International Journal of Materials Engineering and Technology
© 2023 Pushpa Publishing House, Prayagraj, India
http://www.pphmj.com
http://dx.doi.org/10.17654/0975044423001
Volume 22, Number 1, 2023, Pages 1-5 P-ISSN: 0975-0444

SELECT HIGHLIGHTS OF RECENT RESEARCH ON TURNING TEXTILE WASTE AND RECYCLED TEXTILES INTO BIODIESEL

Radhakrishnaiah Parachuru

School of Materials Science and Engineering
Georgia Institute of Technology
Atlanta, GA, U. S. A.

Abstract

Global warming alerts and threats are on the rise due to the utilization of fossil fuels. Alternative fuel sources like bioethanol and biodiesel are being produced to combat these threats. Bioethanol can be produced from a range of substrates. Cellulose-rich substances like cotton waste which is generated in millions of tons around the globe can be used for the production of biofuels. Biodiesel is a long chain mono-alkyl-ester fatty acid derived from renewable feedstock, plant biomass, cellulosic materials, vegetable oils, animal fats, etc. Biodiesel can be mixed with petrol and the mixture can be used as a fuel for internal combustion engines. Figure 1 is an illustration of the main steps involved in turning biomass into biodiesel.

Received: February 25, 2023; Accepted: March 28, 2023

Keywords and phrases: fermentation, corona treatment, enzymatic hydrolysis, bioethanol, cellulose.

How to cite this article: Radhakrishnaiah Parachuru, Select highlights of recent research on turning textile waste and recycled textiles into biodiesel, International Journal of Materials Engineering and Technology 22(1) (2023), 1-5.

http://dx.doi.org/10.17654/0975044423001

Published Online: June 1, 2023

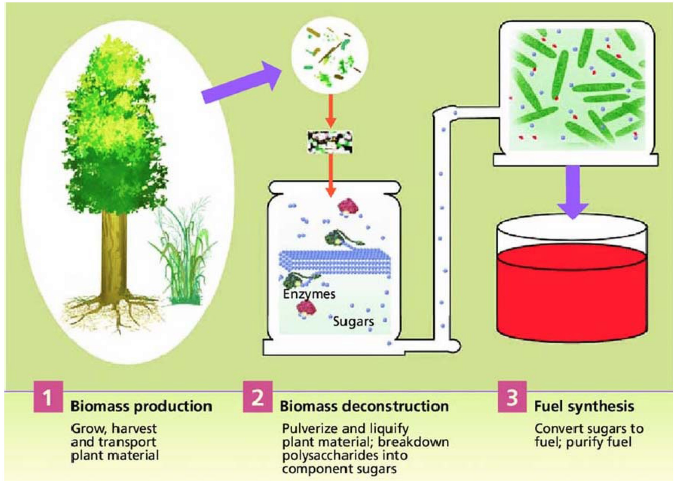

Figure 1. Illustrative image showing steps involved in converting biomass to biofuel. Image adapted from DOE Genome Programs (http://genomics.energy.gov).

Introduction

This paper picked a few selected research papers that focused on the use of textile waste and other cellulosic materials as feedstock for converting them into biodiesel. The main findings of the selected publications are presented in the following highlights. It is hoped that this short paper will serve as a catalyst not only for initiating new research work in the area but also to generate new entrepreneurial interest for turning textile waste into cash while simultaneously reducing the environmental burden.

Research Highlights

This study of Nikolić et al. [1] highlights the potential of cotton fabric as a promising feedstock for the production of bioethanol as renewable biofuel. The effect of corona pretreatment of non-mercerized and mercerized cotton fabrics on glucose and ethanol yield was discussed. Fermentation kinetics for ethanol production and the basic process parameters were assessed and compared. Corona pretreatment of cotton fabrics led to an increase in the glucose yield (compared to control sample) during enzymatic hydrolysis, and consequently to ethanol yield increase during fermentation by yeast Saccharomyces cerevisiae var. ellipsoideus. The system with mercerized cotton fabric was found to be superior giving an ethanol yield of 0.94 g/g (based on glucose) after 6h of fermentation time. Similar results were obtained on waste cotton materials processed under the same process conditions. Results showed that cotton fabric could become an alternative feedstock for bioethanol production. For potential industrial implementation, mercerized cotton scrap yarns, fabrics and garments were considered as the most suitable.

