International Journal of Theoretical & Applied Sciences, 9(1): 60-66(2017)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Thermo Gravimetric Analysis of Cellulose Extracted from Wheat Straw of Himachal Pradesh, India

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(Received 18 April, 2017 accepted 12 June 2017)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Cellulose was separated from the farming deposit, Wheat Straw by chemical methods to inspect their potential for use in various applications. Wheat Straw samples taken from four different districts of Himachal Pradesh, India such as Bilaspur, Hamirpur, Kangra and Mandi. Wheat Straw sample taken from Bilaspur, Hamirpur, Kangra and Mandi due to very less use other than animal feeding and the rest of the Wheat straw is burned. The constituents of Wheat Straw samples were lignin, cellulose and hemicellulose. To assess the suitability of agricultural remaining for the extraction of cellulose and cellulose derivatives. Cellulose was extracted by TAPPI method T-203-cm-99. The extracted Cellulose was analyzed by Thermogravimetric analysis (TGA). The technique can analyze materials that exhibit either mass loss or gain due to decomposition or loss of volatiles component such as moisture. TGA technique has used to check the thermal stability of extracted Cellulose of Wheat Straw and compared the results with the standard Cellulose powder (Cellulose powder pract, Central Drug House (p) Ltd. New Delhi). All extracted Cellulose samples showed good agreement for thermal stability with Standard Cellulose. This analysis shows that Wheat straw extracted cellulose can be used for the preparation of cellulose derivatives.

Keywords: Wheat Straw, TAPPI, Cellulose, TGA, Volatile and Himachal Pradesh.

I. INTRODUCTION

Generally wood is more costly than non-wood. Wood is the vital wellspring of Cellulose for manufacturing paper. Likewise with the enlargement of paper ventures in the nation, mash containing plants are being utilized to a calculable level (Walia, Y. K. 2013). Wood is difficult to transport yet issues with non-wood plants are gathering, stockpiling and high fiery debris content (Kumar, S. and Walia, Y. K. 2014). The yearly renewable farming remainder signifies a plentiful, cheap and readily accessible resource of able to be renewed cellulosic materials. Consistently, cultivating and rural agreement create a large number of huge amounts of stays, for example, corn cobs and husks, groundnut shells, rice and wheat straw, banana shoot and sugar beet (Ruan *et al.,* 1996). The farming buildups can be achieved at a low cost from a decent variety of sources, however the substance and nature of the three noteworthy basic polymeric segments (lignin, cellulose and hemicellulose) rely upon the sort of material (Taherzadeh and Niklasson, 2004). Their usages are pulling in expanded interests the world over, especially for the generation of novel materials for ecologically well-disposed mechanical applications after concoction change (Pandey et al., 2000; Richardson and Gorton, 2003).The nearby chemical analysis of a variety of uncooked materials exhibit that nearly all wood enclose approximately 30-40% non-cellulose component which consist of Ash content, Lignin, Extractives etc. (Walia, Y. K. *et al.,* 2009).

Cellulose, one of the significant segment of lignocellulosic biomass, is a polydispersity polymer of high atomic weight and contained long chains of D-glucose units combined by β-1, 4-glucosidic bonds (Krassig 1985). Huge advances in cellulosic changes and the resultant creation of derivatives with one of a kind substance, physical and physiological properties, have drastically expanded enthusiasm for Cellulose look into over the previous decade. This restored concentrate on Cellulose and its derivatives has brought about the creation of cellulose and its derivatives with shifted physicochemical and utilitarian properties (Azubuike et al. 2012; Ohwoavworhua, and Adelakun, 2005). Celluloses from annual plants have different chemical composition and structures (Han, J. S. and Rowell, J. S. 1996). Biodegradable polymers are materials that undergo bond scission in the backbone of a polymer through chemical, biological and physical forces in the environment at a rate which leads to fragmentation or disintegration of the plastics (Griffin G. J. L.1994). Wheat straw has a content of cellulose 34 % which make it suitable for the preparation of methylcellulose (Clean Washington Centre and Domtar Inc. 1997).

