Felipe Santana Machado
Aloysio Souza de Moura
(Organizadores)

EDUCAÇÃO, MEIO AMBIENTE E TERRITÓRIO 2

Atena Editora
Ano 2019

Felipe Santana Machado
Aloysio Souza de Moura
(Organizadores)

Educação, Meio Ambiente e Território 2

Atena Editora
2019

2019 *by Atena Editora*
Copyright © da Atena Editora
Editora Chefe: Profª Drª Antonella Carvalho de Oliveira
Diagramação e Edição de Arte: Lorena Prestes e Karine de Lima
Revisão: Os autores

Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

E24 Educação, meio ambiente e território 2 [recurso eletrônico] / Organizadores Felipe Santana Machado, Aloysio Souza de Moura. – Ponta Grossa (PR): Atena Editora, 2019. – (Educação, Meio Ambiente e Território; v. 2)

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-85-7247-143-5
DOI 10.22533/at.ed.435192102

1. Divisões territoriais e administrativas 2. Educação ambiental. 3. Meio ambiente – Preservação. I. Machado, Felipe Santana. II.Moura, Aloysio Souza de.

CDD 320.60981

Elaborado por Maurício Amormino Júnior – CRB6/2422

APRESENTAÇÃO

O meio ambiente é o "*locus*" onde se desenvolve a vida na Terra. Resumidamente é a natureza com todos elementos que nela habitam/interagem e inclui os elementos vivos e não vivos que estão intimamente conectados com o planeta. O meio ambiente deveria ser foco prioritário de ações locais, regionais, nacionais e mesmo internacionais para a permanência de uma boa qualidade de suas características em prol das gerações futuras. A obra "Educação, Meio ambiente e Território" apresenta uma série de livros de publicação da Atena Editora. Em seu segundo volume, com 26 capítulos, enfatizamos a importância do ambiente e sua homeostase. Logo a exposição de experiências de como manejar produtos e subprodutos de origem animal, vegetal ou mineral; e seu posterior tratamento e avaliação de aspectos básicos são de fundamental importância para esse equilíbrio.

Para tanto primeiramente apresentamos experiências de reutilização de elementos para o estabelecimento de uma relação harmônica entre produtos manufaturados, sociedade e meio ambiente em via de diminuir custos de vida e favorecer o desenvolvimento sustentável. Em sequência há capítulos que destacam percepção ambiental "*in locu*" de comunidades ribeirinhas e aspectos físico-químico-biológicos de resíduos líquidos e sólidos que são negligenciados pelas diferentes esferas governamentais e que despejados em ambientes urbanos alteram o equilíbrio ambiental. Porém, esse equilíbrio (ou desequilíbrio) não está restrito ao local de despejo, mas também aos espaços não urbanos (rurais e florestais) adjacentes.

Finalizamos este volume com uma abordagem sobre a junção de pesquisas e a modernização da tecnologia compõem um contexto da gestão ambiental, gestão ambiental e tecnologia de alimentos, e, enfim, apresentação de parâmetros em nível de comunidade, destacando primeiramente os fitoplânctons, diatomáceas, e organismos dos reinos *Metaphyta* e *Metazoa*.

A organização deste volume destaca a importância do meio ambiente tanto para o entusiasta quanto para estudiosos de diferentes níveis educacionais, da educação básica ao superior, com intuito de formar personalidades cientes dos problemas ambientais atuais, com o caráter de orientar e capacitar para preservar e conservar as várias paisagens e comunidades que formam o meio ambiente. Por fim, esperamos que a crescente demanda por conceitos e saberes que possibilitam um estudo de melhoria no processo de gestão do ambiente aliada a necessidade de recursos e condições possa fortalecer o movimento ambiental, colaborando e instigando professores, pedagogos e pesquisadores a pratica de atividades relacionadas à Sustentabilidade que corroboram com a formação integral do cidadão. Ademais, esperamos que o conteúdo aqui presente possa contribuir com o conhecimento sobre o meio ambiente e com artífices ambientais para a sua preservação.

SUMÁRIO

CAPÍTULO 24

THERMAL DECOMPOSITION OF FAST GROWING WOODY SPECIES WITH POTENTIAL FOR FIREWOOD PRODUCTION

Júlio César Gonçalves de Souza
Universidade Federal do Amazonas, Faculdade de Ciências Agrárias
Manaus – AM

Eyde Cristianne Saraiva
Bonatto MSc. PhD
Universidade Federal do Amazonas, Faculdade de Ciências Agrárias, Departamento de Engenharia Agrícola e de Solos
Manaus – AM

RESUMO: A matéria-prima de materiais lignocelulósicos e seus derivados podem ser usados para produção de energia. Seu uso como fonte de energia é vantajoso porque é renovável e menos poluente devido às taxas de emissão mais baixas do que os combustíveis fósseis. No entanto, o uso indiscriminado pode diminuir a eficiência da produção de energia e isso é uma realidade em muitas áreas rurais. Assim, é necessário caracterizar a composição da biomassa lenhosa e seu comportamento físico e químico. Para isso, a TGA (Thermal Gravimetric Analysis) e a DTG (Derivative of the Thermal Gravimetric Analysis) têm sido uma ferramenta importante na avaliação do potencial energético da matéria lenhosa e seus resíduos de bioprodutos. A pirólise de um combustível como madeira nos permite calcular a primeira derivada da curva de perda de peso em função da temperatura (dm / dT) e definir parcelas que exercem a dinâmica da degradação de seus três principais componentes: hemicelulose, celulose e lignina . Os experimentos foram conduzidos em atmosfera inerte utilizando gás argônio e taxa de aquecimento a 20 ° C / min. Nove espécies foram analisadas e, de um ponto de vista holístico, as espécies *Tachigali myrmecophilla Ducke* (Tachi-preto) e *Ormosia paraensis Ducke* (Tento) obtiveram melhores resultados para a produção de energia.

