Forest Research
Open Access
ISSN: 2168-9776

Afe, Forest Res 2017, 6:1
DOI: 10.4172/2168-9776.1000196

Research Article Open Access

Significance of Ethanol Product of *Gmelina arborea*

Ademola Johnson Afe*

Department of Forestry and Wood Technology, Federal University of Technology, Nigeria

Corresponding author: Ademola Johnson Afe, Department of Forestry and Wood Technology, Federal University of Technology, Nigeria, Tel: 07030393531, E-mail: afeademola@gmail.com

Rec date: Feb 22, 2017; **Acc date:** Mar 28, 2017; **Pub date:** March 31, 2017

Abstract

This work covers the process of making Ethanol from wood dust instead of starchy biomass which could be meant for food or instead of overdependence on hydrocarbon source. The saw dust of *Gmelina arborea* was collected in a saw mill in Ore, Ondo State, Nigeria and it was used to produce ethanol by hydrolysis and fermentation processes. The density of the wood species was 570 kg/m^3. The ionic constituents of the ethanol from the wood biomass were analyzed using Fourier Transform Infrared Spectrometric Analyzer (FTIR) and Atomic Absorption Spectrometric Analyzer (AAS). The AAS result shows that the ethanol obtained from the wood species contains transition metals like Copper (Cu), Zinc (Zn), Cadmium (Cd) and Chromium (Cr) while the FTIR results show the presence of ethanol functional groups such as OH, Carbon to carbon single covalent bond which and these are normal components of ethanol in the conventional ethanol.

Keywords: Ethanol; Hemicellulose; Lignin; Caustic soda; Tetraoxosulphate (Vi) acid; Sugar; Filtration

Introduction

For several years, the major sources of power in Nigeria apart from the irregular hydroelectric power source as well as the solar power source is the crude oil fractions such as petroleum gas, petrol, kerosene, diesel, gas oil, lubricating oil, paraffin wax, Bitumen [1]. Unfortunately, these fractions are products of refineries which are not based in Nigeria. These petroleum fractions are used in driving engines, lighting of lamps and cooking gargets such as stoves, gas cookers etc.

The petroleum fractions whose sources are from Nigeria and some other countries, are too costly due to high cost of exportation of the crude oil resource for re ining in foreign countries and high cost of importation of the re ined oil.

Apart from the high cost of the crude oil fractions, incomplete combustion of the fractions of petroleum in engines brings about the release of a poisonous gas called carbon (ii) oxide to the atmosphere. Inhalation of carbon (ii) oxide by man and livestock causes serious respiratory problems which cause drastic increase in the mortality rate of organisms in the environment [1,2]. It can also result to the formation of carboxyl hemoglobin which forms insoluble stones that obstruct blood flow. The obstruction to blood circulation can result to hypotension/low blood pressure which can result to impotency [1,2]. The petroleum fractions obtained from some other countries contain lead dust and Sulphur impurities that are also injurious to man respiratory tract [1]. Crude oil mining process has been a major source of land, water and air pollution in Niger delta areas in Nigeria agricultural practices are things of the past in the affected states of the nation.

In order to check the adverse effects of petroleum fractions on lives, scientists discovered the use of ethanol, which burns completely with blue or smokeless flame and without carbon (ii) oxide emission as fuel alternative [3-8]. The common ethanol raw materials discovered over the years are starch (from grains/cereals) and hydrocarbon residue derived a ter fractional distillation of crude oil [1].

As the production of ethanol increased, the effect of biofuel on agricultural markets and the environment became increasingly an important bone of contention. The evolution of new biofuel production technologies helped to alleviate some of the concerns regarding the use of food for fuel by facilitating the use of non-feedstock [9-15]. It also alleviates some of the environmental concerns associated with grain ethanol production. In particular, ethanol produced from wood species is believed to hold great promise in this regard. Hence there brought the need for the development of an alternative means of ethanol derivation that reduces the competition between starch consumers and ethanol biofuel makers and in order to put an end to the use of hazardous and costly petroleum fractions.