Among different utilizations, cellulose is generally utilized as a crude material to set up various excipients. Cellulose is portrayed as sanitized, halfway depolymerized Cellulose arranged by regarding alpha cellulose got as a mash from stringy plant material with mineral acids (Brittain *et al.,* 1993). Alpha cellulose signifies high quality, high molecular mass Cellulose content, the β-cellulose signifies that of low quality Cellulose and the γ-cellulose comprises predominantly of hemicellulose. Industrially accessible cellulose is gotten from profoundly exorbitant hard wood and furthermore filtered cotton. A few strategies secured by licenses have been depicted in the literature for the produce of Cellulose powder. The requirement for less expensive wellsprings of Cellulose has prompted the examination of other lignocellulosic materials in light of horticultural buildups (Paralikar and Bhatawdekar, 1988; Uesu et al., 2000; El-Sakhawy and Hassan, 2007; Ejikeme, 2008, Ohwoavworhua *et al.,* 2009; Suesat and Suwanruji, 2011). The synthetic piece and physical structure of Cellulose depend essentially on the qualities of the crude material utilized and the assembling conditions (Landin *et al.,* 1993). Accordingly, a few sorts of Cellulose are accessible in the market with various physicochemical and warm properties, and in this way, they will have diverse practical parameters and applications. These distinctions can influence their useful properties when utilized in pharmaceutical plans. Aside from advancing the manufacturability of medication item, excipients are relied upon to ensure the strength and bioavailability of the medication substance from the medication item. As an outcome, their portrayal must go past the basic tests for character, immaculateness and quality as endorsed when all is said in done by the Pharmacopeia monographs. Full physical portrayal of strong materials is currently made conceivable with the assistance of high determination explanatory procedures thermogravimetric investigation (TGA) and differential checking calorimetry (DSC)) on the atomic, particulate and mass levels (Pifferi *et al.,* 1999). TGA examinations are regularly embraced to clear up the strength, similarity and advances of period of the excipients. As a component of the on-going endeavors to grow ease neighborhood crude materials from lignocellulosic materials (rural deposits) with wanted physicochemical properties for the mechanical applications, we have in this investigation announced some physical properties of Cellulose extracted from Wheat Straw and furthermore assess their basic and warm properties. The properties of extracted cellulose from Wheat straw were compared with a Standard Cellulose which was purchased from Cellulose powder pract. Central Drug House (p) Ltd. New Delhi.

II. MATERIALS AND METHODS

A. Material

Wheat Straw was taken from local agricultural area of Himachal Pradesh, India from four different districts Bilaspur (BLP), Hamirpur (HMR), Kangra (KNG) and Mandi (MND). Those samples taken from Himachal Pradesh by the reason very less use other than animal feeding. Wheat Straw also burning in the field due to which decrease the soil fertility. Wheat straw samples were dried in sunlight. After drying in sunlight, it was grind and sieved under mesh screens. After that, Wheat straw powder was dried in oven at 105ºC for 3hrs and stored at room temperature in air tight container.

B. Method

Cellulose was extracted from Wheat Straw by TAPPI method, T-203-cm-99. 5gm holocellulose was prepared from oven dry dust which is obtained from Wheat Straw. It was treated with 30ml of 17.5 percent NaOH at 20ºC. After standing for 5minutes duration with 10ml portions with steady rousing, the sample mixture is macerated with flattened glass rod. After 30 minutes, 75ml of uncontaminated water was added at 20ºC with stirring and then the materials was acceptable to place for 30 minutes, 100ml of pure water at 20ºC was added again and the contents were kept for 30 minutes more in contact with alkali. The remains was filtered and then soaked in 8.3% NaOH for few minutes and drained by suction. The residue was rinse with 250ml of pure water and saturated in 2N acetic acid for 5 minutes. In conclusion mixture was rinsed with 400ml of pure water and dehydrated in oven at 105±1ºC.

