Energy Reports 7 (2021) 1256–1266

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Transforming corn stover to useful transport fuel blends in resource-limited settings

Nicholas Munu [a,b,c,*], Noble Banadda [a,d], Nicholas Kiggundu [a], Ahamada Zziwa [a], Isa Kabenge [a], Jeffrey Seay [a,e], Robert Kambugu [a], Joshua Wanyama [a], Albrecht Schmidt [f,g]

[a] Department of Agricultural and Biosystems Engineering, Makerere University, P.O. Box 7062, Kampala, Uganda
[b] Department of Crop Production and Management, Busitema University, Arapai Campus, P.O. Box 203, Soroti, Uganda
[c] Department of Mechanical Engineering, Ndejje University, P.O. Box 7088, Kampala, Uganda
[d] Department of Agricultural and Biosystems Engineering, Iowa State University, 1340 Elings Hall, Ames, IA 50011 – 3270, USA
[e] Department of Chemical and Materials Engineering, University of Kentucky, Paducah, KY 42002, USA
[f] Christliche Fachkräfte International, Wächterstraße 3, 70182 Stuttgart, Germany
[g] Energy Research & Development Centre, Ndejje University, P.O. Box 7088, Kampala, Uganda

ARTICLE INFO

Article history:
Received 25 August 2020
Received in revised form 13 January 2021
Accepted 11 February 2021
Available online xxxx

Keywords:
Bio-oil
Corn stover
Diesel
Emulsion
Fuel

ABSTRACT

Development of local technologies is crucial to the sustainable energy agenda in resource-limited countries and the world. Strengthening local green technologies and promoting local utilization will reduce carbon emissions that could be generated during transportation and delivery of green products from one country to another. In this paper we developed bio-oil/diesel blends using a low-tech pyrolysis system designed for smallholder farmers in developing countries and tested their appropriateness for diesel engines using standard ASTM methods. Corn stover retrieved from smallholder farmers in Gayaza, Uganda were pyrolyzed in a batch rocket stove reactor at 350 °C and liquid bio-oil harvested. Bio-oil chemical composition was analyzed by Gas Chromatography equipped with Flame Ionization Detector (GC-FID). Bio-oil/diesel emulsions in ternary concentrations 5%, 10% and 20% bio-oil weight were developed with 1% concentration of sorbitan monolaurate as an emulsifier. The bio-oil/diesel emulsions and distillates had property ranges: specific gravities at 15 °C 827.4–830.7 kg m^{-3}, specific gravities at 20 °C 823.9–827.2 kg m^{-3}, kinematic viscosities at 40 °C 3.01–3.22 mm^2/s, initial boiling points 140–160 °C, final boiling points 354–368 °C, and calculated cetane indexes 56.80–57.63. These properties of the bio-oil/diesel blends and their distillates compare well with standard transportation diesel fuel. The emulsion distillates meet the standard requirements for automotive diesel in East Africa.

1. Introduction

The current energy and climate change challenges demand quick transition to a renewable energy path. Upsurge in global population, urbanization, standard of living, and transportation signal depletion of world's fossil fuel reserve in the near future (Ogunkunle and Ahmed, 2019; Capellán-Pérez et al., 2014; Shafiee and Topal, 2009; Dresselhaus and Thomas, 2001). This concern coupled with the fact that fossil fuels emit large quantities of primary greenhouse gases CO_2, CO, NO_x and unburnt HCs (Shekofteh et al., 2020; Heidari-Maleni et al., 2020) that catapult global warming contextualizes recent expansion in alternative fuel research (Kumar et al., 2020a; Karmee, 2016). Currently, however, fossil fuel provides 76% of world's energy supply (Olivier et al., 2017) and is expected to be the lead energy source for the foreseeable future (Dresselhaus and Thomas, 2001). It is anticipated that global transition to cleaner energies with lower carbon footprint will be gradual and present strategy consists in consistently lowering and replacing fossil fuel content of energy carriers with cleaner renewable contents. One approach fuel scientists are exploring is blending petroleum fuels with alternative fuels in order to decrease fossil fuel dependence and enhance alternative fuel utilization in the present transportation fuel infrastructure (Farooq et al., 2019). For example, European Union (EU) member states aimed for a 10% renewable share in transportation fuel mix by 2020 (Al Jamri et al., 2020).

* Corresponding author at: Department of Agricultural and Biosystems Engineering, Makerere University, P.O. Box 7062, Kampala, Uganda.
E-mail address: nicholasmunu@yahoo.com (N. Munu).

https://doi.org/10.1016/j.egyr.2021.02.038