PALAVRAS-CHAVE: lenha, TGA, DTG, biomassa

ABSTRACT: The feedstock of ligno-cellulosic materials and their derivatives may be used for energy production. Its use as energy source is advantageous because it's renewable and less polluting due to the lower emission rates than fossil fuels. Nevertheless, the indiscriminate use may decrease energy production efficiency and this is a reality in many rural areas. Thus, it is necessary to characterize woody biomass composition and its physical and chemical behavior. In order to do that, TGA (Thermal Gravimetric Analysis) and DTG (Derivative of the Thermal Gravimetric Analysis) has been an important tool in evaluating the energy potential of woody matter, and their waste bio-products. The pyrolysis of a fuel as timber allows us to calculate the first derivative of the weight loss

curve in function of the temperature (dm/ dT) and set plots that exert the dynamics of the degradation of its three major components: hemicellulose, cellulose and lignin. The experiments were conducted in an inert atmosphere using argon gas and heating rate at 20 °C / min. Nine species were analyzed and by a holistic point of view, the species *Tachigali myrmecophilla* Ducke (Tachi-preto) and *Ormosia paraensis* Ducke (Tento) obtained better results for energy production.
KEYWORDS: Firewood, TGA, DTG, Biomass

1 I INTRODUCTION

1.1 THE FIREWOOD USAGE CONTEXT IN AMAZONAS

The illegal deforestation has been one of the most current criminal acts highlighted for its following ecology and climatic problems. The anthropic intervention at rain forests is a matter of concern for this type of impact in biodiversity within this kind of ecosystem is greater for the high environmental complexity.

Amazonas rural areas afford many potential energetic biomass resources and it's widely accepted that they don't contribute to the greenhouse effect due to the CO2 neutral conversion (VASSILEV et al., 2015) and lignin-cellulosic feedstocks have an important role in this context for their renewability and for the great forest extension (SANTOS et al., 2005).

Firewood is a product of this activity and is consumed as much as in Manaus' metropolitan region, which is formed by 13 municipalities (Manaus, Manaquiri, Autazes, Itapiranga, Iranduba, Careiro, Careiro da Várzea, Itacoatiara, Silves, Presidente Figueiredo, Rio Preto da Eva and Manacapuru) as in inner cities and rural areas. Iranduba and Manacapuru are at the spotlight of this subject for the establishment of pottery, bakery and steel industries (BARROS et al., 2012; SANTOS e SILVA, 2013).

Wood is considered one of the oldest materials used as a source of energy and as it is renewable, it has been a standard in sustainability (FATEH et al., 2014). There isn´t no doubt about their current and future social economic impact as well (MAMLEEV et al., 2007; LI et al., 2014). In addition, woody residues represent an environmental and economic problem that can be mitigated through its reuse (NOVAIS et al., 2014). The use of biomass is particularly framed to meet the energy demand of rural areas where the raw material and the use of the site are more economically convenient than conventional equipment. According to Santos et al. (2005) the rural area of Amazonas has several biomass energetic potentialities, the most evident being the firewood thanks to the large extension of miscellaneous species forests. Nevertheless, the indiscriminate use is highly practiced by the population due to the lack of information to supply the demand on the hub of pottery, steel and baking, resulting in a lack of fuel efficiency and equipment damage, as well as favoring deforestation. Unfortunately, the vegetation suppression it's done indiscriminately and bearing in mind that an anisotropic material such as wood that has a great range of species makes this practice irrational and it leads to the population shortage in case of those that are empiric known as good fuels and are exploited.

In recent years, combustion and re-combustion of renewable energy gained attention for their fuel flexibility, high combustion efficiency, high heat transfer, and low emission of NOx, SOx besides being CO2 neutral (GAŠPAROVIČ et al., 2012; JAYARAMAN et al., 2017). The different molecules and the many ways of their rearrangement among trees results at distinct energies potentials. Woody biofuels can be evaluated through pyrolysis and by its composition.

Pyrolysis is the conversion of biomass to liquid, solid and gaseous fractions and is a process that has called attention for creating renewable by-products (METTLER et al., 2012). It occurs by heating to high temperatures in an inert atmosphere such as nitrogen or argon (FERRARA et al., 2014), but other authors conduct their experiments in an oxidizing atmosphere, such as (CHANDRASEKARAN & OPKE, 2012). The efficiency of a wood combustion process depends on mineral substances that vary with the species and is of great importance for the proper choice of wood to be used (QUIRINO et al., 2005). Santos et al. (2007) stated that introducing exotic species into the Amazonian ecosystem isn't convenient because they are considered invasive and the propagation of these species can generate environmental problems in Amazonian ecosystem in future. Pinheiro and Witkoski (2013) called attention for the lack of synchronization between the plant regeneration and production and Barros et al. (2012) affirm that it causes a logistic problem because the feedstock is getting continuously more distant from the communities. The need of multiple management of forests is urgent and also the surveillance of protected areas in Amazonian rain forests and incentive laws aiming sustainability and public policies that benefits both communities and entrepreneurs.

In this work were chosen native species because they're able to maintain balance with plantations and the diversity around them at all trophic levels. To Santos and her colleagues (2005), exotic species may have difficulties in adaptation and even been considered as invasive. *Eucalyptus sp*. and pines are an example of harmful introduction because they don't support undergrowth so other plants can't coexist with them increasing vulnerability to biotic and abiotic disturbances (JINDAL et al., 2008; VERHEYEN et al., 2016). The chosen trees are also pioneers that are characterized by fast growing providing high soil cover potential and favoring forest succession (DOUTERLUNGNE et al., 2013).