The alpha-cellulose content was determined on Oven Dry (O.D.) basis as:

$$\text{Percentage of alpha - cellulose content} = \frac{w \times 100}{W}$$

Where; w = weight in gram of residue and W = weight in gram of holocellulose taken for test.

The cellulose samples obtained via above process were labeled as CBLP, CHMR, CKNG and CMND. The thermal properties of the cellulose powders obtained from the Wheat straw were compared with that of Standard Cellulose (SC) powder (Cellulose powder pract, Central Drug House (p) Ltd. New Delhi). TGA studies were performed using NETZSCH STA 409 C/CD instrument at a heating rate of 50 to 500ºC and DTA/TG crucible alumina pot as indication under constant run of nitrogen 50mL/min. A 10mg sample was utilized and the mass decreases were recorded from room temperature to 500ºC.

III. RESULTS AND DISCUSSION

Four Wheat Straw extracted Cellulose samples (CBLP, CHMR, CKNG, CMND) were obtained, and their characteristic were compared with Standard Cellulose (SC).

The thermograms in Figures 1 to 5 show that all Cellulose samples follow similar degradation patterns. The numerical data from the TGA experiments (Table 1) also reveal that the Cellulose samples derived from the Wheat Straw have similar thermal properties with the SC. TGA thermo-gram of SC sample showed two step thermal degradation event. The sample started to degrade thermally at around 54.9ºC and it ended at around 499.9ºC. The SC sample lost 57.73% of its original weight during this event. The SC sample had lost 57.73 and 9.70% in the first and second step of degradation, respectively of their total original weight during this process. The major weight loss was in the first step of degradation 57.73%, which occurred in the temperature range of 54.9–350ºC, which was complied with the TGA thermo-gram. The residual mass of SC is 28.81% at temperature 499.9ºC.

