

Study on Modified Pineapple Leaf Fiber

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ABSTRACT

On the analysis of TG, DTG and DTA curves for untreated and treated PALF, we have got the thermal stability of different modified fiber. Thermal stability of raw fiber is high but acrylonitrile (AN) enhanced the stability in case of bleached PALF. Thermal stability of acid & 25% NaOH treated fiber is low & high respectively from raw fiber. Thermal stability is increased by increasing the concentration of sodium hydroxide.

Keywords: PALF (Pineapple Leaf Fiber), Acrylonitrile (AN), Thermal analysis, TG, DTG, DTA

1. INTRODUCTION

Agriculture is an important sector in Bangladeshi economy. Traditionally, agricultural materials have been shipped away for processing, or disposed of postharvest. Diversification of the industry is crucial in encouraging economic stability and growth. Value-added processing would help in agricultural diversification. Pineapple Leaf Fiber (PALF), the subject of the present study, is thermal effect on pineapple leaf fiber.



Picture 1. Pineapple (*Ananas comosus*) Plant

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A polymer is a versatile material. In the present era of science is the most promising and comprehensive field. Development of polymer is a continuous process for achieving polymer in a specific application under certain environmental condition [1]. The bombardment of the invention of different polymer field is increased day by day. The natural polymer is biodegradable, abundantly available, and easily decomposable in the environment and eco-friendly [2]. The polymer materials that are biodegradable are now enjoying considerable popularity, especially from the standpoint of environmental protection [3].

2. EXPERIMENTAL PROCEDURE

2.1 Raw Materials

Picture 1 shows *Ananas Comosus* plant and from which the fiber is collected. These

fibers are comprised of vascular systems, the cells are small and bound together by pectin's and for that reason this fibers have widespread uses. The leaves are cut at the base, rolled and keep under water for some days to scrape away other mushy tissues from the fibers. The fibers are then washed with a lot of clean water and then dried in the closed place. This gives fibers which are subjected for investigation.

Local Name: Pineapple

Scientific Name: *Ananas Comosus*

Family: Bromeliaceae

3. THERMAL ANALYSIS

3.1 Differential Thermal Analysis (DTA)

The technique of DTA is an important tool to study the structural and phase changes occurring both in solid and in liquid materials during heat treatment. These changes may be due to dehydration, transition from one crystalline form to another, destruction of crystalline structure, melting, oxidation, decomposition, degradation temperatures, etc, DTA is a process of accurately measuring the difference in the temperature between a thermocouple embedded to a sample and a thermocouple in a standard inert material such as aluminum oxide while both are being heated at a uniform rate [4]. The principal of DTA consists of measuring heat changes associated with the physical or chemical changes occurring when any substance is gradually heated. The thermocouple (platinum-platinum rhodium 13%) for DTA is incorporated at the end of each of the balance beam ceramic tubes, and the temperature difference between the holder on the sample side and the holder on the references side is detected. This signal is amplified and becomes the temperature difference signal used to measure the thermal change of the sample. These differences of temperatures appear because of the phase transitions or chemical reactions in the sample involving the evolution of heat and are known as exothermic reaction or absorption of heat known as endothermic reaction. The

exothermic and endothermic reactions are generally shown in the DTA traces as positive and negative deviations respectively from a base line. So DTA offers a continuous thermal record of reactions in a sample. The areas under the bands or peaks of DTA spectra are proportional to the amount of heat absorbs or evolved from the sample under investigation, where temperature and sample dependent thermal resistance are the proportionality factors. Thus DTA is needed primarily for the measurement of transition temperature.

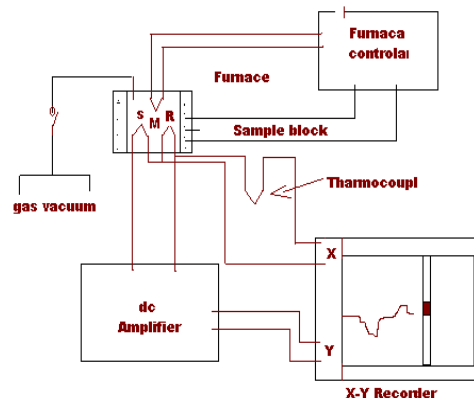


Figure 1. Schematic diagrams showing different part of a DTA apparatus

3.2 Differential Thermo Gravimetry (DTG)

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DTG stands for Differential Thermo Gravimetry. If not the weight itself rather the first derivative of the sample weight with respect to time at constant temperature or with respect to temperature at constant value of heating is determined then this procedure is termed as DTG.

3.3 Thermo Gravimetric Analysis (TGA)

The TGA is a special branch of thermal analysis, which examines the mass change of a sample as a function of temperature in the scanning mode or as a function of time in the isothermal mode. Not all thermal events bring about a change in the mass of the sample (for example melting, crystallization or glass transition), but there are some very important exceptions which

include absorption, sublimation, vaporization, oxidation, reduction and decomposition. The TGA is used to characterize the decomposition and thermal stability of materials under a variety of conditions, and to examine the kinetics of the physico-chemical process occurring in the sample. Sample weight changes are measured as described in figure.

Figure shows the sample balance beam and reference balance beam are independently supported by a driving coil/pivot. When a weight change occurs at the beam end, the movement is conveyed to the opposite end of the beam via the driving coil/pivot, when optical position sensors detect changes in the position of a slit. The signal from the optical position sensor is sent to the balance circuit. The balance circuit supplies sufficient feedback current to the driving coil so that

the slit returns to the balance position. The current running to the driving coils to the sample side and the current running to the driving coil on the reference side is detected and converted into weight signals.