Arthe and coworkers [2] demonstrated that cellulose rich waste can be used for the production of bioethanol with the help of microbial cellulase enzyme. They studied the bioconversion of cellulosic cotton waste to ethanol with the help of cellulase enzyme synthesized from Trichoderma reesei (MTCC#164). They felt that this approach would help textile manufacturers and waste recycling companies to generate wealth from waste. Since all types of cellulosic biomass may not be fermentable without an appropriate pretreatment, dilute sulfuric acid pretreatment was applied to make the cellulose contained in the waste susceptible to cellulase enzyme. A range of acid pretreatments of cotton waste were made, and the pretreated cotton waste samples were fermented with Saccharomyces cereviseae. The waste material pretreated with 3% dilute sulfuric acid produced viable yield of ethanol.

Ethanol production from waste biomass using a slightly modified bio-refinery approach was demonstrated by Ramamoorthy and his associates [3]. A mixture of surgical waste cotton and waste packaging cardboard showed 70% lignin removal after a 15% v/v ammonia pretreatment. Optimized saccharification using in-house cellulases produced from Trichoderma harzanium ATCC 20846 had a percentage saccharification of 45%. Optimized fermentation using Saccharomyces cereviseae strain RW143 resulted in a yield of 0.4g ethanol/g glucose. The distilled ethanol had 90% (v/v) concentration and 180 proof purity. 1kg of biomass mixture when processed as mentioned yielded 120mL ethanol. Two diesel-ethanol blends (E-10 and E-20) and a commercial diesel control were used to rate an IC engine's brake power.

Another group of researchers claim a number of environmental and economic benefits for biofuels [4] derived through natural fibers. According to them, production of bioethanol from biomass is one way to reduce both consumption of crude oil and environmental pollution. The use of bioethanol blended gasoline fuel for automobiles can significantly reduce petroleum use and exhaust greenhouse gas emissions. Bioethanol can be produced from different kinds of raw materials. These raw materials are classified into three categories of agricultural raw materials: simple sugars, starch, and lignocellulose. Bioethanol from sugarcane, produced under the proper conditions, is essentially a clean fuel and has several clear advantages over petroleum-derived gasoline in reducing greenhouse gas emissions and improving air quality in metropolitan areas. Conversion technologies for producing bioethanol from cellulosic biomass resources such as forest materials, agricultural residues and urban wastes are evolving and may become commercially viable within the next few years.

According to Gupta and Verma [5], maize, sugarcane and sugar beets are major traditional agricultural crops used for bioethanol production, but these crops are unable to meet the global demand of bioethanol production due to their primary value of food and feed. Hence, cellulosic materials such as agroresidues are attractive feedstock for bioethanol production. Cellulosic materials are the most abundant biomass on the earth. Bioethanol from agroresidues could be a promising technology that involves the processes of pretreatment, enzymatic hydrolysis, fermentation, and distillation. These processes have several challenges and limitations such as biomass transport and handling and efficient pretreatment for removing lignin from lignocellulosic agroresidues. Proper pretreatment process may increase the concentrations of fermentable sugars after enzymatic hydrolysis, thereby improving the efficiency of the whole process. Other improvements in the form of efficient microbes, and genetically modified microbes may also enhance the enzymatic hydrolysis. Conversion of cellulose to ethanol requires new and improved pretreatments and more efficient enzymatic and fermentation technologies, to make the whole process cost-effective. The group talked about current and future technologies for sustainable bioethanol production from agroresidues.

Summary and Conclusions

This brief review suggests that generating biofuel from cellulosic material is a viable option. At the same time, the review also indicates that problems remain to be solved to scale up conversion to commercially viable levels.

References

[1] S. Nikolić, V. Lazić, Đ. Veljović and L. Mojović, Production of bioethanol from pre-treated cotton fabrics and waste cotton materials, Carbohydrate Polymers 164 (2017), 136-144. https://doi.org/10.1016/j.carbpol.2017.01.090.

[2] R. Arthe, R. Rajesh, E. M. Rajesh, R. Rajendran and S. Jeyachandran, Production of bioethanol from cellulosic cotton waste through microbial extracellular enzymatic hydrolysis and fermentation, Electronic Journal of Environmental, Agricultural and Food Chemistry 7(6) (2008), 2948-2958.

[3] N. Kumar Ramamoorthy, S. Ravi and R. Sahadevan, Production of bioethanol from an innovative mixture of surgical waste cotton and waste cardboard after ammonia pre-treatment, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 40(20) (2018), 2451-2457. https://doi.org/10.1080/15567036.2018.1502843.

[4] M. Balat and H. Balat, Recent trends in global production and utilization of bio-ethanol fuel, Applied Energy 86(11) (2009), 2273-2282. https://doi.org/10.1016/j.apenergy.2009.03.015.

[5] A. Gupta and J. P. Verma, Sustainable bioethanol production from agro-residues: a review, Renewable and Sustainable Energy Reviews 41 (2015), 550-567. https://doi.org/10.1016/j.rser.2014.08.032.