This research therefore reveals a cost-effective method of ethanol production from the saw dust of (*Gmelina arborea*), the yield and the chemical composition of the ethanol produced from the saw dust of the wood dust (*Gmelina arborea*) in comparison with that of conventional ethanol.

Materials and Methods

Hydrolysis of lignocellulosic material

Gmelina arborea wood was turned to dust with the aid of a sanding machine. The dust was sieved to create uniformity of particles with the aid of sieve with the mesh size of 200 picometre (pm). The saw dust samples were then air dried for 12 hours to remove moisture. Air drying was preferably used to avoid massive escape of minerals to the atmosphere due to volatilization. A conical flask was filled with 100 g of dry sawdust of *Gmelina arborea* and 300 ml of 18 M H_2SO_4 (sawdust to acid (w/v) ratio is 1:3) was added to each of them at standard conditions. In 1000 ml beaker, 200 ml of distilled water was added and the acid solution was poured and stirred thoroughly [16-18].

Neutralization of acidified sugar solutions

8.5 M NaOH (caustic soda/sodium hydroxide) solution was prepared and added to the acidified sugar solution obtained. This is done to increase the pH of the resulting hydrolyzed cellulosic paste to about pH of 5-6 which is the suitable pH for the growth of Saccharomyces (Yeast cell) needed for fermentation.

Filtration of hydrolyzed solution

The neutralized solution was poured on the open flat surface of Buchner funnel whose protruding end was placed in a conical lask [19-25]. By so doing, the lignin component of the solution in form of black solid residue remained in the funnel, from where it was disposed while liquid filtrate of fermentable sugar solution was collected in the conical flask.

Fermentation and purification

About 10 g of potato dextrose Agar (PDA) was dissolved completely in 250 ml of water in a conical flask. The mixture was covered with cotton wool and foil paper and then sterilized in an autoclave at 121°C for 5 minutes. On removal, it was allowed to cool and then poured into Petri dishes and set aside so as to solidify. The Saccharomyces cerevisiae cells were then introduced into the Petri dishes with the aid of a sterilized inoculating loop. The Petri dishes were sealed and kept in an incubator for 48 hours at a temperature of 250°C.

The culture of Saccharomyces cerevisiae in the agar slant tube was dissolved in 10 ml of distilled water containing a drop of tween80 oil (an oil whose presence aids the growth of yeast according to Tran et al.) in a separate conical flask [26-35]. 10 ml of the solution was then added to the filtrate samples to ferment them. Ethanol fermentation was performed in a shaker incubator at 150 rpm (revolution per minute) for 72 hours at 36°C to allow it to ferment completely. The Ethanol solution was distilled using a distillation bath at 78°C as water distilled at 100°C. A pure ethanol was then obtained.

Chemical analysis of ethanol product of the wood

The authenticity of the ethanol was ascertained by determining its density according to Ababio and compared with that of conventional ethanol which is made from petroleum (hydrocarbon).

Ethanol derived from the wood dust of *Gmelina arborea* was tested for the concentration of Cadmion (Cd), Copper (Cu), Zinc (Zn), Chromium (Cr) as it was passed through Atomic Absorption Spectrometer. In the process, the ethanol was aspirated into an air-acetylene flame, which caused evaporation of the solvent and vaporization of the free metal atoms; a process known as atomization [36-45]. The concentration in part per million (PPM) of each of the metals present in the ethanol was measured with a conventional UV visible dispersive spectrometer with photomultiplier detector.

The various functional groups that constitute the molecular structure of ethanol was also tested for by passing the sample of the ethanol derived from the wood dust of *Gmelina arborea* through Fourier Transform Infrared Spectroscopy (FTIR) analyzer. The FTIR analysis was performed on a thermos Scientific-Nicolet 6700 FTIR spectrometer in attenuated total reflection infrared mode. The spectra were recorded in the wave number range of 4000 to 400 cm^{-1} in the transmittance mode at a resolution of 4 cm^{-1}, with 64 scans per specimen.