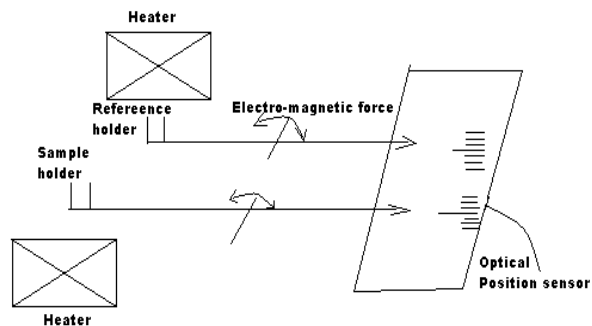


Figure 2. Principal of TGA measure

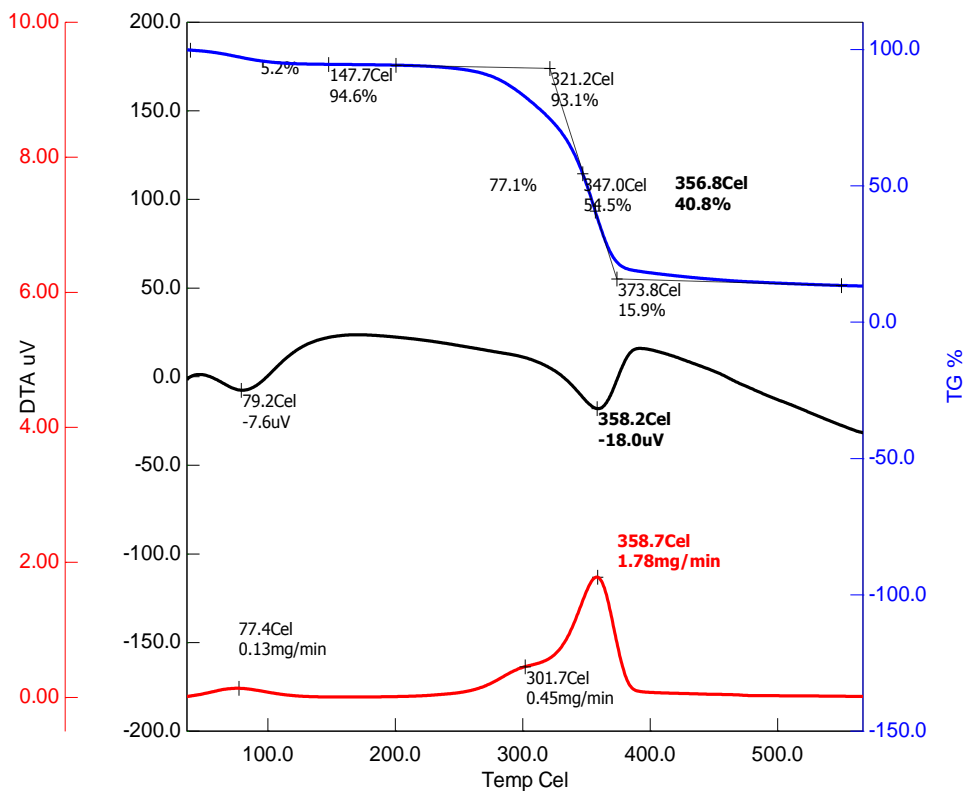


Figure 3. TG, DTA and DTG curves of raw pineapple leaf fiber

4. RESULTS & DISCUSSION

4.1 TG, DTA & DTG curves of raw pineapple leaf fiber

Figure 3 shows that TG, DTA and DTG of raw PALF. The TG curve shows that initially 5.2% loss corresponded to moisture content. Then the mass is decreased initially as slow rate and finally the rate increased. Light substances have removed first than the heavy one.

Two endothermic DTA peaks at 79.2°C, 358.2°C are obtained. The 1st peak at 79.2°C due to the removal of moisture & 2nd peak for degradation of fiber.

Three DTG peaks are also found at 77.4°C, 301.7°C and 358.7°C correspond to light & heavy material.

DTG curve of raw PALF depicts that the maximum degradation occurs at the temperature 358.7°C with the rate of 1.78 mg/min.

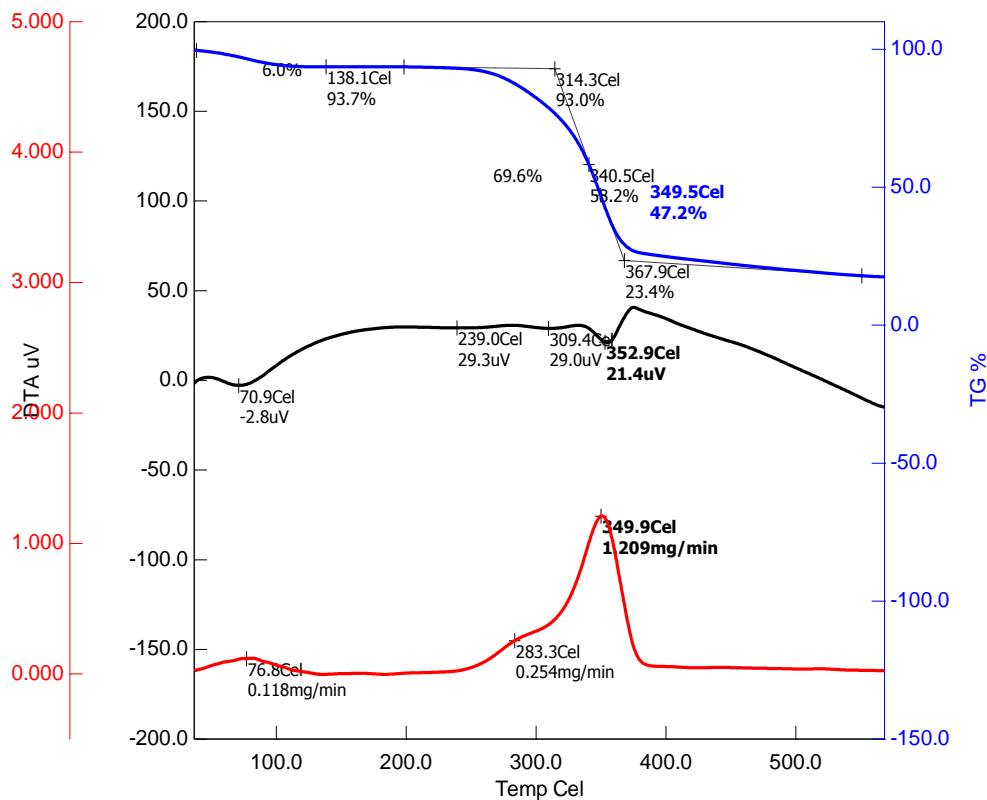


Figure 4. TG, DTA and DTG curves of scoured pineapple leaf fiber

4.2 TG, DTA and DTG curves of scoured pineapple leaf fiber

Fig.4 shows that TG, DTA and DTG of scoured PALF. The TG curve shows an initial 6% loss corresponds moisture content. The mass is losing initially at slower rate

than it ended. Light substances have removed first than the heavy material.

Four endothermic DTA peaks 70.9°C, 239°C, 309.4°C and 352.9°C are obtained. The 1st peak at 70.9°C is due to removal of moisture. 4th peak is for degradation.

Three DTG peaks are also found at 76.8⁰ C, 283.3⁰C and 349.9⁰C that corresponded to light & heavy material. DTG curve of

scoured PALF depicts that the maximum degradation has occurred at the temperature 349.9⁰ C with the rate of 1.209 mg/min.