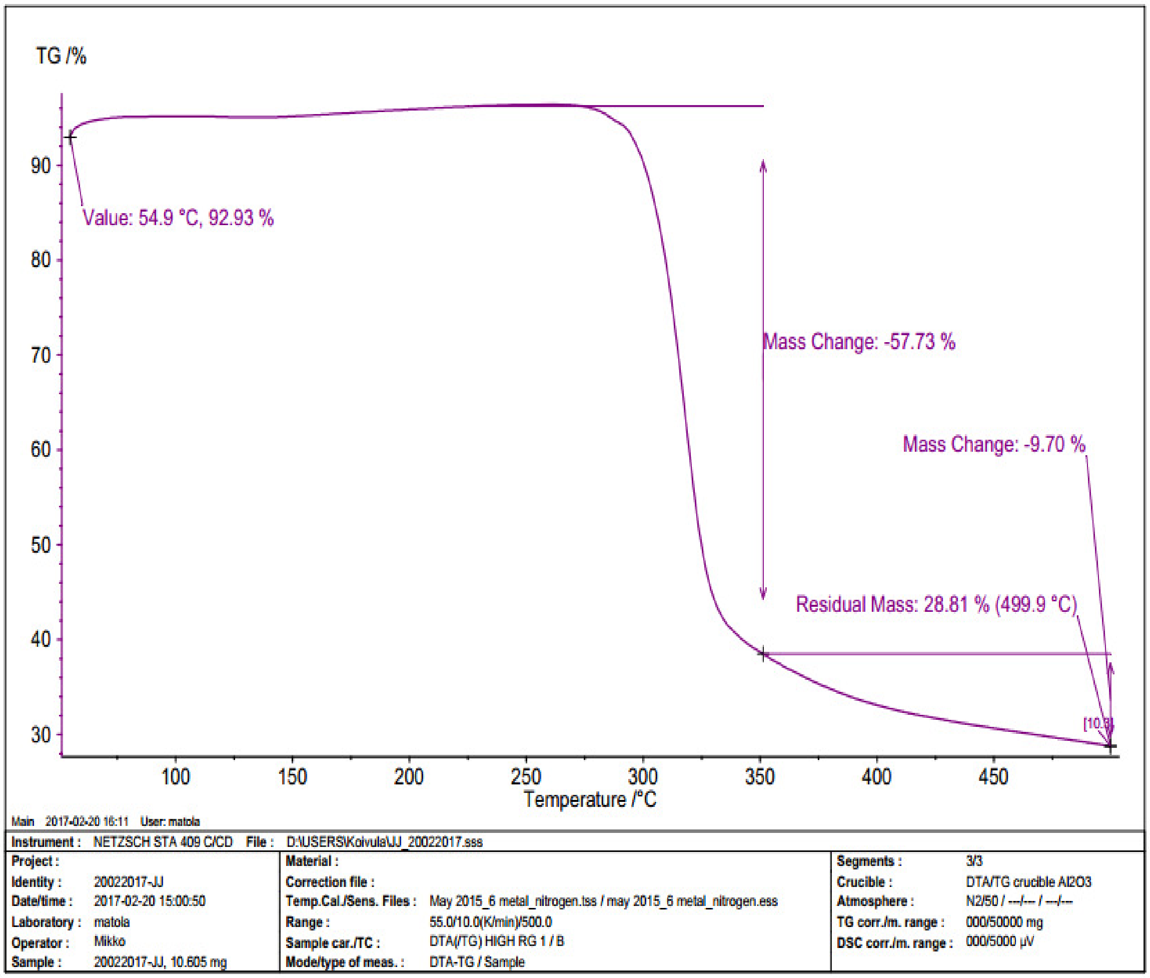

Fig. 1. Thermo-gravimetric Analysis (TGA) of Standard Cellulose (SC).

The sample CBLP started to degrade thermally at around 55.3ºC and it ended at around 500ºC. The CBLP sample lost 61.64% of its original weight during this event. The CBLP sample had lost 61.64 and 7.84% in the first and second step of degradation, respectively of their total original weight during this process in figure. The major weight loss was in the first step of degradation 61.64%, which occurred in the temperature range of 55.3–350ºC, which was complied with the TGA thermo-gram. The residual mass of CBLP is 22.75% at temperature 500ºC.

The sample CHMR started to degrade thermally at around 54.9ºC and it ended at around 500ºC. The CHMR sample lost 60.50% of its original weight during this event. The CHMR sample had lost 60.50 and 6.97% in the first and second step of degradation, respectively of their total original weight during this process in figure. The major weight loss was in the first step of degradation 60.50%, which occurred in the temperature range of 54.9–350ºC, which was complied with the TGA thermo-gram. The residual mass of CHMR is 24.48% at temperature 500ºC.