Results and Discussion

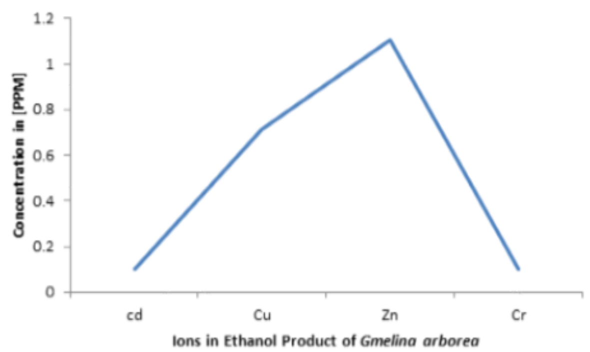

Figure 1: The Concentration in part per million (PPM) of some metallic ions constituent of ethanol sample produced from the wood dust of *Brachystegia eurichoma*.

The concentration in part per million (PPM) of Cadmion (Cd), Copper (Cu), Zinc (Zn) and Chromium (Cr) ion in the ethanol produced from the wood dust of *Gmelina arborea* is 0.100 ± 0.0028, 0.712 ± 0.0011, 1.103 ± 0.0009, 0.099 ± 0.0002 respectively. Copper (Cu) has the highest concentration in the ethanol product of *Gmelina arborea* . The metallic ion having the least concentration is the Cadmium ion (Cd) [46-50]. The metallic ion with the next highest concentration after Copper (ii) (Cu) ion is the Zinc (Zn) ion. The concentration of Cadmium (Cd) ion is lower than that of Zinc (Zn) and Copper (Cu) ion but higher than that of Chromate (Cr) in the ethanol made from the wood of *Gmelina arborea* (Figure 1).