1.2 PYROLYSIS IN WOODY FUELS

The pyrolysis of lignocellulosic materials originates a large number of chemical compounds which are grouped into three types for engineering application: permanent gases, pyrolysis liquid (oil, tar) and coal (DIBLASI, 2009).

The factors that should be considered in the pyrolysis process are: solid particle size, residence time, gas (atmosphere), final temperature and heating rate (VELDEN et al., 2010; ASADULLAH et al., 2010; GONZÁLEZ, 2015).

González (2015) also describes that the temperature defines the break between the chemical bonds of the compounds and the higher the temperature is more ruptures will exist resulting in larger fractions of gases. Zeng et al. (2011) also concluded in their work that the yield of the coal is related to the pyrolysis temperature, which decreases with the temperature and the heating rate, and Burhenne et al. (2013) concluded that the coal produced at lower temperatures shows more reactivity in CO2.

The increase in residence in pyrolysis implies in two things: the probability that any secondary rupture occurs increases and also the possibility of catalytic reactions between coal and pyrolysis substances (KANURY, 1972).

Zhang et al (2013) studying pines charcoal found that when the samples were under a slow heating rate the volatile matter was released and escaped through the natural porosity of sawdust during pyrolysis and the original characteristics of the fiber remained. However, when the heating rate was rapid, a plastic deformity occurred and the fibrillar structures were destroyed and the surface of the material was smooth. The gaseous products released by the molten particles were released, analogously as bubbles bursting. The heating rate affects both the location of the TGA curve and the maximum decomposition rate. At higher heating rates, individual conversion values are reached at higher temperatures. Maxima of the decomposition rate are also slightly shifted towards higher temperatures. This fact can be a consequence of heat and mass transfer limitations (GAŠPAROVIČ et al., 2010).

As regards to the atmosphere of the equipment there are differences between an oxidizing environment from an inert, the loss of mass with respect to temperature variation, in the presence of oxygen, the three phases of mass loss are defined as dehydration, oxidative pyrolysis and oxidation of coal. Wu et al. (2014) describe this process approximately this way: The first phase of mass loss occurs at 150 ° C, and this occurs due to the removal of moisture, however it is worth noting that this loss is not in relation to the water of constitution. At this stage, the lignin gradually begins to decompose to form tar and charcoal and the cellulose units begin to dehydrate. When there is presence of oxygen at high temperatures most of the volatile gases ignite leading to the loss of mass of the wood. The third stage from 260 °C to 400 °C is the carbonization phase, the hemicellulose continues in pyrolysis while the cellulose undergoes the same process, but in drastic way, producing a large amount of volatile gases and tar. Lignin continues to decompose and produce tar in the same way. After this temperature range the oxidation of the tar occurs and the loss of mass tends to become more stable. When the loss of mass occurs under inert conditions, it is also divided into three parts, named as dehydration, volatilization and carbonization (SU et al., 2012).

In lignocellulosic compounds the thermal degradation reveals the presence of three main constituents: hemicellulose and cellulose (holocellulose) and lignin (ZENG et al., 2011; POLLETO et al., 2012).

The hemicellulose begins to degrade in the range of 180 ° C to 260 ° C, at this stage the pyrolysis leads to the formation of volatile gases such as CO2, CO, CH4, CH3OH and CH3COOH (WU et al., 2014).

Cellulose is a linear b-1-4-glucanium and is the most abundant polymer available. In nature, they occur as crystalline fibers called micro fibrils and the level of polymerization are important factors in heat transport and thermal degradation (KIM et al., 2010). Most of the pyrolysis processes in cellulose heating under inert atmosphere occur almost simultaneously, as if some mechanism simultaneously activates all decomposition reactions independently of the chemical nature of its final products (MAMLEEV et al., 2007). The same author states that the pyrolysis of cellulose occurs through two passages: one is the formation of volatile tar and the other is the formation of light gases and coal. Both processes have high activation energy. As the temperature rises, the formation of cellulose tar vapor becomes predominant, while the degradation of lignin also reaches high levels forming gases such as CO2, CO, CH4 and H2 (DIBLASI, 2009).

Lignin is an aromatic hetero-polymer complex and the main constituent of the second plant cell wall (VINARDELL et al., 2008). As regards their chemical behavior in pyrolysis, Huang et al. (2015) state that the breakdown of Ca-Cb bonds is the initial step of the thermal degradation of lignin and its main products are p-hydroxyphenyl formaldehyde4, p-hydroxyphenyl-methanol5, p-hydroxyphenyl-acetadiene7 and p-hydroxyphenyl- ethylene10.

According to TranVan et al. (2014), due to the presence of three main constituents, the thermogravimetric analysis of the wood results in an overlap of each decomposition. When carrying out a kinetic study of pyrolysis, it must be taken care with the process conditions. If they are not correctly selected it is possible that secondary reactions or a high influence of mass and heat transport phenomena occurs and that prevent the possibility of analyzing the independent decomposition reactions, which is the interest in a kinetic reaction (GONZÁLEZ, 2015).

2 I MATERIAL AND METHODS

2.1 PROXIMAL ANALYSIS

The laboratory tests took place at the Federal University of Amazonas' Bioenergy Laboratory located at Faculty of Agrarian Sciences. The results were put through analysis of variance (ANOVA) and Tuckey test at 5% of probability. The software used was Assistat.

2.1.1 Ashes contents

Saw-wood samples of 1 g were put inside a muffle oven previously heated until 700°C, remaining 3 minutes at the oven tamp than 24 minutes with the oven closed. The percentage of ashes contents were calculated as (a) Equation.