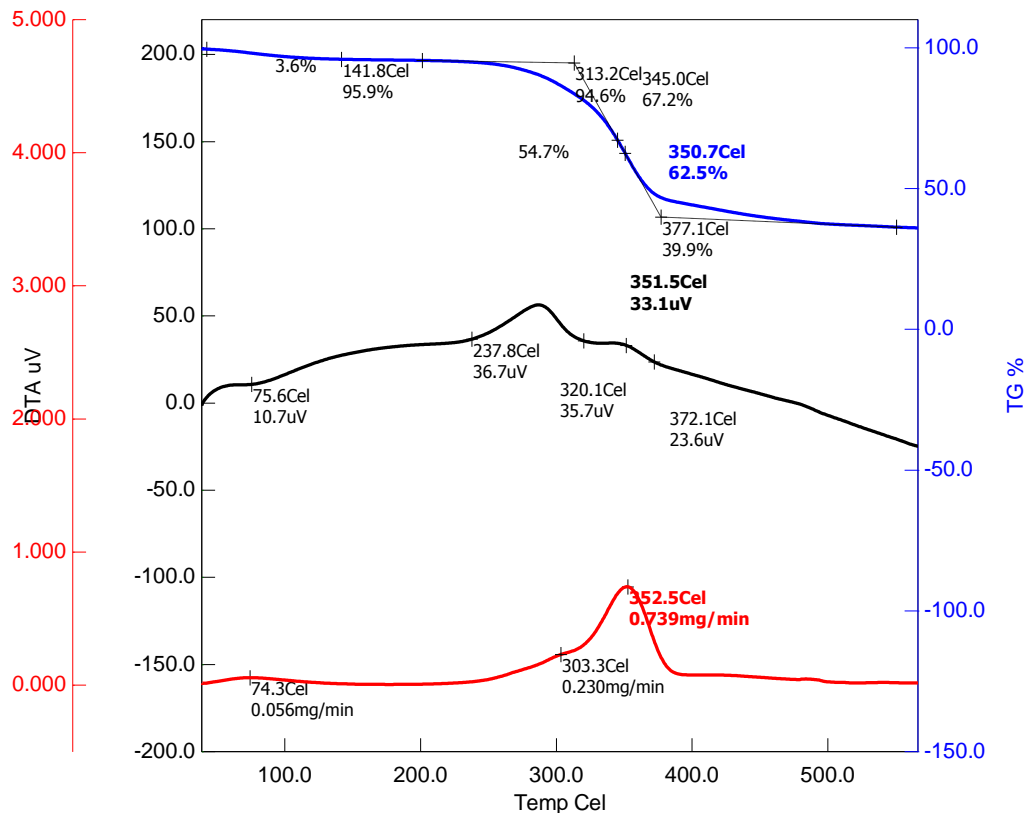


Figure 5. TG, DTA and DTG curves of a grafted pineapple leaf fiber

4.3 TG, DTA and DTG curves of AN grafted pineapple leaf fiber

Fig.5 shows that TG, DTA and DTG of a grafted PALF. The TG curve shows an initial 3.6% loss for moisture content. The mass is losing initially at slower rate than it ended. Light substances have removed initially than heavy material.

Four endothermic DTA peaks 75.6⁰C, 237⁰C, 320.1⁰C and 372.1⁰C are obtained. The 1st peak at 75.6⁰ due to removal of moisture. 4th peak for degradation.

Three DTG peaks are also found at 74.8⁰ C, 303.3⁰C and 352.5⁰C which corresponded to light and heavy material. DTG curve of scoured PALF depicts that the maximum degradation occurred at the temperature 352.5⁰ C with the rate of 0.739 mg/min.

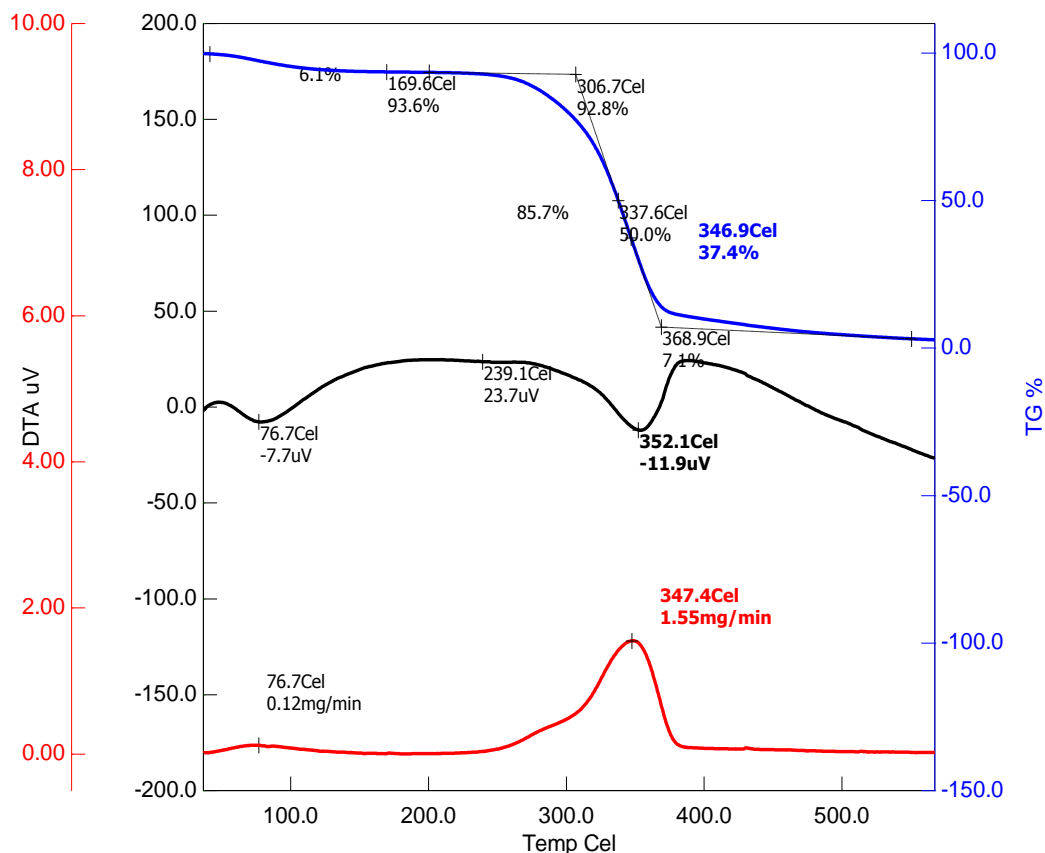


Figure 6. TG, DTA and DTG curves of bleached pineapple leaf fiber.

4.4 TG, DTA and DTG curves of bleached pineapple leaf fiber

Fig.6 shows that TG, DTA and DTG of bleached PALF. The TG curve shows an initial 6.1% loss corresponds moisture content. The mass is losing initially at slower rate than it ended. Light substances have removed initially than heavy material.

Three endothermic DTA peaks 76.7°C, 239.1°C and 352.1°C are obtained. The 1st peak at 76.7°C due to removal of moisture. 3rd peak is for degradation.

Two DTG peaks are also found at 76.7°C and 347.4°C which are corresponds to light and heavy material respectively. DTG curve of scoured PALF depicts that the maximum degradation at the temperature 347.4°C with the rate of 1.55 mg/min.