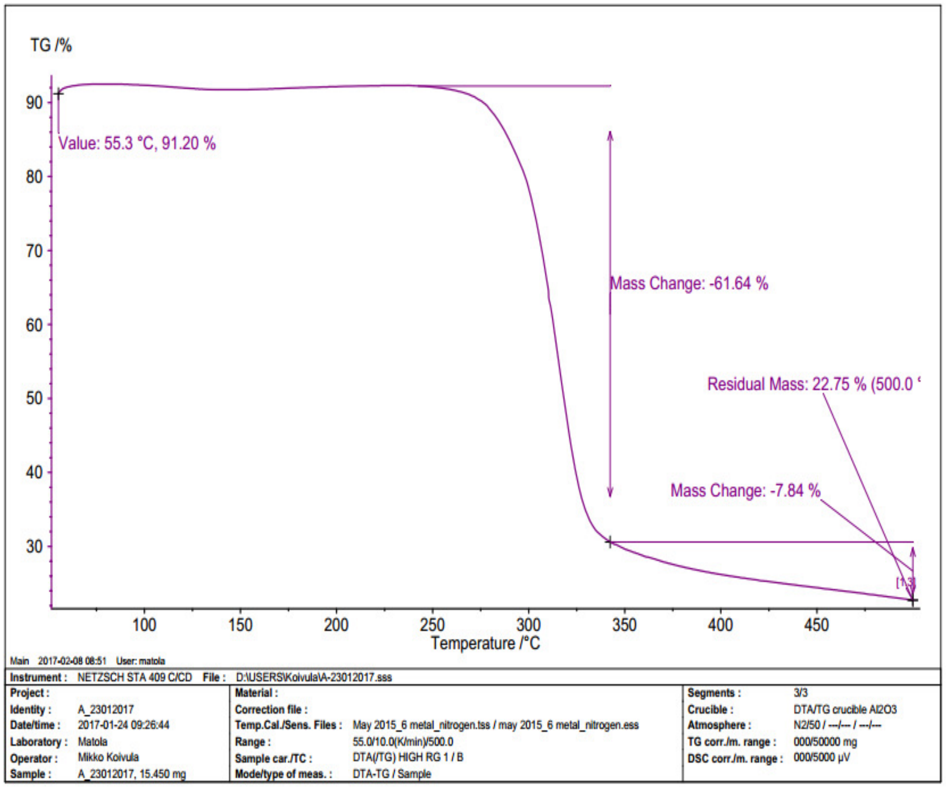

Fig. 2. Thermo-gravimetric Analysis (TGA) of extracted Cellulose from Bilaspur District Wheat Straw (CBLP).

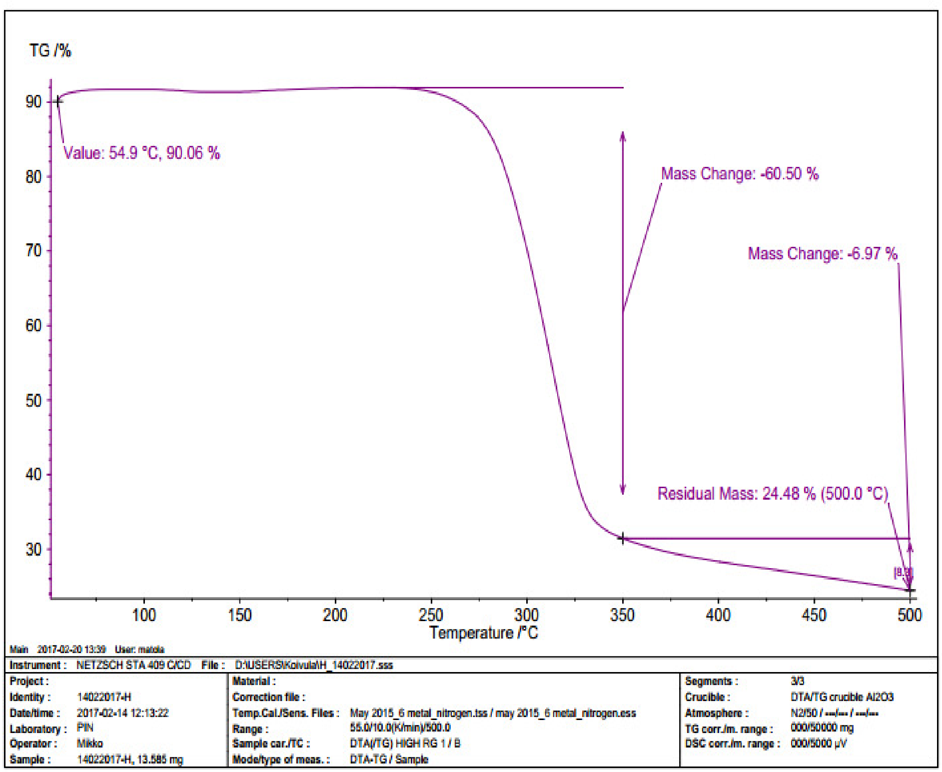

Fig. 3. Thermo-gravimetric Analysis (TGA) of extracted Cellulose from Hamirpur District Wheat Straw (CHMR).

