

Research Application Summary

**Pyrolysis of blended and non-blended residues of pine and eucalyptus
forestry woods**

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Abstract

Over 11% of the 241551 sq. km of total land in Uganda is under forestry and woodland producing over 34.4 million tonnes of wood resource. However, about 65% of this resource remains as wood waste in form of saw dust, chips and offcuts of which 90% is unutilized, i.e., left to rot or burnt in the open at saw mills posing environmental and health issues. The main objective of this research is to assess the potential of pine and eucalyptus forestry wood wastes in the production of bio-fuels, that is, vinegar, bio-ethanol, bio-char and tar by pyrolysis that can be used as alternative sources of energy. Two (2) kilograms of wood wastes of each pine, eucalyptus and a blended mixture of pine and eucalyptus were fed in a 0.0376 m³ batch reactor initially at 27°C and heated at a rate of 10°C/min. to 400°C and held for 45 minutes. Chemical analysis of the obtained wood vinegar and tar samples was conducted using a gas chromatograph (GC) model 7820A equipped with a flame ionization detector (FID). Results showed that pine, eucalyptus, and a blended of the two produced vinegar that contained 15, 9 and 11 notable components, respectively. The principle components of wood vinegar were determined to beacetic acid, acetaldehyde, furfural, methyl-propyl-ketone (MPK), propanoic acid, acetone, and 3-hexanone. The tar made from pine, eucalyptus, and blended of the two contained 12, 9 and 11 notable components, respectively. The presence of the oxygenated aliphatic and aromatic hydrocarbons make the bio-oils a potential source of transportation fuels.

Key words: Bio-char, bio-ethanol, bio-fuels, eucalyptus, pine, pyrolysis, vinegar, tar, wood wastes

Résumé

Plus de 11% des 241551 Km² de la superficie totale en Ouganda est couverte de forêts et de bois produisant plus de 34,4 millions de tonnes de ressources en bois. Cependant, environ 65% de cette ressource reste en tant que déchets de bois sous forme de sciure, des copeaux, et des tronçons dont 90% est inutilisé, i.e, délaissés pour pourrir ou brûlés à l'air libre dans les scieries, posant des problèmes environnementaux et de santé. L'objectif principal de

cette recherche est d'évaluer le potentiel des déchets de bois de pin et d'eucalyptus dans la production de biocarburants, notamment le vinaigre, la bio-éthanol, le bio-char et le goudron par pyrolyse qui peuvent être utilisés comme sources alternatives d'énergie. Deux (2) kilogrammes de déchets de bois de chaque pin, d'eucalyptus et un mélange homogène de pins et d'eucalyptus ont été alimentés dans un réacteur par lot de 0,0376 m³ initialement mis 27°C et chauffé à un taux de 100°C / min. jusqu'à 400°C et maintenue pendant 45 minutes. L'analyse chimique des échantillons de vinaigre et de goudron de bois obtenus a été réalisée en utilisant un chromatographe en phase gazeuse (GC) modèle 7820A équipé d'un détecteur à ionisation de flamme (FID). Les résultats ont montré que le pin, l'eucalyptus, et un mélange homogène des deux ont produit du vinaigre contenant 15, 9 et 11 éléments notables, respectivement. Les principaux composants du vinaigre de bois ont été déterminés à l'acide beacétique, l'acétaldéhyde, le furfural, la méthyl-propyl-cétone (MPC), l'acide propanoïque, l'acétone et la 3-hexanone. Le goudron de bois de pin, d'eucalyptus, et du mélange homogène des deux contenait 12, 9 et 11 éléments notables, respectivement. La présence des hydrocarbures aliphatiques et aromatiques oxygénés fait les bio-huiles une source potentielle de carburants de transport.