4.5 Comparison (DTA & DTG) of Raw, Bleached, Scoured & AN grafted fiber

From above curves it may conclude that the degrade temperature for Raw, Bleached, Scoured and AN grafted PALF are respectively 358.7°C, 347.4°C, 349.9°C and 352.5°C where maximum temperature of raw fiber is 358.7°C. Here we may found that maximum degraded temperature of raw fiber is the highest and the lowest for bleached fiber. Due to bleach most of the lignin, pectic matters, waxes etc have loosed so thermal stability reduced. In case of grafted fiber the temperature of maximum degradation more than raw fiber because of Acrylonitrile enhanced the thermal stability of bleached PALF.

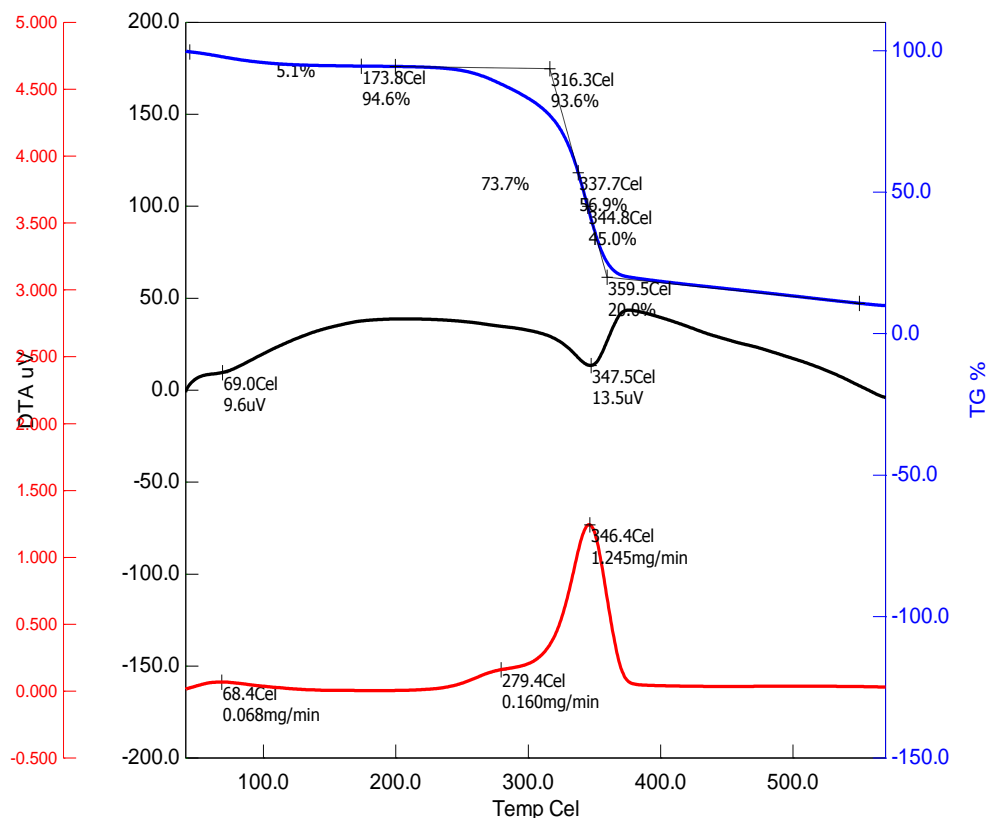


Figure 7. TG, DTA and DTG curves of 5% CH₃COOH treated fiber

4.6 TG, DTA and DTG curves of 5% CH₃COOH treated fiber

Fig.7 shows that TG, DTA and DTG of 5% CH₃COOH treated PALF. The TG curve shows an initial 5.1% loss corresponds to moisture content. Then the mass is losing initial slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 69^oC, 347.5^o C are

obtained. The 1st peak at 69^o C is due to removal of moisture. 2nd peak is for degradation. Three DTG peaks are also found at 68.4^o C, 279.4^oC and 346.4^o C which are corresponds to light and heavy material respectively. DTG curve of 5% CH₃COOH treated PALF depicts that the maximum degradation occurs at the temperature 346.4^o C with the rate of 1.245 mg/min.

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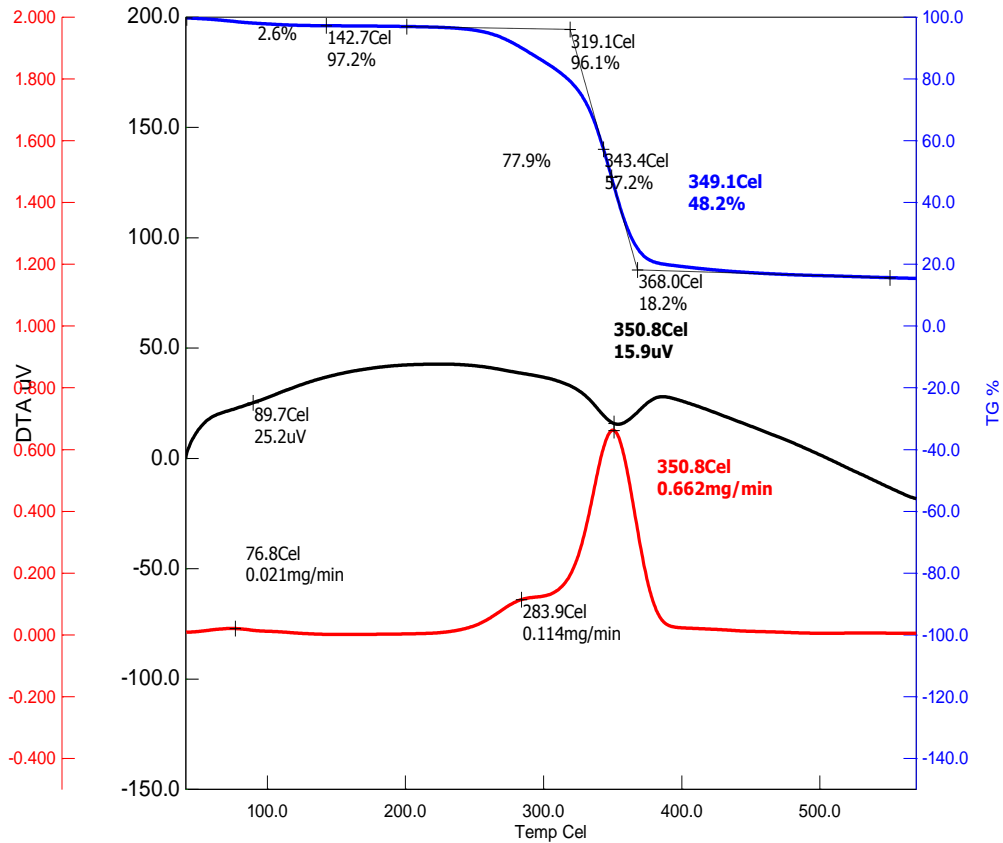


Figure 8. TG, DTA and DTG curves of 10% CH₃COOH treated fiber

4.7 TG, DTA and DTG curves of 10% CH₃COOH treated fiber

Fig.8 shows that TG, DTA and DTG of 10% CH₃COOH treated PALF. The TG curve shows an initial 2.6% loss corresponds moisture content. Then the mass is continuous losing having initial slower rate and ending faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks

89.7⁰C, 350.8⁰ C are obtained. The 1st peak at 89.7⁰ C is due to removal of moisture. 2nd peak is for degradation.