(a) Equation: $A = (m1\text{-}m0) / (m \times 100)$

Where *A* is the ashes contents percentage; *m0* is the crucible mass grams; *m1* is the crucible mass plus the saw-wood sample; and *m* is the residue mass (g).

2.1.2 Volatile contents

It is a similar way of ashes contents determination; however the residence time changed to 7 minutes and the temperature were set to reach 900 °C. The (b) equation shows the volatile contents percentage.

(b) Equation: $MV = (m2\text{-}m3) / (m \times 100)$

Where *MV* is the volatile contents percentage, *m2* is the initial crucible mass plus saw-wood mass; *m3* is the final crucible mass plus the residue mass; *m* is the sample mass of residue (g).

2.1.3 Fixed carbon

This parameter is an indirect measure and is calculated as such as (c) equation.

(c) Equation: $CF = 100 - (A + MV)$

Where, *CF* is for fixed carbon percentage; *A* is for ashes contents percentage; and *MV* is for volatile contents percentage.

2.2 THERMOGRAVIMETRIC AND ELEMENTARY ANALYSIS

The thermogravimetric and the elementary analysis were performed at the Campinas University. The mass loss were measured at an inert atmosphere (Argon) by using a Thermobalance Universal 25V23CTA Instruments, and the temperatures ranging from 25°C to 950°C, at a heating rate of 20°C per minute.

2.3 HIGH HEAT VALUE (HHV)

The HHV was calculate using the applicative Microsoft Excel 2010 according to the equation developed by Gašparovič et al (2009):

$HHV\ MJkg{-1} = 0.3491wC + 1.1783wH + 0.1005wS- - 0.1034wO - 0.0151wN - 0.0211wA$

Where wC, wH, wS, wO, wN, and wA are the mass fractions of carbon, hydrogen, sulfur, oxygen, nitrogen, and ash, respectively.

2.4 SPECIES USED FOR SAMPLES

The forest species used were: *Cassia leiandra Benth* (Mari-mari), *Tachigali myrmecophilla* Ducke (Taxi-preto), *Scleronema micranthum* (Ducke) Ducke (Cardeiro), *Sacoglottis guianensis* Benth (Achuá), *Ormosia paraensis* Ducke (Tento), *Parkia pendula* (Willd.) Benth. ex Walp. (Faveiro), *Ocotea guianensis* Aubl. (Louro-seda), *Licania Octandra* (Hoffmanns. ex Roemer & Schult.) O. Kuntze (Caraipé) and *Hymenaea intermedia* Ducke (Jutaí-açú).

3 I RESULTS AND DISCUSSION

3.1 TGA AND DTG ANALISYS

The peaks of the first derivative (DTG) indicates the point of highest rate of change in the weight loss (Fig. 1). The TGA curves were plotted with the DTG in individuals graphs for a cleaner display. Usually, as was stated before, hemicellulose is the first component to be degraded and appears in the curve of the derivative more as a "shoulder" than as a well-defined peak, because it is hidden at the peak of cellulose decomposition (TRANVAN, 2014). Figure 1 exerts the thermogravimetric analysis of the most important samples are shown individually (FIG.2 – FIG.5). Hemicellulose and cellulose form a strong peak in the temperature range of 200°C at 400°C, which may be followed by a second peak or not. The second peak corresponds to the decomposition of lignin that begins along with hemicellulose and

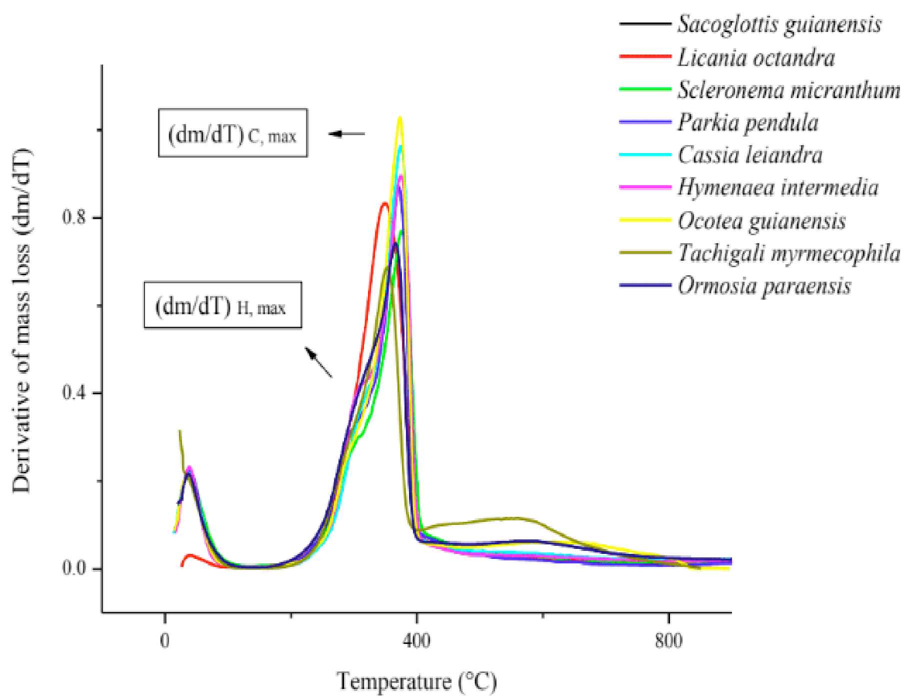

Fig. 1 Thermal degradation of nine amazonian fast growing woody species

continue through a wide range of temperature, and it may appear diffusely instead of peak, as in the case of our samples (SU et al., 2012; TRANVAN et al., 2014; YUAN et al., 2015). Due to the overlap of curves the degradation of hemicellulose may be more evident (FIG. 2), or the curve may be even incospicuos (FIG. 3).