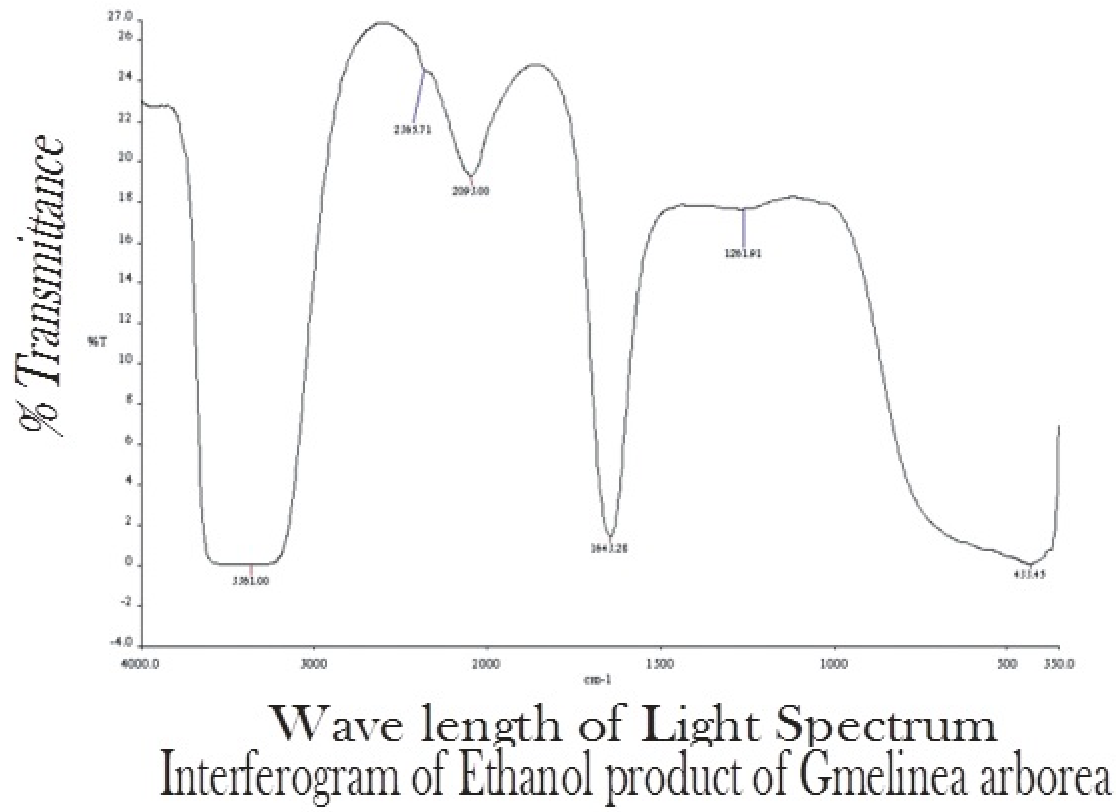

Figure 2: Wave length of Light spectrum.

Figure 2 above shows the interferogram of Ethanol produced from *Gmelina arborea*. The figure shows the following peaks of wave numbers: 3361 cm^{-1}, 2365.71 cm^{-1}, 2093 cm^{-1}, 1643.28 cm^{-1}, 1261.91 cm^{-1}, 433.45 cm^{-1}. The Wave number 3336 cm^{-1} shows the presence of OH compound like Ethanol, Xylitol, Alcoholic Lignin, Sugars from Cellulose and Hemicellulose [51-55]. The Wave number 2091 cm^{-1} shows the presence of compounds with carbon to hydrogen bond (CH) as in ethanol, Lignin, Cellulose and Hemicellulose sugars. The wave number 1643.28 cm^{-1} Shows the presence of compound that contain carbon to carbon double bond (C=C). This is common to phenolic compound like Lignin sub unit. The wave number 1259.06 cm^{-1} shows the presence of Phenolic OH group like Lignin. These are in agreement with the speci ication made by Bodîrlău et al. [56-60].

Conclusion

Waste wood biomass in form of saw dust can serve as the source of greenhouse free ethanol fuel as a good alternative to petroleum products whose cost of production is higher and also pollutes the air as it burns with smoky flames as well as a good alternative to ethanol produced from starchy Agricultural food stuffs which has been competing with man's food availability [61-65].

The ethanol from the wood biomass contains the following metallic ions: Cu^{2+}, Cd^{2+}, Zn^{2+} and Cr^{2+}. The ethanol from the wood biomass contains the following functional groups: -OH, C-C, C-H by which it is actually confirmed to be a real organic compound and the presence of OH group confirms that it is an organic compound that belongs to the same homologous series as ethanol [66-69]. The density of the ethanol produced from *Brachystegia eurichoma* sawdust is 0.8033 g/cm^3 and with this unique density the ethanol from the wood species is confirmed to be ethanol [70].

Recommendation

Petroleum economy is enviable but has a lot of terrible associated problems. Nations that rely solely on petroleum economy often slum into unforeseen fatal problems. Agro based Economy is therefore recommended because of its lasting effects, particularly for the African nations that are agrarians.

The wood biomass (*Gmelina arborea*) is recommended for ethanol production due to the priceless availability of its saw dust instead of depending on feed stock raw materials in order to save them for food security and continuity and instead of depending on very expensively produced fossil fuels called petroleum whose combustion releases poisonous exhaust to the environment.

Transition metals like Cu, Cd, Cr, Zn play important roles in binding enzymes to substrate sugars during the production of ethanol. They are readily present in the wood biomass of *Gmelina arborea*. For more efficient production of ethanol, the addition of transition metals to the substrate or the use of the sawdust of any of the three-wood species like *Gmelina arborea* is therefore recommended. Ethanol from wood biomass is therefore recommended as a good fuel alternative to costly and smoky petroleum fuel.