Mots clés: Bio-char, bio-éthanol, bio-carburants, l'eucalyptus, le pin, la pyrolyse, le vinaigre, le goudron, les déchets de bois

Background

Uganda has approximately 241,551 sq. km of which currently 11% is under forestry and woodland (UBOS, 2014). In 2013, Uganda Bureau of Statistics (UBOS) and National Forestry Authority approximated that Uganda produced 44.7 million tonnes of wood resource (UBOS, 2014). In 2010, 117,000 m³ of sawn wood was produced. However, with the reported 20-35% sawmilling recovery (Kaboggoza, 2011), more than 76,000 m³ of sawmilling waste was produced. In most developing countries this resourceful wood waste is underutilized (UNEP, 2009; Mourant *et al.*, 2013). Currently in Uganda, less than 10% of the produced sawdust is utilized. This leaves almost all the produced sawdust unutilized and left to rot and/or is burnt in the open at the saw mills. This pose environmental and health issues such as greenhouse gas emission, formation of leachates, and blockage of sewer systems, water courses and channels. Therefore, there is an urgent need for proper usage and handling of this otherwise useful waste. Considering the sawdust handling shortcomings and the declining fossil fuels reserves and their related environmental issues, wood residues could be incorporated in the energy line. Assessing and implementing the potential of sawdust in the production of bioethanol will certainly boost the economic development of Uganda and improving the livelihoods of farmers at large.

Pyrolysis of wood biomass ensures efficient utilization of the natural resource and also prevents environmental pollution that results from their usual inappropriate disposal. The use of pyrolysis fuels comes with significant environmental benefits in terms of reduced global warming contribution, reduced fossil CO₂ emissions, reduced fossil fuel dependence, but also boosts rural development. The major products of pyrolysis of biomass include; vinegar, tar, bio-char and the flammable non-condensable gases. Vinegar from different

sources has been reported to contain about 200 chemicals (Kim *et al.*, 2008). The use of pyrolysis oil from various biomasses has for long proved a suitable replacement of the petrochemicals (Serrano-Ruiz *et al.*, 2012). In addition to that, vinegar has for long been considered a promising substitute for dangerous synthetic pesticides. Many research and policy documents have highlighted the need for replacement of such pesticides (Tiilikkala *et al.*, 2010). This oil is considered a better alternative because it is got from renewable sources, has proved to be environmentally friendly, and can easily breakdown in the environment. It is also relatively of low cost compared to inorganic pesticides. Bio-char is considered to be a good soil re-conditioner, whereas tar is useful for tarmacking of roads. The non-condensable gases of pyrolysis are flammable and therefore a potential source of energy. With such value added products, pyrolysis of wood residues is a potential solution for the underutilized wood residues.

Pine and eucalyptus are the most grown and harvested exotic tree species in Uganda for saw log and plywood production (Kaboggoza, 2011). Pine occupies 80% of government plantations in Uganda (Kaboggoza, 2011). Though Eucalyptus has been traditionally used for poles and firewood, it is also currently recognized as a reliable source of timber for heavy and light construction projects. By the end of 2010, pine made up of 54% of private plantations, followed by Eucalyptus at 17% (Kaboggoza, 2011). Therefore, the residues of pine and eucalyptus forestry woods were the focus of this study. The main objective of this study was to examine the potential of pine and eucalyptus forestry wood wastes in the production of bio-fuels, that is, vinegar, bio-ethanol, bio-char and tar by pyrolysis that can be used as alternative sources of energy.

Study description

The study was carried out at Makerere University Agricultural Research Institute Kabanyolo (MUARIK). Pine, eucalyptus and a blended mixture of pine and eucalyptus wood wastes each of 2kg were fed in a 0.0376m³ batch reactor initially at 27°C and ran at a heating rate of 10°C/min. to 400°C and held for 45 minutes. Gas chromatography was used to analyse the wood vinegar samples collected from various biomass sources. For the chromatography analysis, a gas chromatograph (GC) model 7820A from Agilent Technologies was utilized. Experiments were conducted using an Agilent DB-624 UI column with a length of 30 m, diameter of 0.250 mm, and film thickness of 1.40 µm. The GC was equipped with a flame ionization detector (FID). The temperature program began at 35°C, held for 1 minute, then ramped at 120°C/minute to 265°C and held for 10 minutes, for a total run time of 34 minutes.