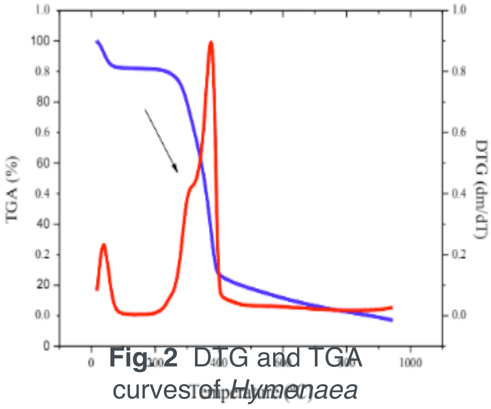

Fig. 2 DTG and TGA curves of *Hymenaea intermedia*

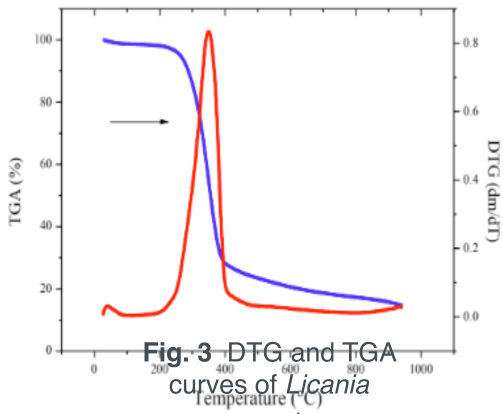

Fig. 3 DTG and TGA curves of *Licania octandra*

As the samples are from fast growing species their density is low, it means that their lignin content is also low, so the thermal degradation doesn't reveal a well-defined peak. However, *Tachigali myrmecophilla* (FIG. 4), *Ormosia paraensis* (FIG. 5) and *Ocotea guianenses* have higher lignin contents. A likely explanation for *Tachigali myrmecophilla* differentiated behaviour at the beginning of the pyrolysis at 20 °C to 100 °C is that it has low humidity compared to other species as was found in the first phase of this research. The first derivatives are in agreement with the results of the immediate analysis, where the species have the high volatile content and according to Meng et al. (2015), most of the volatile gases are released in the holocellulose decomposition.

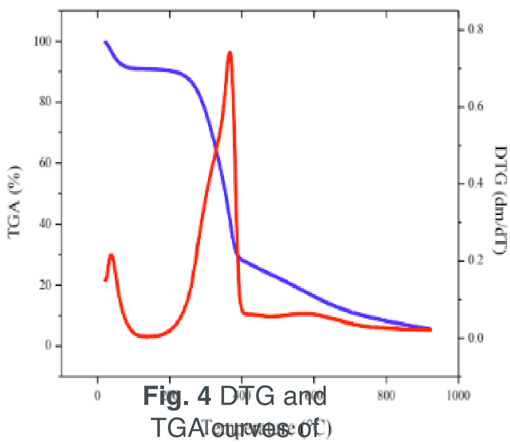

Fig. 4 DTG and TGA curves of Ormosia paraensis

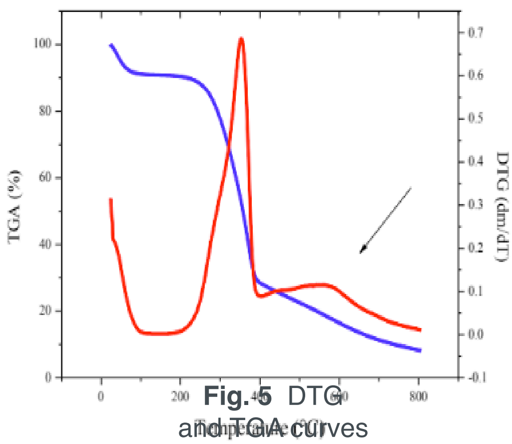

Fig. 5 DTG and TGA curves of Tachigali myrmecophila

3.1 PROXIMAL / ELEMENTARY ANALYSIS AND HHV

The proximate and ultimate analysis of biomass are necessary for their efficient and clean utilization, while the High Heating Value (HHV) of these materials determine the quantitative energy content of these fuels (PARIKH et al., 2007). In Table 1 are the results of the proximal, elementary analysis and HHV.

Most volatile content means faster ignition and more time at the stage of flame, this happens for its temperature ignition is low, this occurs during direct burning of wood, in which gases are released in function of the volatile matter content (VLASSOV, 2001; FERREIRA et al., 2017). The species with higher volatile matter is *Scleronema micranthum* (96,03%) and it differs statistically from the others in this parameter.

Ash deposition on combustor surfaces plays a significant role in issues that determine the design machine and the operation. In this parameter it's desirable for the fuel to have lower values because the ashes turn the incineration more difficult, pollute the environment and increase the costs of thermal installations, with the construction of ashes exhaust fan systems and particulate materials (VLASSOV, 2001; DEMIRBAS, 2017). *Ormosia paraensis* and *Ocotea guianensis* both have the minor value for this parameter (1,60%) and they differ statistically from others. The major value was found in *Sacoglottis guianensis* (9,15%). Lower percentages of ash contents present in the feedstock indicate greater ease of processing during pyrolysis of biomass (AHMED et al., 2018).

High elemental carbon doesn't means high fixed carbon, because part of the elemental carbon constitutes the volatile matters contents and also the type of lignin influences it. According to Demirbas (2017), increasing the lignin aromaticity, the unsaturated carbon content also increases, and thus the carbon content of lignin increases. Increasing H/C or O/C ratio implies decreasing aromaticity of the fuel. Increasing O/C ratio implies increasing hydroxyl, carboxyl, ether, and ketone functional groups in the fuel.