References

1. Ababio OY (2010) New School Chemistry for Senior Secondary Schools. AFP African First Publishers PLC. 3rd edn., IT Igbani Street, Malam Shehu Plaza, Jebi, Enugu, Nigeria, p: 628.
2. Idodo UG (2010) Idodo Umeh College Biology. 3rd edn. Idodo Umeh Publishers Limited, Eweh Road, Benin City, Nigeria, p: 657.
3. Otulugbu K (2012) Production of Ethanol from cellulose (sawdust). BSc Degree Thesis, Plastic Technology Department, University of Science and Technology, Arcada, Finland, p: 47.
4. Anyahoha MW (2010) New School Physics for Senior Secondary Schools. AFP African First Publishers PLC, 3rd edn, IT Igbani Street, Malam Shehu Plaza, Jebi, Enugu, Nigeria, p: 540.
5. Almeida JR, Modig T, Petersson A (2007) Increased tolerance and conversion of inhibitors in lignocellulosic hydrolysate by Saccharomyces cerevisiae. Chem Technol and Biotechnol 82: 340-349.
6. Akin DE, Benner R (1988) Degradation of polysaccharides and lignin by ruminal bacteria and fungi. Appl Environ Microbiol 54: 1117-1125.
7. American Plywood Association (APA) (2011) Ethanol fuel, Fuel Flow Meter. Retrieved from http://www.fuelflowmeter.net/ethanol-fuel/ Chicago.
8. Atchison JE, Hettenhaus JR (2003) Innovative Methods for Corn Stover Collecting, Handling, Storing and Transporting. National Renewable Energy Laboratory, US Department of Energy, USA, pp: 1-51.
9. Kenneth H (1990) Official methods of Analysis of Association of Official Analytical Chemists. 15th edn, AOAC International, Arlington, Virginia 22201, USA, pp: 1-656.
10. Ball DW (2006) Field Guide to Spectroscopy. SPIE Publication, Bellingham, USA, p: 124.
11. Baurhoo B, Ruiz-Feria CA, Zhao X (2008) Purified lignin: Nutritional and health impacts on farm animals-A review. Animal Feed Science and Technology 144: 175-184.
12. British Standard Institution BS 373 (1957) Methods of testing clear small specimen of timber. British Standard Institution, London, p: 32.
13. Bhat R, Karim AA (2009) Exploring the nutritional potential of wild and underutilized legumes. Comprehensive Reviews in Food Science and Food Safety 8: 305-331.
14. Bolza E, Keating WG (1972) African timbers: the properties, uses and characteristics of 700 species. Division of Building Research, CSIRO, Melbourne, Australia, p: 751.
15. Boullanger E (1924) Distilleria Agrico et industrielle. (Paris) Translation from the French by F. Marc de piolen, USA, pp: 3-8.
16. Burkill HM (2000) The useful plants of West Tropical Africa. 2nd edn. Families S-Z, Addenda, Royal Botanic Gardens, Kew, Richmond, United Kingdom, p: 686.
17. Burkill HM (1997) The useful plants of West Tropical Africa. 2nd edn. Families M-R, Royal Botanic Gardens, Kew, Richmond, United Kingdom, p: 969.
18. Chafe SC (1991) A relationship between equilibrium moisture content and specific gravity of wood. Journal of moisture of wood science 12: 119-122.
19. Chen CL (1991) Lignins: occurrence in woody tissues, isolation, reactions, and structure. Int Fiber Sci Technol 11: 183.
20. Cruz JM, Dominguez JM, Dominguez H, Parajo JC (2001) Antioxidant and antimicrobial effects of extracts from hydrolysates of lignocellulosic materials. J Agric Food Chem 49: 2459-2464.
21. David LN, Michael C (2005) Lehninger Principle of Biochemistry. 4th edn. Biochemistry and Molecular Biology Education 33: 74-75.
22. Desh HE, Dinwoodie JM (1963) Timber: Its structure, properties and utilization. 6th edn. Macmillan Education, London, p: 410.
23. Dinwoodie JM (1989) Wood nature's polymeric fibre composite. The institute of Metal, London, p: 138.
24. Doherty W, Mousavioun P, Fellows C (2011) Value-adding to cellulosic ethanol: Lignin polymers. Industrial Crops and Products 33: 259-276.