Three DTG peaks are also found at 76.8⁰ C, 283.9⁰C and 350.8⁰ C which are corresponds to light and heavy material respectively. DTG curve of 10% CH₃COOH treated PALF depicts that the maximum degradation occurs at the temperature 350.8⁰ C with the rate of 0.662 mg/min.

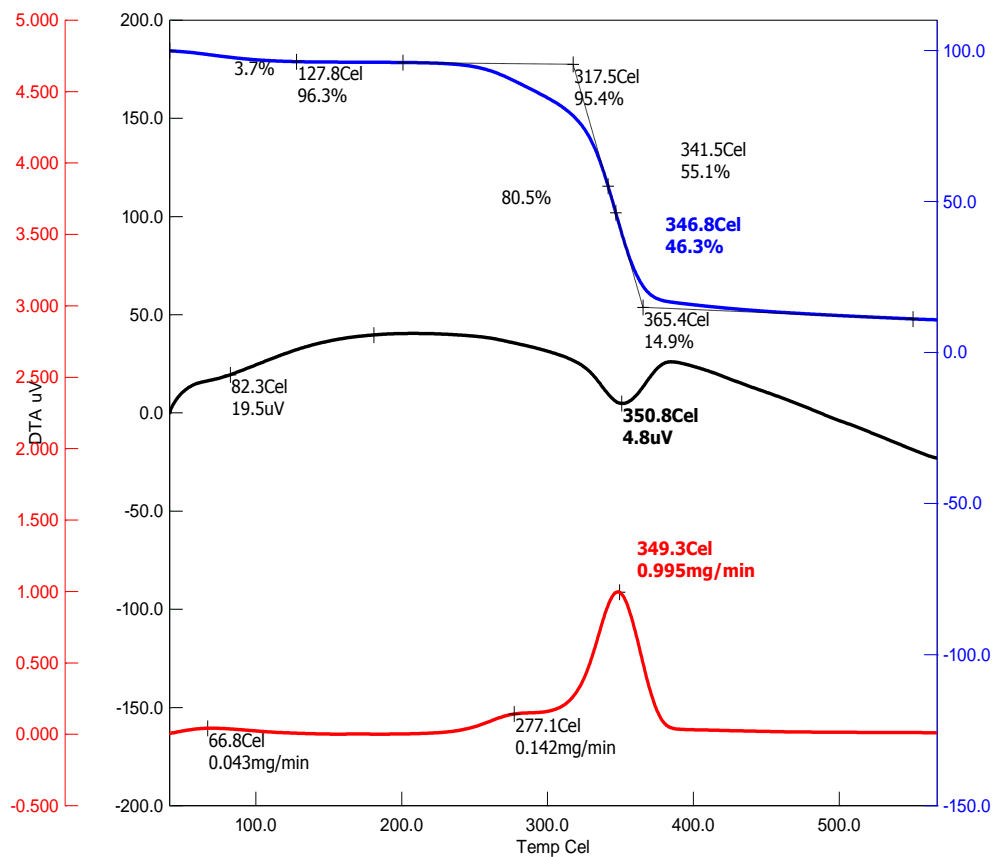


Figure 9. TG, DTA and DTG curves of 15% CH₃COOH treated fiber

4.8 TG, DTA and DTG curves of 15% CH₃COOH treated fiber

Fig.9 shows that TG, DTA and DTG of 15% CH₃COOH treated PALF. The TG curve shows an initial 3.7% loss corresponds moisture content. Then the mass is losing initial slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 82.3^oC, 350.8^o C are obtained. The 1st peak at 82.3^o C is

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due to removal of moisture. 2nd peak is for degradation.

Three DTG peaks are also found at 66.8^o C, 277.1^oC and 349.3^o C which are corresponds to light and heavy materials respectively. DTG curve of 5% CH₃COOH treated PALF depicts that the maximum degradation occurs at the temperature 349.3^o C with the rate of 0.995 mg/min.

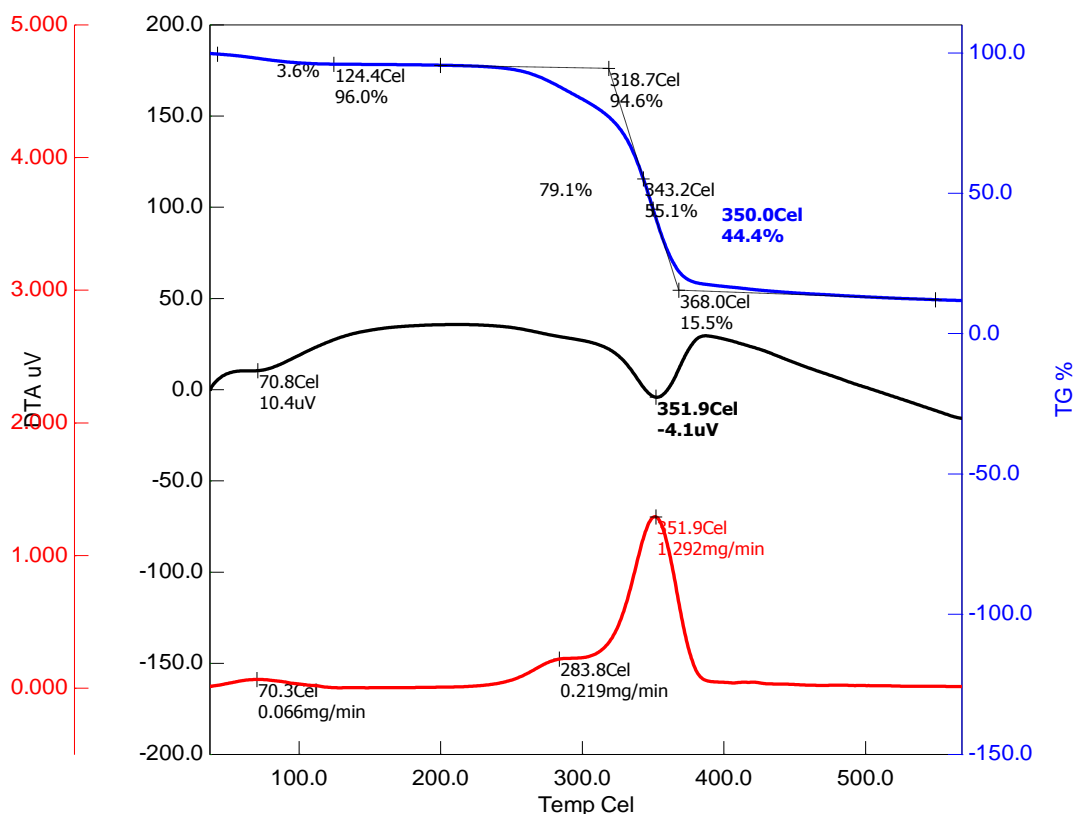


Figure 10. TG, DTA and DTG curves of 20% CH₃COOH treated fiber

4.9 TG, DTA and DTG curves of 20% CH₃COOH treated fiber

Fig.10 shows that TG, DTA and DTG of 20% CH₃COOH treated PALF. The TG curve shows an initial 3.6% loss corresponds moisture content. Then the mass is losing initially at slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 70.8⁰C, 351.9⁰

C are obtained. The 1st peak at 70.8⁰ C is due to removal of moisture. 2nd peak is for degradation.