Elementary Analysis (%)				Proximal Analysis (%)			HHV (MJkg−1) [44]
Species	C	H	N	V	A	F	
Sacoglottis guianensis	45.6	6.1	0.28	86.61 **e**	9.15 **a**	4.24	26.59797
Licania octandra	45.1	5	0.3	92.30 **bc**	3.66 **d**	4.05	24.57765
Scleronema micranthum	45.8	6.5	0.27	96.03 **a**	2.37 **de**	1.6	27.5242
Parkia pendula	45.7	6.1	0.54	89.17 **d**	7.33 **bc**	3.51	26.66735
Cassia leiandra	45	6.3	0.3	89.62 **d**	5.78 **c**	4.61	26.81591
Hymenaea intermedia	45.7	6.1	0.34	89.52 **d**	6.22 **bc**	4.26	26.69379
Ocotea guianensis	45.2	6.3	0.31	94.35 **ab**	1.6 **e**	4.3	26.97378
Tachigali myrmecophila	45.7	6.1	0.54	88.47 **de**	7.76 **ab**	3.77	26.65828
Ormosia paraensis	44.2	5.8	0.5	89.94 **cd**	1.6 **e**	8.45	25.73031

Table 1. Proximate and Elementary Analisys. HHV calculated by CHANNIWALA & PARIKH (2002) equation.

The aromaticity and the oxygen-containing functional groups influence the modes of occurrence of inorganic material in fuel (BAXTER, 1993).

Fast growing species have low density and then less content of lignin in wood then slow growing trees, for that reason the samples results show low carbon fixed content compared with energy commercial trees. The better value was found in *Ormosia paraensis* with 8,45%, this means that from all the other woods of the research it needs more time of residence for a complete combustion, which is desirable for firewood as product. Nevertheless, *Ormosia paraensis* show inferior results in this subjected compared to other species studied for energy production like *Acacia auriculiformis* (AHMED et al., 2018) with 27.92%, Beech wood (OBERNBERGER et al., 2006) with 14.3%, *Eucalyptus grandis* with 25,58 % of yield of fixed carbon (RABAÇAL et al., 2014). This evidence the need of research in field for more suitable native fast growing hardwood species and the breeding of highest phenotype in order of have more competitive products in the market.

According to Silva et al. (1986) higher contents of carbon and lower contents of oxygen in biomass tend to increase the heating value of the biomass and in this parameter *Scleronema micranthum* presented the highest result (27,5242 MJ/kg). The species studied had shown better HHV than others reported in literature, for instance Spruce wood and Beech wood with 19,5 MJ/kg and 18,6 MJ/kg respectively (SAIDUR et al., 2011).

4 I CONCLUSION

Through the thermogravimetric analysis it was possible to evaluate the amount of lignin. It isn't a real value because it's difficult to learn the loss of mass corresponding to each element constituting of the wood, bearing in mind that each individual has a peculiar chemical composition. However, for the generation of energy, it is desirable that among other features the ligno-cellulosic materials have a high percentage of lignin. In this context, the best indicated forest species is *Tachigali myrmecophilla* which in addition also emits few pollutants. Another advantage is that the species studied are also volatiles high content which results in a faster ignition point. In general, the *Ormosia paraensis* also had good energy performance when compared to the other nine species of this research and it has economic, social and ecological benefits as well.

REFERENCIES

AHMED, Ashfaq et al. Thermochemical characterisation of *Acacia auriculiformis* tree parts via proximate, ultimate, TGA, DTG, calorific value and FTIR spectroscopy analyses to evaluate their potential as a biofuel resource. **Biofuels**, p. 1-12, 2018.

ASADULLAH, Mohammad et al. Effects of biomass char structure on its gasification reactivity. **Bioresource technology**, v. 101, n. 20, p. 7935-7943, 2010.

BARROS, Sâmia Valéria dos Santos; NASCIMENTO, Claudete Catanhede do; AZEVEDO, Celso Paulo de. Caracterização tecnológica da madeira de três espécies florestais cultivadas no amazonas: alternativa para produção de lenha. **Floresta**, v. 42, n. 4, p. 725-732, 2012.

BARROS, Sâmia Valéria dos Santos; NASCIMENTO, Claudete Catanhede do; AZEVEDO, Celso Paulo de. Caracterização tecnológica da madeira de três espécies florestais cultivadas no amazonas: alternativa para produção de lenha. **Floresta**, v. 42, n. 4, p. 725-732, 2012.

BAXTER, Larry L. Ash deposition during biomass and coal combustion: a mechanistic approach. **Biomass and Bioenergy**, v. 4, n. 2, p. 85-102, 1993.

BURHENNE, Luisa; DAMIANI, Marco; AICHER, Thomas. Effect of feedstock water content and pyrolysis temperature on the structure and reactivity of spruce wood char produced in fixed bed pyrolysis. **Fuel**, v. 107, p. 836-847, 2013.

CHANDRASEKARAN, Sriraam R.; HOPKE, Philip K. Kinetics of switch grass pellet thermal decomposition under inert and oxidizing atmospheres. **Bioresource technology**, v. 125, p. 52-58, 2012.

CHANNIWALA, S. A.; PARIKH, P. P. A unified correlation for estimating HHV of solid, liquid and gaseous fuels. **Fuel**, v. 81, n. 8, p. 1051-1063, 2002.