25. Ede RM, Kilpelaeinen I (1995) Homo- and hetero-nuclear 2D NMR techniques: unambiguous structural probes for non-cyclic benzyl aryl ethers in soluble lignin samples. Res Chem Inter med 21: 313-328.
26. Veronica F, Mariana OF, Sabrina MS, Nei P (2010) Simultaneous Saccharification and Fermentation process of different cellulosic substrate using a recombinant Saccharomyces cerevisiae harboring the β-glucosidase gene. Electronic Journal of Biotechnology 13: 1-8.
27. Eric M (2014) Wood database available at www.wood-database.com
28. Evans JW, Scarft JF, Gren DW (2000) Juvenile wood effect in red Adler: Analysis of physical and mechanical data to delineate Juvenile and wood zone. Forest Products Journal 50: 75-87.
29. Evans PO (1991) The strength properties of clear wood. Material Forum 15: 231-244.
30. Farmer RH (1981) Handbook of hardwoods. 2nd edn. Her Majesty's Stationery Office, London, United Kingdom, p: 243.
31. George GM (1975) The age of wood material engineering. Key note Address at the world consultation on wood based panels, New Delhi, India, pp: 1-4.
32. Harris EE, Beglinger GJ, Hajny, Sherrard EC (1945) Hydrolysis of Wood: Treatment with Sulfuric Acid in a stationary digester. Industrial and Engineering Chemistry 37: 12-23.
33. Hall JS, Medjibe V, Berlyn GP, Ashton PMS (2003) Seedling growth of three co-occurring Entandrophragma species (Meliaceae) under simulated light environments: implications for forest management in central Africa. Forest Ecology and Management 179: 135-144.
34. Hans-Walter H (2005) Plant biochemistry. 3rd edn. Elsevia Academic Press 200, Wheeler Road, Burlington, MA 01803, USA, p: 557.
35. Haygreen JG, Bowyer JL (1989) Forest Products and Wood Science: An Introduction. 2nd edn. Iowa state University Press, Ames Iowa, USA, p: 495.
36. Humphrey CN, Okafoagu UC (2007) Optimization of ethanol production from Garanian Kola (bitter kola) pulp Agro waste. Afr J Biotechnol 6: 2033-2037.
37. Henry NW, Dadmun MD (2009) Cell 217: Model compatibilizers for the lignin-polystyrene interface. The 237th ACS National Meeting, Salt Lake City, UT, United States.
38. Ifebueme SC (1977) National durability of wood with particular reference to west African timbers. Proceedings of international workshop on wood preservation, held at Ibadan, Nigeria, pp: 41-96.
39. Inderwildi OR (2009) Quo vadis biofuels? Energy and Environmental Science 2: 343-346.
40. Katende AB, Birnie A, Tengnäs B (1996) Useful trees and shrubs for Uganda: identification, propagation and management for agricultural and pastoral communities. Technical Handbook 12, Regional Soil Conservation Unit, Nairobi, Kenya.
41. Keay RWJ (1989) Trees of Nigeria: A revised version of Nigerian trees (1960, 1964). Clarendon Press, Oxford, United Kingdom, p: 476.
42. Keay RWJ, Onochie CFA, Stanfield DP (1965) Nigerian Tree. Department of Forest Research, Ibadan, Nigeria, p: 495.
43. Kirk TK (1971) Effects of microorganisms on lignin. Annu Rev Phytopathol 9: 185-210.
44. Kukkola EM, Koutaniemi S, Poellaenen E, Gustafsson M, Karhunen P, et al. (1970) Gmelina arborea. Fast growing timber trees of the lowland tropics No 1. Commonwealth Forestry Institute, Oxford, United Kingdom, p: 31.
45. Lourmas M, Kjellberg F, Dessard H, Joly HI, Chevallier MH (2007) Reduced density due to logging and its consequences on mating system and pollen flow in the African mahogany Entandrophragma cylindricum. Heredity 99: 151-160.
46. Massmann H (1968) Vergleich von Atomabsorption und Atomfluoreszenz in der Graphitküvette, Spectrochim. Acta Part B 23: 215-226.
47. Miidla H (1980) Lignification in plants and methods for its study. Regul Rosta Pitan Rast p: 87.