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Three DTG peaks are also found at 70.3⁰ C, 283.8⁰C and 351.9⁰ C which are correspond to light and heavy material. DTG curve of 20% CH₃COOH treated PALF depicts that the maximum degradation occurs at the temperature 351.9⁰ C with the rate of 1.292 mg/min.

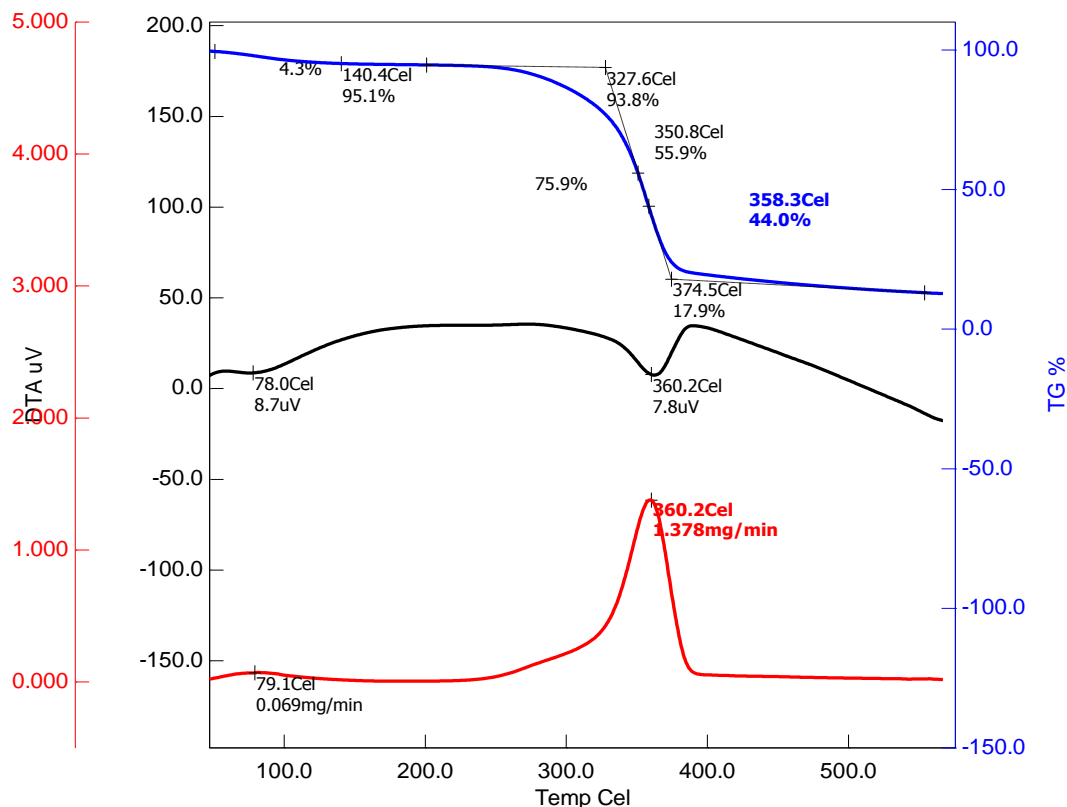


Figure 11. TG, DTA and DTG curves of 5% NaOH treated fiber

4.10 TG, DTA and DTG curves of 5% NaOH treated fiber

Fig.11 shows that TG, DTA and DTG of 5% NaOH treated PALF. The TG curve shows an initial 4.3% loss corresponds to moisture content. Then the mass is losing initially slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 78⁰C, 360.2⁰ C are

obtained. The 1st peak at 78⁰ C is due to removal of moisture. 2nd peak is for degradation.

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Three DTG peaks were also found at 79.1⁰ C and 360.2⁰C which are corresponds to light and heavy materials respectively. DTG curve of 5% NaOH treated PALF depicts that the maximum degradation occurs at the temperature 360.2⁰ C with the rate of 1.378 mg/min.

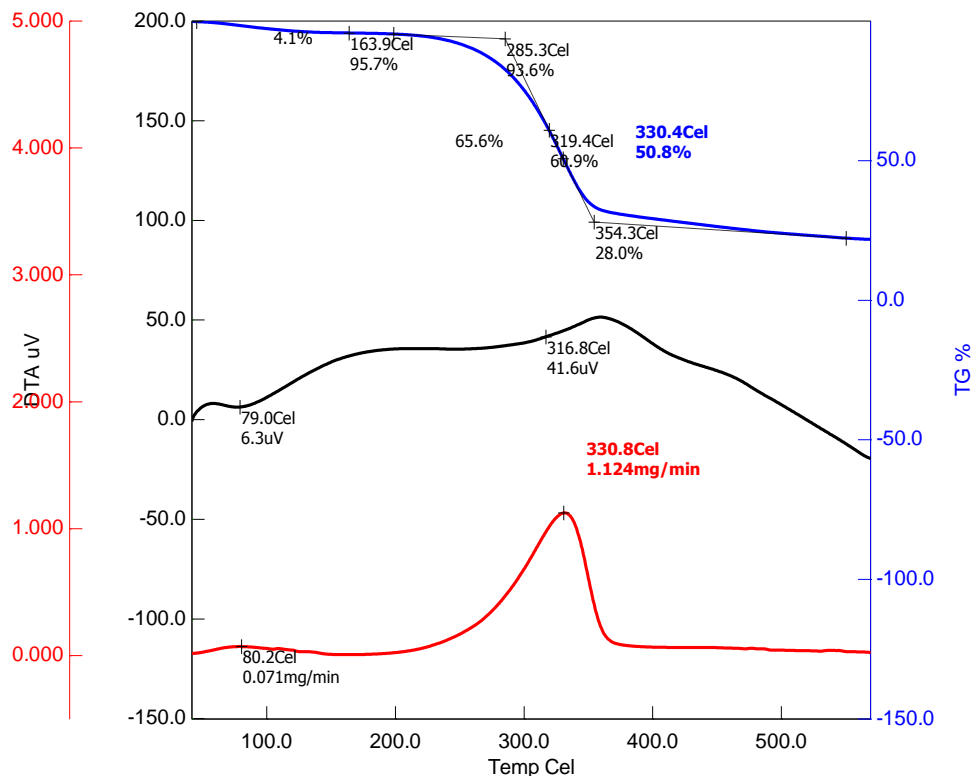


Figure 12. TG, DTA and DTG curves of 10% NaOH treated fiber

4.11 TG, DTA and DTG curves of 10% NaOH treated fiber

Fig.12 shows that TG, DTA and DTG of 10% NaOH treated PALF. The TG curve shows an initial 4.1% loss corresponds moisture content. Then the mass is losing initially slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 79°C, 316.8°C are

obtained. The 1st peak at 79°C is due to removal of moisture. 2nd peak is for degradation.