DEMIRBAS, Ayhan. Higher heating values of lignin types from wood and non-wood lignocellulosic biomasses. **Energy Sources, Part A: Recovery, Utilization, and Environmental Effects**, v. 39, n. 6, p. 592-598, 2017.

DI BLASI, Colomba. Combustion and gasification rates of lignocellulosic chars. **Progress in energy and combustion science**, v. 35, n. 2, p. 121-140, 2009.

DOUTERLUNGNE, David; THOMAS, Evert; LEVY-TACHER, Samuel I. Fast-growing pioneer tree stands as a rapid and effective strategy for bracken elimination in the N eotropics. **Journal of Applied Ecology**, v. 50, n. 5, p. 1257-1265, 2013.

FATEH, Talal et al. Characterization of the thermal decomposition of two kinds of plywood with a cone calorimeter–FTIR apparatus. **Journal of Analytical and Applied Pyrolysis**, v. 107, p. 87-100, 2014.

FERRARA, Francesca et al. Pyrolysis of coal, biomass and their blends: Performance assessment by thermogravimetric analysis. **Bioresource technology**, v. 171, p. 433-441, 2014.

FERREIRA, Maraísa Costa et al. Biomass and energy production at short rotation *Eucalyptus* clonal plantations deployed in Rio Grande do Norte 1. **Revista Árvore**, v. 41, n. 5, 2017.

GAŠPAROVIČ, L. et al. Calculation of kinetic parameters of the thermal decomposition of wood by distributed activation energy model (DAEM). **Chemical and biochemical engineering quarterly**, v. 26, n. 1, p. 45-53, 2012.

GAŠPAROVIČ, Lukáš; KOREŇOVÁ, Zuzana; JELEMENSKÝ, Ľudovít. Kinetic study of wood chips decomposition by TGA. **Chemical Papers**, v. 64, n. 2, p. 174-181, 2010.

GONZÁLEZ, Martha Patricia et al. **Análisis Termogravimétrico de la Pirólisis de Biosólidos de la Planta de Tratamiento de Agua Residual El Salitre**. Tese de Doutorado. Universidad Nacional de Colombia. 2015.

JAYARAMAN, Kandasamy; KOK, Mustafa Versan; GOKALP, Iskender. Pyrolysis, combustion and gasification studies of different sized coal particles using TGA-MS. **Applied Thermal Engineering**, v. 125, p. 1446-1455, 2017.

JINDAL, Rohit; SWALLOW, Brent; KERR, John. Forestry-based carbon sequestration projects in Africa: Potential benefits and challenges. In: **Natural Resources Forum**. Oxford, UK: Blackwell Publishing Ltd, 2008. p. 116-130.

KANURY, A. Murty. Thermal decomposition kinetics of wood pyrolysis. **Combustion and Flame**, v. 18, n. 1, p. 75-83, 1972.

KIM, Ung-Jin; EOM, Seok Hyun; WADA, Masahisa. Thermal decomposition of native cellulose: influence on crystallite size. **Polymer Degradation and Stability**, v. 95, n. 5, p. 778-781, 2010.

LI, Xiang et al. The utilization of bamboo charcoal enhances wood plastic composites with excellent mechanical and thermal properties. **Materials & Design**, v. 53, p. 419-424, 2014.

MAMLEEV, Vadim; BOURBIGOT, Serge; YVON, Jacques. Kinetic analysis of the thermal decomposition of cellulose: the main step of mass loss. **Journal of Analytical and Applied Pyrolysis**, v. 80, n. 1, p. 151-165, 2007.

MENG, Haiyu et al. Thermal behavior and the evolution of char structure during co-pyrolysis of platanus wood blends with different rank coals from northern China. **Fuel**, v. 158, p. 602-611, 2015.

METTLER, Matthew S.; VLACHOS, Dionisios G.; DAUENHAUER, Paul J. Top ten fundamental challenges of biomass pyrolysis for biofuels. **Energy & Environmental Science**, v. 5, n. 7, p. 7797-7809, 2012.

NOVAIS, Rui M.; SEABRA, M. P.; LABRINCHA, J. A. Wood waste incorporation for lightweight porcelain stoneware tiles with tailored thermal conductivity. **Journal of Cleaner Production**, v. 90, p. 66-72, 2015.

OBERNBERGER, Ingwald; BRUNNER, Thomas; BÄRNTHALER, Georg. Chemical properties of solid biofuels—significance and impact. **Biomass and Bioenergy**, v. 30, n. 11, p. 973-982, 2006.

PARIKH, Jigisha; CHANNIWALA, S. A.; GHOSAL, G. K. A correlation for calculating elemental composition from proximate analysis of biomass materials. **Fuel**, v. 86, n. 12-13, p. 1710-1719, 2007.

PINHEIRO, Hamida Assunção; WITKOSKI, Antonio Carlos. Entre a racionalidade produtiva e a conservação do ambiente: a produção oleira do município de Iranduba e suas consequências ambientais. **Latitude**, v. 5, n. 2, 2018.

POLETTO, Matheus et al. Thermal decomposition of wood: Influence of wood components and cellulose crystallite size. **Bioresource Technology**, v. 109, p. 148-153, 2012.

QUIRINO, Waldir F. et al. Poder calorífico da madeira e de materiais ligno-celulósicos. **Revista da Madeira**, v. 89, n. 100, p. e106, 2005.

RABAÇAL, Miriam et al. Kinetic modelling of sawdust and beech wood pyrolysis in drop tube reactors using advance predictive models. **CHEMICAL ENGINEERING**, v. 37, 2014.

SAIDUR, Rahman et al. A review on biomass as a fuel for boilers. **Renewable and sustainable energy reviews**, v. 15, n. 5, p. 2262-2289, 2011.