Table 1: Thermo-gravimetric Analysis (TGA) of Cellulose and extracted Cellulose from Wheat Straw.

Sample/ parameters	Temp. ºC (TG/ %)	Mass change%	Residue mass % (temp. ºC)
SC	54.9ºC (92.93%)	67.43	28.81(499.9ºC)
CBLP	55.3ºC (91.20%)	69.48	22.75 (500 ºC)
CHMR	54.9ºC (90.06%)	67.47	24.48 (500 ºC)
CKNG	55.4ºC (92.48%)	67.08	26.33 (500ºC)
CMND	55.6ºC (94.63%)	66.87	26.91 (500ºC)

The CHMR sample showed a considerable same degradation temperature (i.e. 350°C) as compared to the SC sample. The comparative evaluation of the maximum temperature showed same in thermal stability of treated CHMR as compared to SC.

The sample CKNG started to degrade thermally at around 55.4ºC and it ended at around 500ºC. The CKNG sample lost 60.10% of its original weight during this event. The CKNG sample had lost 60.10 and 6.98% in the first and second step of degradation, respectively of their total original weight during this process in figure. The major weight loss was in the first step of degradation 60.10%, which occurred in the temperature range of 55.4–350ºC, which was complied with the TGA thermo-gram. The residual mass of CKNG is 26.33% at temperature 500ºC.

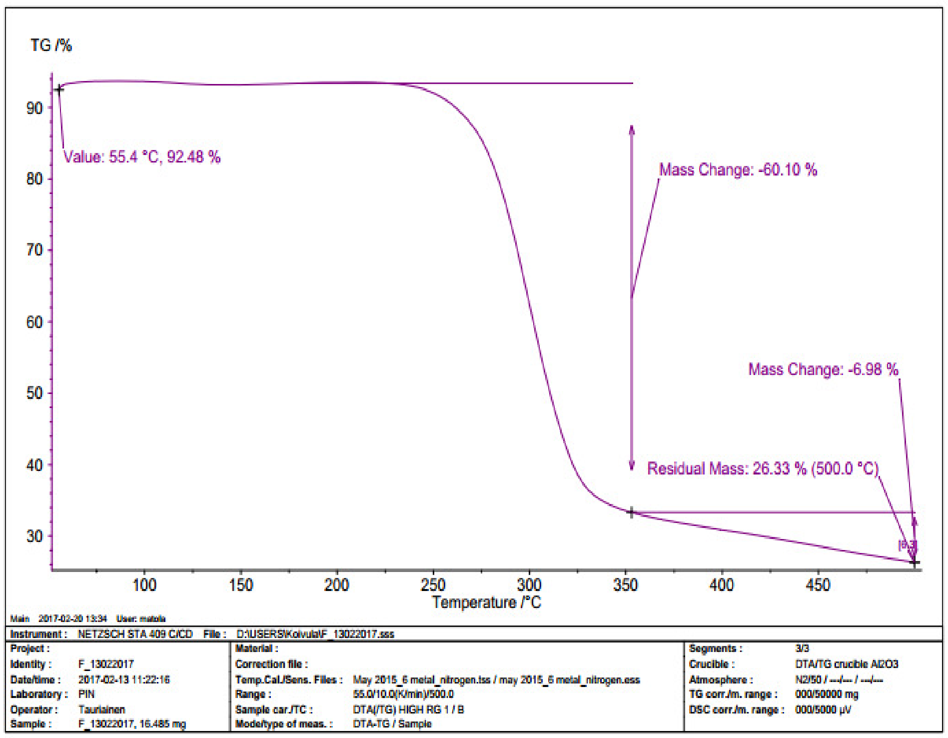

Fig. 4. Thermo-gravimetric Analysis (TGA) of extracted Cellulose from Kangra District Wheat Straw (CKNG).