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Three DTG peaks are also found at 80.2°C and 330.8°C which are correspond to light and heavy materials respectively. DTG curve of 10% NaOH treated PALF depicts that the maximum degradation occurs at the temperature 330.8°C with the rate of 1.124 mg/min.

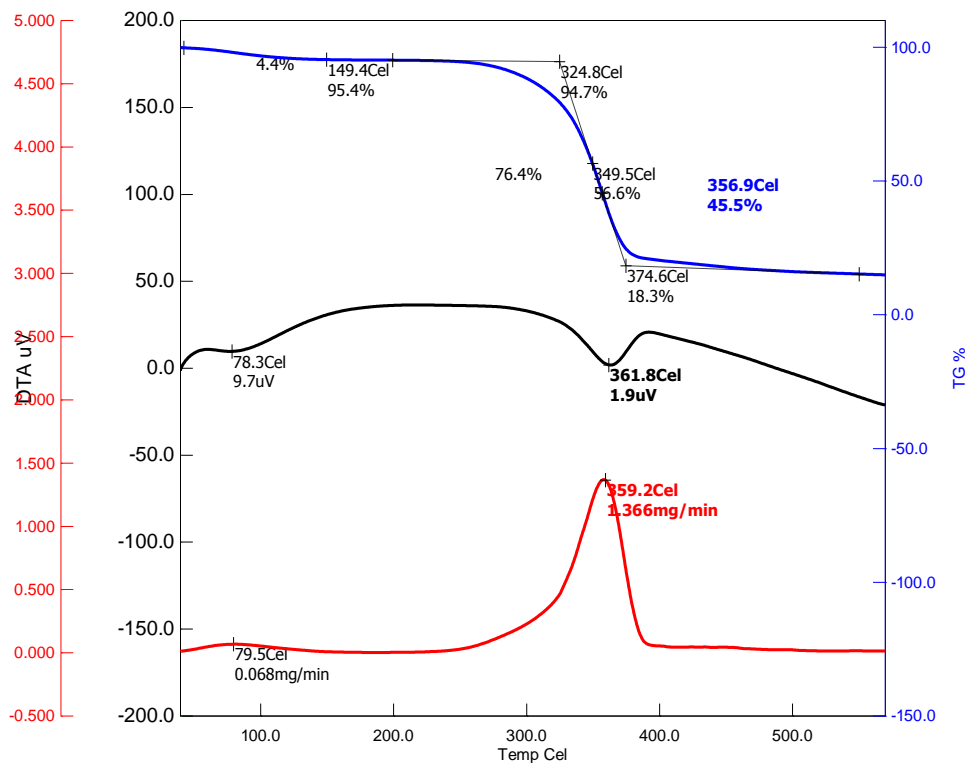


Figure 13. TG, DTA and DTG curves of 15% NaOH treated fiber

4.12 TG, DTA and DTG curves of 15% NaOH treated fiber

Fig.13 shows that TG, DTA and DTG of 15% NaOH treated PALF. The TG curve shows an initial 4.4% loss corresponds to moisture content. Then the mass is losing initially slower rate and ending is the faster rate. Lighter substances have removed initially and then heavier material removed. Two endothermic DTA peaks 78.3°C, 361.8°C

are obtained. The 1st peak at 78.3°C is due to removal of moisture. 2nd peak is for degradation.

Three DTG peaks are also found at 79.5°C and 359.2°C which correspond to light and heavy materials respectively. DTG curve of 15% NaOH treated PALF depicts that the maximum degradation occurs at the temperature 359.2°C with the rate of 1.366 mg/min.

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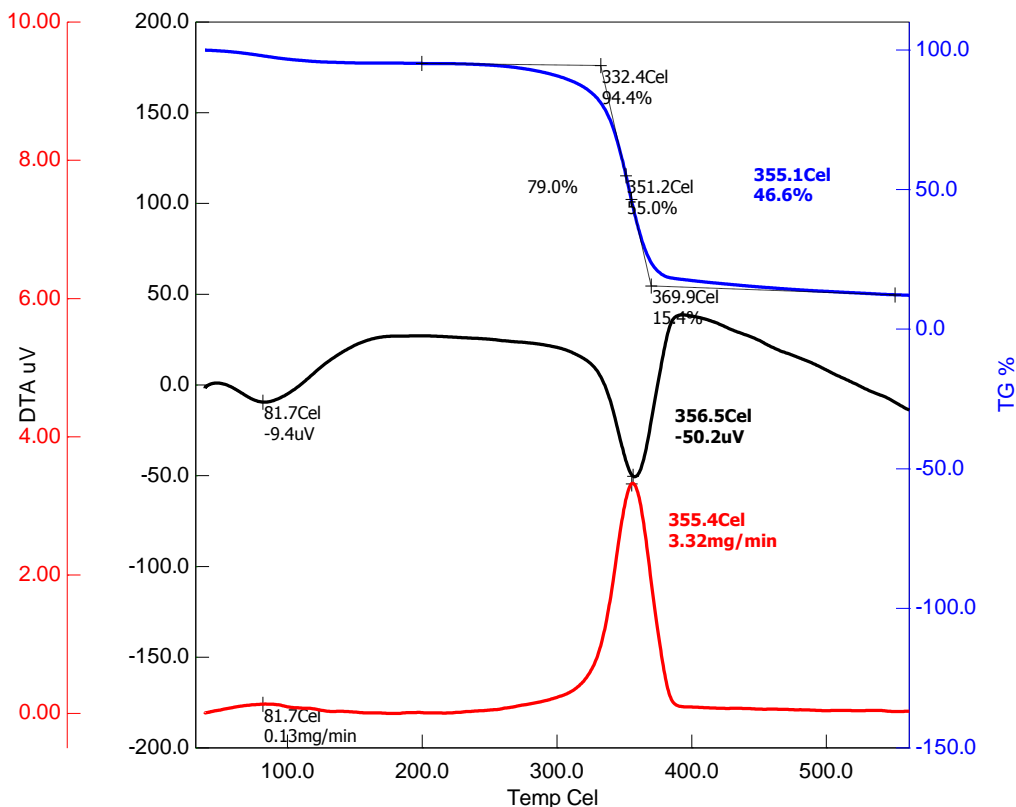


Figure 14. TG, DTA and DTG curves of 25% NaOH treated fiber

4.13 TG, DTA and DTG curves of 25% NaOH treated fiber

Fig.14 shows that TG, DTA and DTG of 25% NaOH treated PALF. The TG curve shows an initial loss corresponds moisture content. Then the mass is losing initially slower rate and ending is the faster rate. Light substances have removed initially and then heavier material removed. Two endothermic DTA peaks 81.7°C, 356.5°C are obtained. The 1st peak at 81.7°C is due to removal of moisture. 2nd peak is for degradation.