Results

Results showed that vinegar from pine, eucalyptus, and a blended of the two contained 15, 9 and 11 notable components, respectively. The principle components of wood vinegar were mainly oxygenated aliphatic and aromatic hydrocarbons, that is, acetic acid, acetaldehyde, furfural, methyl-propyl-ketone, propanoic acid, acetone, and 3-hexanone. The tar from pine, eucalyptus, and blend of the two contained 12, 9 and 11 notable components, respectively. The chromatograms obtained from the GC analysis are shown in Figures 1-6.

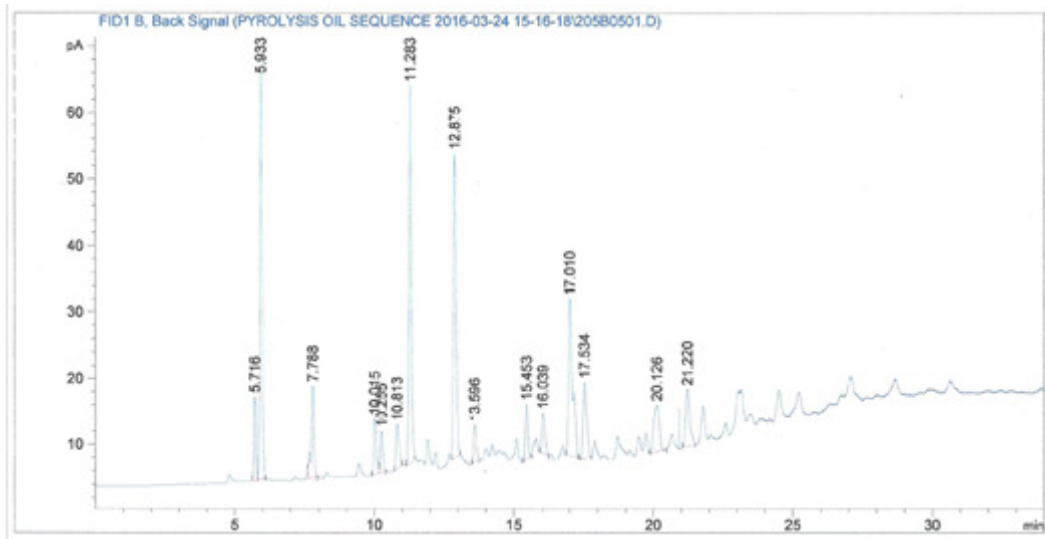