The sample CMND started to degrade thermally at around 55.6ºC and it ended at around 500ºC. The CMND sample lost 58.68% of its original weight during this event. The CMND sample had lost 58.68 and 8.19% in the first and second step of degradation, respectively of their total original weight during this process in figure. The major weight loss was in the first step of degradation 58.68%, which occurred in the temperature range of 55.6–350ºC, which was complied with the TGA thermo-gram. The residual mass of CMND is 26.91% at temperature 500ºC.

The CMND sample showed a considerable same temperature (350ºC) as compared to the SC sample. The comparative evaluation of the maximum temperature showed same thermal stability of treated CBLP and CMND as compared to SC.

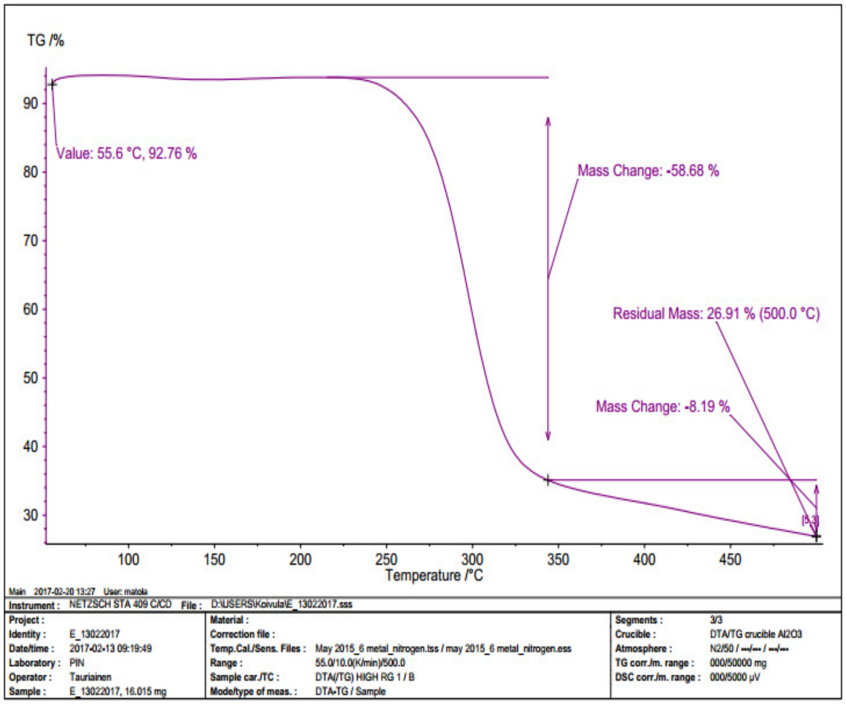

Fig. 5. Thermo-gravimetric Analysis (TGA) of extracted Cellulose from Mandi District Wheat Straw (CMND).

CONCLUSION

The cellulose powders obtained from the Wheat Straw compared favorably with the commercial brand of cellulose powder (Cellulose powder pract, Central Drug House (p) Ltd. New Delhi), in terms of their thermal properties. However, all the cellulose samples obtained from Wheat Straw exhibited same thermal stability. Moreover, among the cellulose samples obtained from Wheat Straw, thermal analysis studies showed that the samples had the highest residual char weight at 500°C and the lowest value of inflection slope. TGA thermo-gram of all samples showed two step thermal degradation event. The sample started to degrade thermally at around 50ºC and it ended at around 500ºC. The SC sample lost 57.73% of its original weight during this event and other samples lost weight CBLP 61.64%, CHMR sample lost 60.50%, CKNG sample lost 60.10% and CMND 58.68% respectively. The residual mass percentage of SC and extracted cellulose samples (CBLP, CHMR, CKNG and CMND) is 28.81, 22.75, 24.48, 26.33 and 26.91 respectively in Table 1. So, Wheat Straw as a waste material, it would ultimately be a cheaper source of the costly brand of Cellulose.

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