48. McCarthy GJ (2012) Walsh, Alan-Biographical entry. Encyclopedia of Australian Science, England.
49. Metcafe CR (1972) Botanical communications with special reference to Plant Anatomy in Ghouse. In: Yunus M, Reasearch Trends in Plant Anatomy. Tata McGraw Hill, New Delhi, USA, pp: 7-18.
50. Onyekwelu JC, Adeniji AO, Sanni DM (2008) Potentials of Gmelina arborea fruit pulp for ethanol production. In: Research for Development in Forestry, Forest Products and Natural Resources Management. Onyekwelu JC, Adekunle VAJ, Oke DO (eds.). Proceedings of the First National Conference of the Forest and Forest Products Society, Federal University of Technology Akure, Nigeria, pp: 177-181.
51. Oyeleke SB, Jibrin NM (2009) Production of bioethanol from guinea corn husk and Millet husk. African Journal of Microbiology research 3: 147-152.
52. Panshin AJ, Dezeuw C (1980) Textbook of wood Technology: structure, identification, properties, and uses of the commercial woods of the United States and Canada. 4th edn, McGraw Hill, New York, p: 722.
53. Ralph J, Lundquist K, Brunow G, Lu F, Kim H, et al. (2004) Lignins: Natural polymers from oxidative coupling of 4-hydroxyphenylpropanoids. Phytochem Rev 3: 29-60.
54. Raneses R, Hanson K, Shapouri H (1998) Economic impacts from shifting cropland use from food to fuel. Biomass bioenergy 15: 417-422.
55. Robert W (1990) Chromatography/Fourier transform infrared spectroscopy and its applications. Marcel Dekker, New York, p: 14.
56. Rubaba I (2007) An Analysis of producing Ethanol and Electric Power from Residues and Agricultural Crops in east Texas. Texas A & M University, USA, pp: 27-47.
57. Reti C, Casetta M, Duquesne S, Bourbigot S, Delobel R (2008) Flammability properties of intumescent PLA including starch and lignin. Polym Adv Technol 19: 628-635.
58. Saptari V (2003) Fourier-Transform Spectroscopy Instrumentation Engineering. SPIE Publication, Bellingham.
59. Stringer TW, Oslon JR (1987) Radial and Vertical variations in stem properties of juvenile black locus. Wood and Fibre Sci 19: 59-67.
60. Stuart B, George B, Peter M (1996) Modern Infrared Spectroscopy. Wiley, New York, USA, p: 66.
61. Smook GA (2002) Handbook for Pulp and Paper Technologies. 3rd edn, Angus Wilde Publications, Vancouver, British Columbia.
62. (2009) Journal of Wood Chemistry and Technology 30.
63. Toh K, Nakano S, Yokoyama H, Ebe K, Gotoh K (2005) Anti-deterioration effect of lignin as an ultraviolet absorbent in polypropylene and polyethylene. Polym J 37: 633-635.
64. Ugartondo V, Mitjans M, Vinardell MP (2008) Comparative antioxidant and cytotoxic effects of lignins from different sources. Bioresour Technol 99: 6683-6687.
65. Walsh A (1955) The application of atomic absorption spectra to chemical analysis. Spectrochim Acta 7: 108-117.
66. Africa Publisher and Sensitivity Analysis of a Gasifier and a Bioreactor. pp: 10-12.
67. Slavin W, Manning DC, Carnrick GR (1981) The stabilized temperature platform furnace. At Spectrosc 2: 137-145.
68. Zschiegner HJ (1999) Use of lignins and lignin derivatives as UV protectants for biological insecticides. DE 19: 750.
69. Bodirlau R, Teaca CA (2007) Chemical investigation on wood tree species in temperate forest, east- northern Romania. Bio Res 2: 41-57.
70. Afe AJ (2016) Examination of Chemical Properties of Ethanol Product of Brachystegia eurichoma Wood. Forest Res 5: 186.