Figure 1. The chromatogram obtained from the GC analysis of Pine wood vinegar

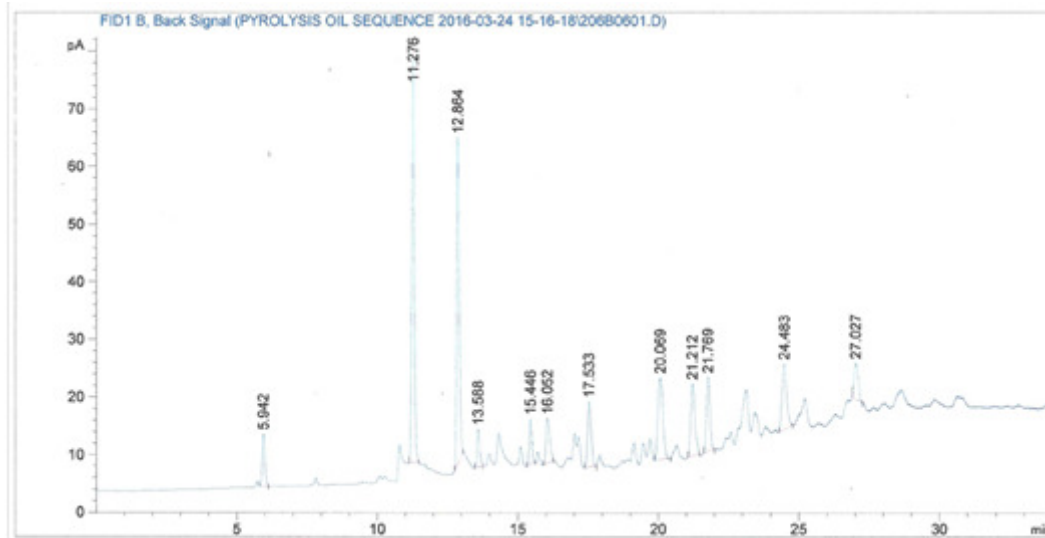


Figure 2. The chromatogram obtained from the GC analysis of Pine tar

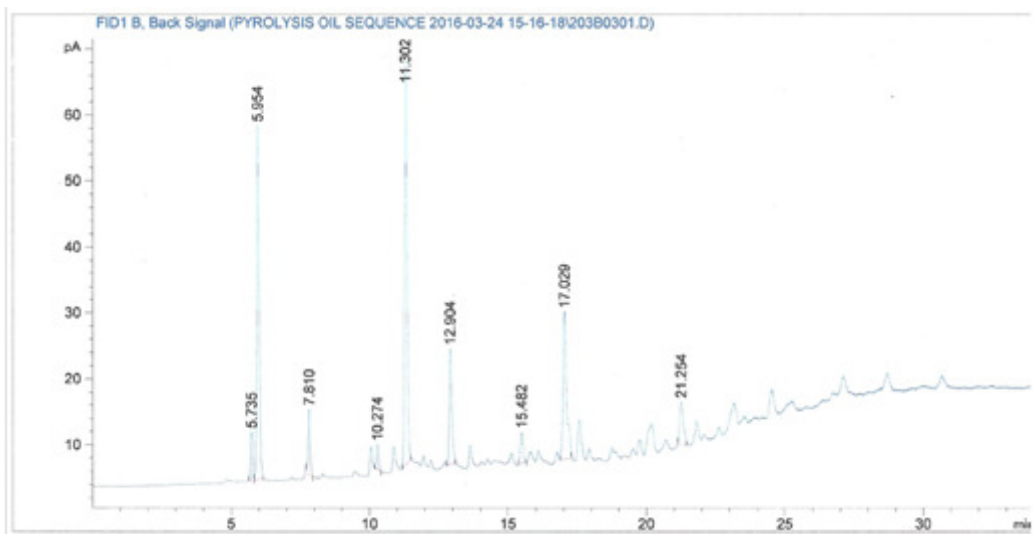


Figure 3. The chromatogram obtained from the GC analysis of Eucalyptus vinegar

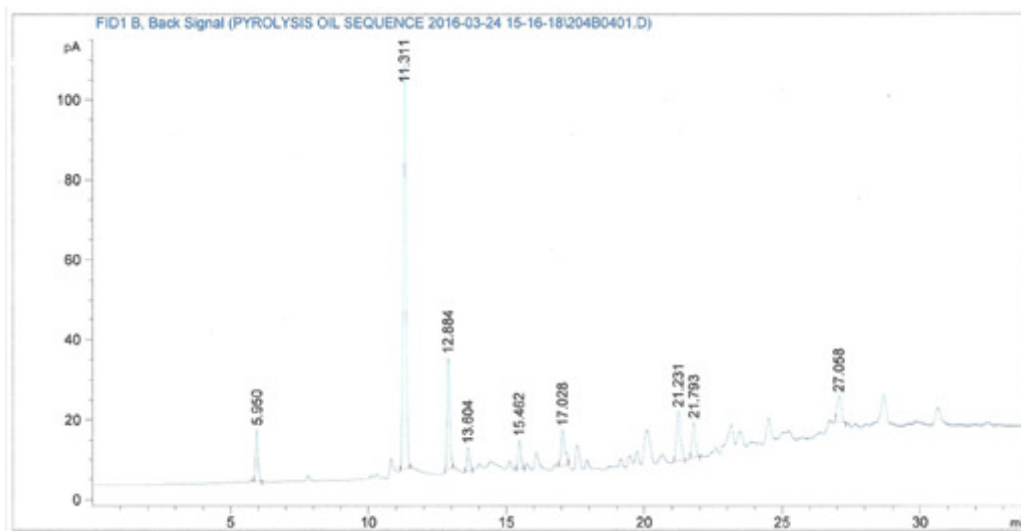


Figure 4. The chromatogram obtained from the GC analysis of Eucalyptus tar

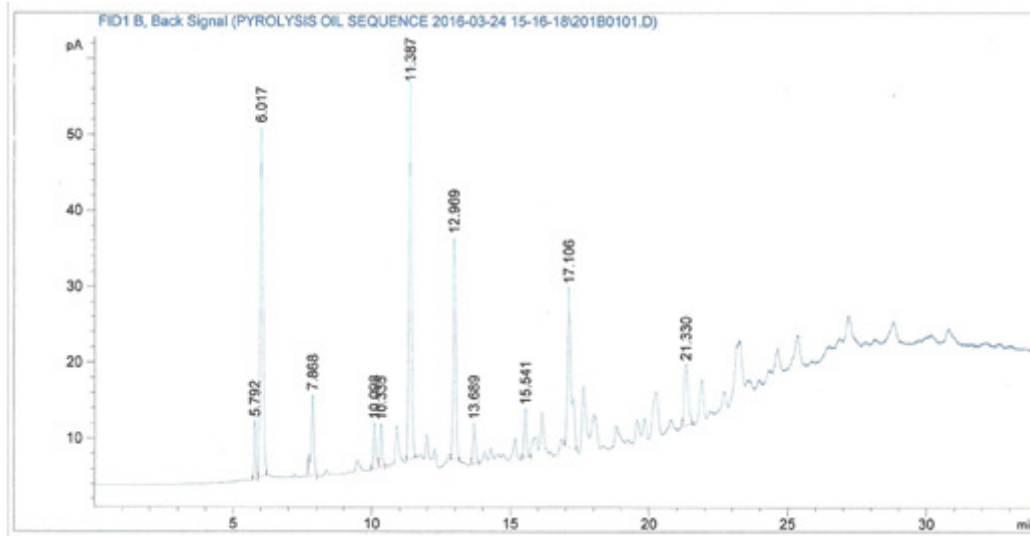


Figure 5. The chromatogram obtained from the GC analysis of Eucalyptus and pine vinegar

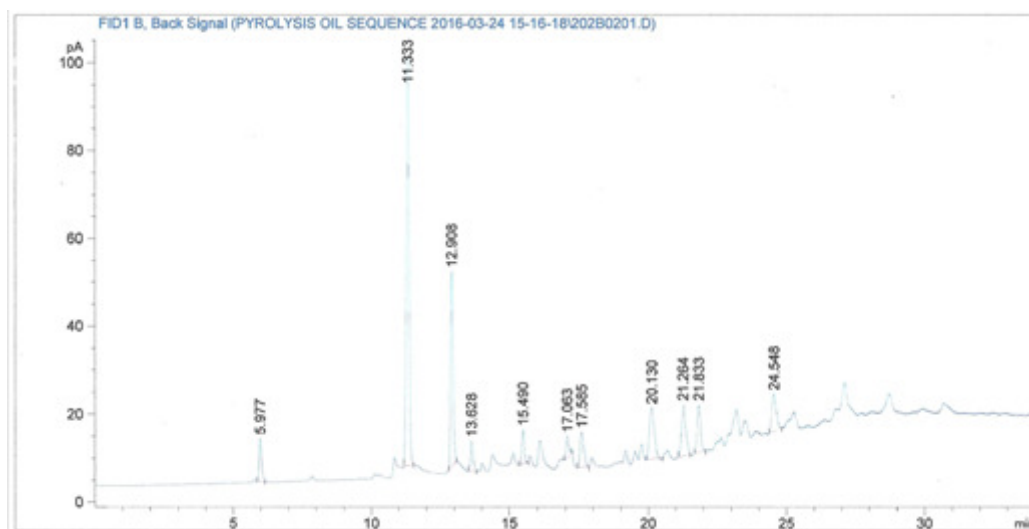


Figure 6. The chromatogram obtained from the GC analysis of Eucalyptus and pine tar

Conclusion

Wood residues from eucalyptus and pine forestry woods seems to be a suitable raw material for pyrolysis conversion into value added liquid and gaseous products. The presence of aliphatic and aromatic hydrocarbons in the wood vinegar is useful for production of transport fuels. This is in agreement with Yorgun and Yildiz (2015) study on paulownia woods. The study is still ongoing on the suitability of the wood vinegar for use as a pesticide and the quality of the produced bio-char.

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