Three DTG peaks are also found at 81.7°C and 355.4°C which are correspond to light

and heavy materials respectively. DTG curve of 15% NaOH treated PALF depicts that the maximum degradation occurs at the temperature 355.4°C with the rate of 3.32 mg/min.

4.14 Comparison (DTA& DTG) of Raw & CH₃COOH treated fiber

From above curves it may concluded that the maximum degradation temperature of different CH₃COOH treated pineapple leaf fiber is lower than the raw fiber. This may due to the degradation of fiber by acid treatment and its thermal stability decreases.

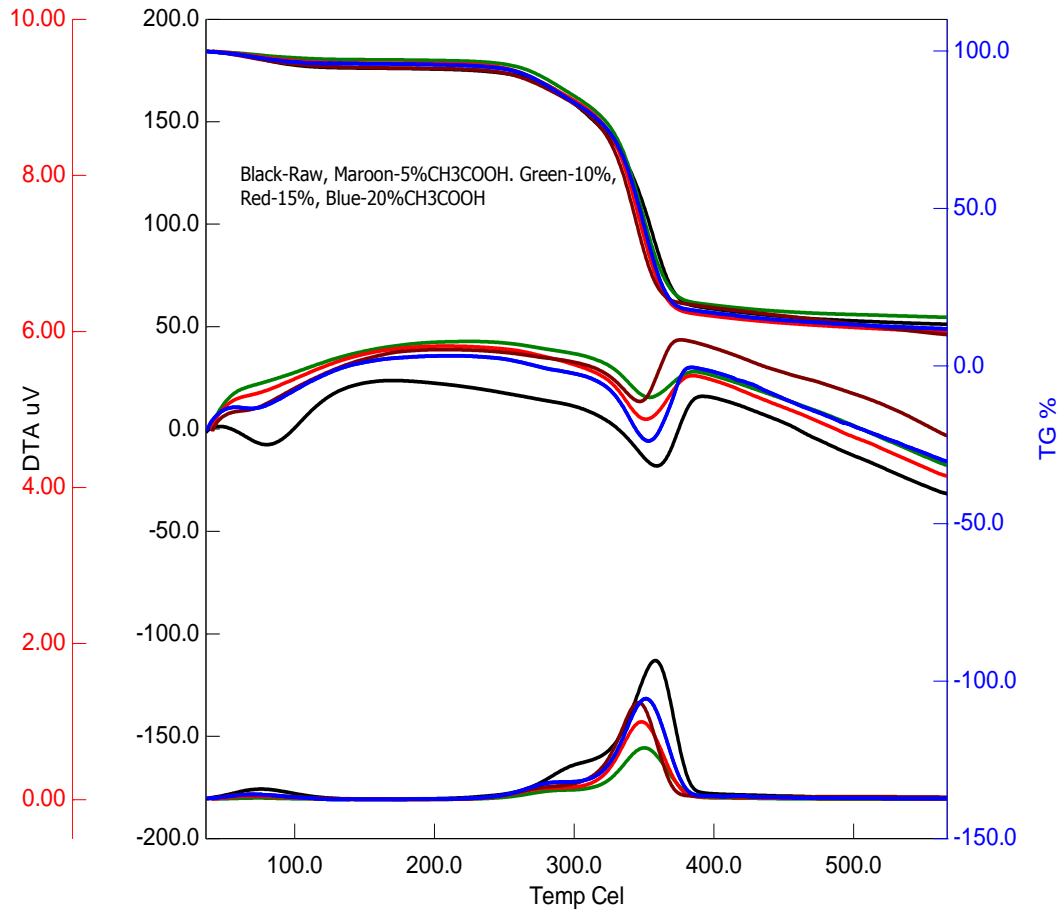


Fig.15 TG, DTA & DTG of raw & different CH₃COOH treated pineapple leaf fiber

Fig.15 shows that the thermal stability of raw fiber is maximum & decreases by

treating acid. This may due to the action of acid fiber is degraded.

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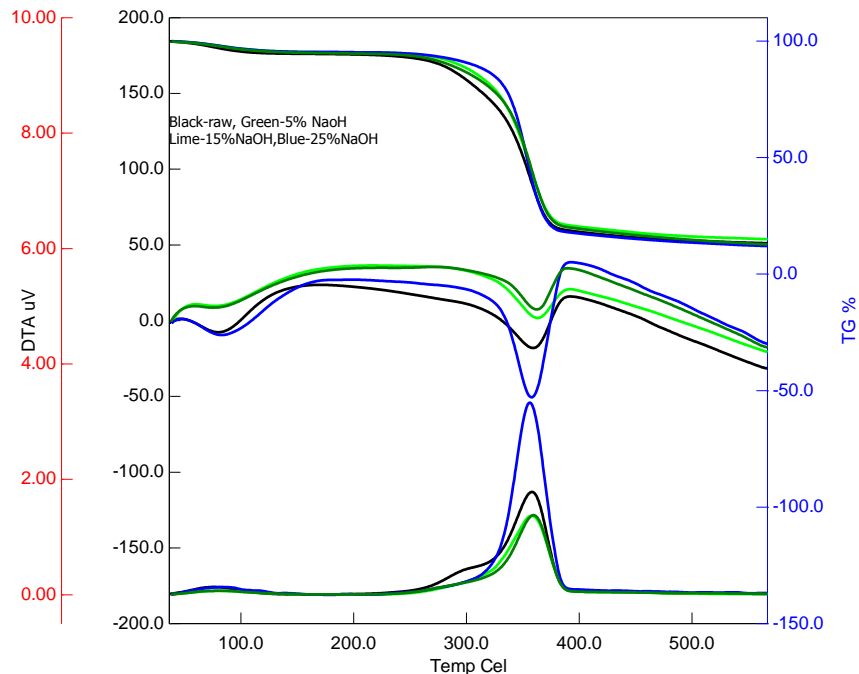


Fig.16 TG, DTA & DTG of raw & different N_aOH treated pineapple leaf fiber

4.16 Comparison (DTA& DTG) of Raw & different N_aOH treated fiber:

Fig.16 shows that the thermal stability of 25% N_aOH treated fiber is maximum & wide range of TG curve. This may due to the formation of Cell-ON_a bond with the cellulose of the raw fiber & increases its thermal stability.

5. CONCLUSIONS

Thermal stability of raw fiber is high & Acrylonitrile enhanced the thermal stability of bleached PALF. Thermal stability of acid & 25% N_aOH treated fiber is low & high respectively from raw fiber. Thermal stability is increased by increasing the concentration of sodium hydroxide. This may due to the formation of Cell-ON_a bond with the cellulose of the raw fiber & increases its thermal stability.

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