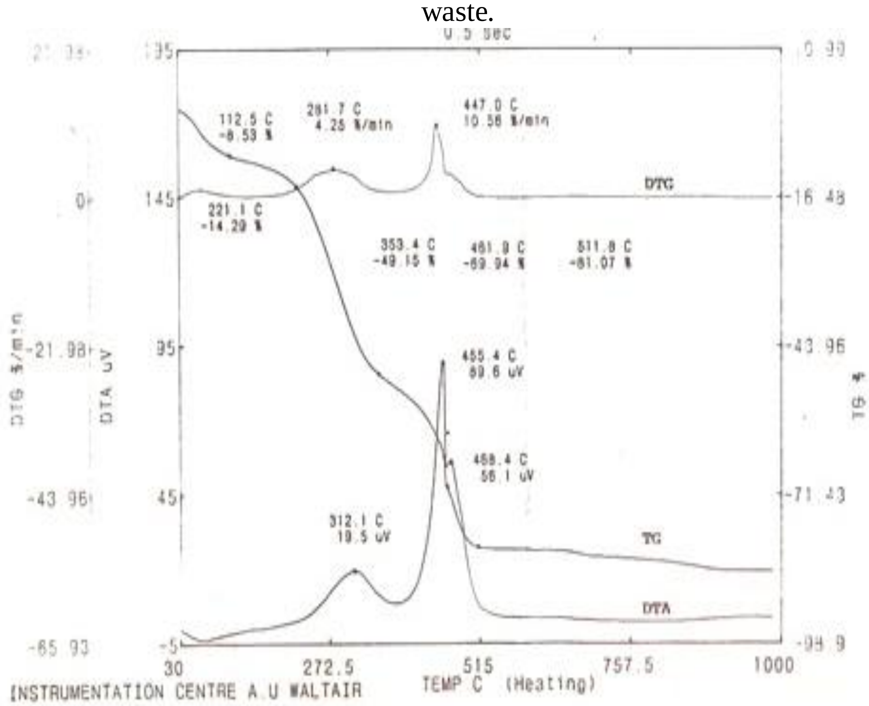

Figure 2: Thermo gravimetric, differential thermo gravimetric and differential thermal analysis of a typical Hyderabad market solid waste

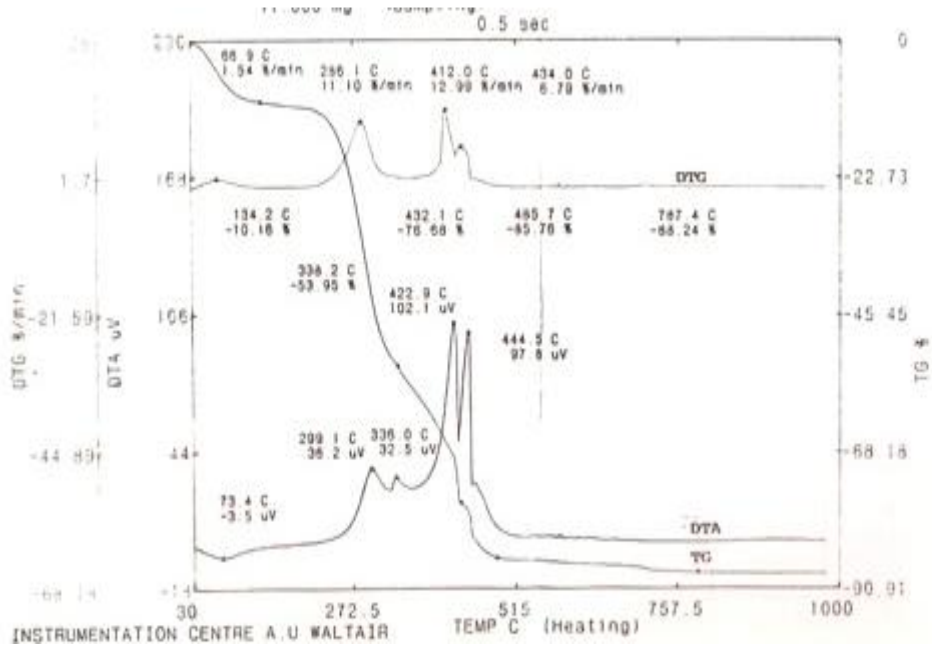

Figure 3: Thermo gravimetric, differential thermo gravimetric and differential Thermal analysis of a typical Warangal Residential solid waste