SANTOS, E. C. S. D.; SOUZA; R. C. R.; BARBOSA, K. H. N.;VASCONCELOS, M. A. D.,.

Caracterização energética de espécies lenhosas nativas da amazônia. Bonito. 2007.

SANTOS, Eyde C. S. D.; SOUZA, Rubem C. R.; SILVA Ennio P. D. et a. Elementos Contemporâneos Que Criam Oportunidade Para O Uso De Biomassa Lenhosa Para Fins Energéticos Na Amazônia. **Revista Brasileira De Energia**. 2005.

SANTOS, Eyde Cristianne Saraiva; SILVA, Ennio Peres da. Suprimento de biomassa lenhosa para cadeia produtiva da indústria oleira no Estado do Amazonas-Brasil. **Informe Gepec**, v. 17, n. 1, p. 132-149, 2013.

SILVA, J. de C.; BARRICHELO, L. E. G.; BRITO, J. O. Endocarpos de babaçu e de macaúba comparados a madeira de Eucalyptus grandis para a produção de carvão vegetal. **Ipef**, v. 34, p. 31-34, 1986.

SU, Yi et al. Characteristics of pine wood oxidative pyrolysis: Degradation behavior, carbon oxide production and heat properties. **Journal of analytical and applied pyrolysis**, v. 98, p. 137-143, 2012.

TRANVAN, Luan; LEGRAND, Vincent; JACQUEMIN, Frédéric. Thermal decomposition kinetics of balsa wood: Kinetics and degradation mechanisms comparison between dry and moisturized materials. **Polymer Degradation and Stability**, v. 110, p. 208-215, 2014.

VAN DE VELDEN, Manon et al. Fundamentals, kinetics and endothermicity of the biomass pyrolysis reaction. **Renewable energy**, v. 35, n. 1, p. 232-242, 2010.

VASSILEV, Stanislav V.; VASSILEVA, Christina G.; VASSILEV, Vassil S. Advantages and disadvantages of composition and properties of biomass in comparison with coal: An overview. **Fuel**, v. 158, p. 330-350, 2015.

VERHEYEN, Kris et al. Contributions of a global network of tree diversity experiments to sustainable forest plantations. **Ambio**, v. 45, n. 1, p. 29-41, 2016.

VINARDELL, M. P.; UGARTONDO, V.; MITJANS, M. Potential applications of antioxidant lignins from different sources. **Industrial crops and products**, v. 27, n. 2, p. 220-223, 2008.

VINARDELL, M. P.; UGARTONDO, V.; MITJANS, M. Potential applications of antioxidant lignins from different sources. **Industrial crops and products**, v. 27, n. 2, p. 220-223, 2008.

VLASSOV, Dmitri. **Combustíveis, combustão e câmaras de combustão**. UFPR, 2001.

WU, Yiqiang et al. Flame retardancy and thermal degradation behavior of red gum wood treated with hydrate magnesium chloride. **Journal of Industrial and Engineering Chemistry**, v. 20, n. 5, p. 3536-3542, 2014.

YUAN, Haoran et al. Influences of copper on the pyrolysis process of demineralized wood dust through thermogravimetric and Py–GC/MS analysis. **Journal of Analytical and Applied Pyrolysis**, v. 112, p. 325-332, 2015.

ZENG, Jijiao; SINGH, Deepak; CHEN, Shulin. Thermal decomposition kinetics of wheat straw treated by *Phanerochaete chrysosporium*. **International biodeterioration & biodegradation**, v. 65, n. 3, p. 410-414, 2011.

ZHANG, Zhezi et al. Effect of temperature and heating rate in pyrolysis on the yield, structure and oxidation reactivity of pine sawdust biochar. **Chemeca 2013: Challenging Tomorrow**, p. 863, 2013.

SOBRE OS ORGANIZADORES

Felipe Santana Machado

Felipe é professor de biologia, especialista em morfofisiologia animal e gestão ambiental, mestre em Ecologia Aplicada e doutor em Engenharia Florestal. Atualmente é professor efetivo de educação básica e tecnológica do Estado de Minas Gerais e apresenta vínculo funcional com o Programa de Pós Graduação em Engenharia Florestal (PPGEF) da Universidade Federal de Lavras (UFLA). Além de lecionar, atua em estudos de conservação e manejo de animais silvestres, principalmente sobre a relação da vegetação com vertebrados terrestres. Sua experiência profissional gerou uma ampla gama de publicações técnicas e científicas que incluem artigos científicos em revistas nacionais e internacionais, bem como relatórios técnicos de avaliação de impactos ambientais. Participa do grupo de pesquisa CNPq "Diversidade, Sistemática e Biogeografia de Morcegos Neotropicais" como colaborador.

Aloysio Souza de Moura

Aloysio é Biólogo, mestre em Ecologia Florestal, pelo Departamento de Ciências Florestais (DCF) da Universidade Federal de Lavras (UFLA) com ênfase em Avifauna de fitofisionomias montanas. É observador e estudioso de aves desde 1990, e atualmente doutorando em Ecologia Florestal, pelo Departamento de Ciências Florestais (DCF) da Universidade Federal de Lavras (UFLA) tendo como foco aves e vegetações de altitude. Atua em levantamentos qualitativos e quantitativos de avifauna, diagnostico de meio-biotico para elaborações de EIA-RIMA. Tem experiência nas áreas de Ecologia e Zoologia com ênfase em inventario de fauna, atuando principalmente nos seguintes temas: Avifauna, Cerrado, fragmentação florestal, diagnóstico ambiental, diversidade de fragmentos florestais urbanos e interação aves/plantas.

Agência Brasileira do ISBN
ISBN 978-85-7247-143-5
9 788572 471435