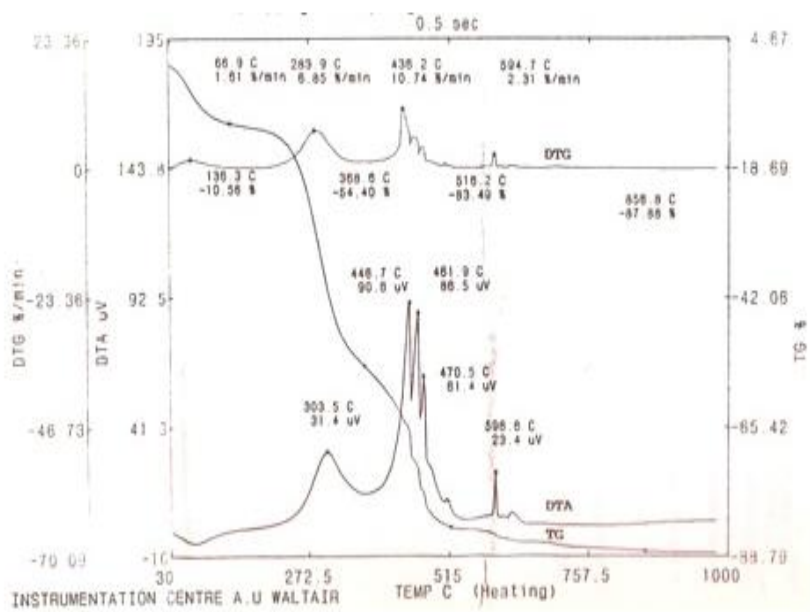

Figure 4: Thermo gravimetric, differential thermo gravimetric and differential thermal analysis of a typical Warangal market solid waste

Hyderabad market waste records an 8.50% weight loss in the range 112-240 ^{0}C with a rate of 14.29% weight loss per minute centigrade at 221 ^{0}C. This is attributed to the loss of moisture. Since the temperature at which the weight loss commenced is slightly higher than 100 ^{0}C, it may be concluded that the water molecules are weakly bound and not simply held. Since the mass of the sample handled is 9.1

mg, the absolute mass loss is 9.1x8.55/100 = 0.7762 g and this corresponds to 0.04312 moles of water. The process is endothermic with a relative heat loss corresponding to 5 µv mol^{-1}. Between the temperature range 250-355 ^0C, the loss is to the extent of 41 % (altogether ~ 49%) centered at 282 ^0C. This is attributed to the formation of volatile oxides such as SO_2 and SO_3. At ~ 310 ^0C, this sample exhibits an exothermic thermodynamic event with a heat loss corresponding to 19.5 µv of relative detector units. Since there is a weight loss associated with this event, we attribute it to the formation of a volatile oxide such as sulfur dioxide from the sulfur contents of the solid waste sample. There is a pair of exothermic processes again at ~ 455 and ~ 470 ^0C with cumulative weight losses of 69.94 and 81.07 % respectively. The process at 455 ^0C is more exothermic than that at 470 ^0C and it is suggested to be due to the formation of carbon dioxide from the organic matter and the latter to that of nitrogen dioxide from the nitrogen content of the solid waste.The thermal data for other representative samples are provided in the Tables 1-2**.**

APPLICATIONS

In current scenario production of energy from biodegradable solid waste has a great importance in environmental and public health aspects. Here, the calorific value of Residential and market biodegradable solid wastes are more compare to average calorific of solid wastes.

CONCLUSIONS

It is clear that the market yard solid waste has the higher fuel content than the residential waste. This is attributed to the fact that market yards have greater organic constituents than the Residential samples.

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