Fuel 153 (2015) 19–30

Contents lists available at ScienceDirect

Fuel

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

Fuel property quantification of triglyceride blends with an emphasis on industrial oilseeds camelina, carinata, and pennycress

A.C. Drenth [a,*], D.B. Olsen [a], K. Denef [b]

[a] Department of Mechanical Engineering, Engines and Energy Conversion Laboratory, Colorado State University, Fort Collins, CO, USA
[b] Department of Chemistry, Central Instrument Facility, Colorado State University, Fort Collins, CO, USA

HIGHLIGHTS

- Triglyceride blends are physically and chemically stable.
- Camelina, carinata, and pennycress fuel properties are similar to traditional oils.
- Renewable diesel has similar fuel property performance to petroleum diesel.
- Triglyceride blends may be an ideal fuel pathway for farm-scale fuel production.

ARTICLE INFO

Article history:
Received 20 January 2015
Received in revised form 19 February 2015
Accepted 20 February 2015
Available online 7 March 2015

Keywords:
Industrial oilseeds
Biodiesel
Renewable diesel
Triglyceride blends
Emulsion fuels
NMR spectroscopy

ABSTRACT

Industrial oilseeds camelina (*Camelina sativa* L.), carinata (*Brassica carinata*), and pennycress (*Thlaspi arvense* L.) offer great potential as biofuel feedstocks. Their positive agronomic attributes allow for cropping systems and rotations that increase biofuel production on existing lands. The objective of this study was to perform a comprehensive fuel property evaluation of these promising oilseeds and compare them to several traditional oils. Three industrial (camelina, carinata, pennycress) and four conventional (soybean, canola, sunflower, corn) oilseed feedstocks were evaluated and compared. Both crude and refined oils were used in the evaluation to determine refinement's effect on fuel properties. Straight vegetable oil (SVO), biodiesel (B100), triglyceride blends (TGB), and renewable diesel (R100) fuel pathways were compared to petroleum diesel for the fuel properties that were measured. The paper focuses on TGBs as an on-farm fuel pathway, since the commercial market for these oils is still emerging. The TGB blend percentage of vegetable oil to E10 gasoline was varied to show its effects on fuel properties. For several feedstock and fuel pathway combinations, this paper presents the first published fuel property results. The physical and chemical properties of TGBs were also studied through phase diagrams and NMR spectroscopy. TGBs were found to be both physically and chemically stable over the expected timescale of use. For the TGBs, several fuel properties were improved compared to SVO due to the addition of gasoline, such as viscosity, density, speed of sound, heating value, and cold flow properties. Flash point was reduced due to the volatility of the gasoline component, hence users should treat TGBs with same handling and storage precautions as gasoline. The results were similar for the industrial oils as the traditional oils in the evaluation. The results show TGB may be an ideal fuel pathway for farm-scale fuel production or for other users in remote areas using locally sourced plant oils as feedstock.

Published by Elsevier Ltd.

1. Introduction

1.1. Industrial oilseed's role in a constrained agronomic environment

Industrial oilseeds camelina (*Camelina sativa* L.), carinata (*Brassica carinata*), and pennycress (*Thlaspi arvense* L.) are alternative non-food oilseeds which have great potential to increase biofuel use and reduce cost. The positive agronomic attributes of these oilseeds allow them to fit into cropping systems and rotations that increase biofuel production on existing lands [1]. One example is fitting into the wheat-fallow rotation common in the Western U.S. Due to their short growing season and low water demands, camelina and carinata could be grown during this normally fallow period. Instead of a fallow period, an oilseed offers growers additional revenue from the energy crop as well as increased weed control, decreased soil erosion, carbon

* Corresponding author at: Powerhouse Energy Campus, 430 N. College Ave., Fort Collins, CO 80524, USA. Tel.: +1 850 4993844; fax: +1 970 4913827.
E-mail address: aaron.drenth@colostate.edu (A.C. Drenth).

http://dx.doi.org/10.1016/j.fuel.2015.02.090
0016-2361/Published by Elsevier Ltd.

sequestration, disruption of undesirable pest cycles, and other benefits for the follow-on crop [2].

These oilseeds may also play an important role in the future of agriculture in areas that face harsh growing conditions. Industrial oilseeds have shown reduced water demand compared to traditional oilseed crops in some scenarios [3]. For example, agronomic trials have found camelina is better able to compensate for early water deficits [4] and has less aggressive soil water extraction than some traditional oilseeds [5]. Another benefit is fall planted and spring harvested oilseeds have peak water needs during a traditionally low water demand period [6]. Finally, these industrial oilseeds may also work well in fields that are under water leasing arrangements. This arrangement may be especially important to Colorado and other regions with water constraints. More than 80% of Colorado's 5.2 million population lives in the 12 county region of the Front Range [7]. The population growth in this region has been higher than the national average for over 20 years, with projected population to nearly double between year 2000 and 2040 [8]. Population growth can create a struggle for water between agriculture and municipal uses. Rotational fallowing or other water leasing arrangements are alternatives that would allow water resource availability for municipal use while still sustaining agricultural production. For example, this type of ag/urban water sharing agreement is under study in Colorado's Arkansas River Basin and would provide an estimated 9100 acre-feet of water annually by 2050 [9].

Despite the promise of these industrial oilseeds, the commercial market for them is still maturing. For example, it was recently estimated camelina is only grown on ~1% of the wheat-fallow acreage it is well-suited for, with 95% of camelina oil production used in biofuel test programs [10]. Until the commercial market matures, the use of these oilseeds to produce on-farm fuel may be the only viable market in some areas. Recent studies have found the economics for farm scale fuel production can be favorable in some scenarios [11,12]. The quantity of fuel used on farms is significant; in some Midwestern U.S. states farm use of distillate fuel represents more than 20% of total consumption [13].

1.2. Fuel pathways for vegetable oil

Due to the great potential of oilseeds camelina, carinata, and pennycress in this region, the Engines and Energy Conversion Laboratory (EECL) at CSU recently completed a compression ignition engine (diesel engine) performance and emission evaluation of these feedstocks using multiple biofuel pathways [1]. The objective of the study reported herein is to build on the engine testing results with a comprehensive evaluation of several fuel properties for these promising oilseeds, including three industrial oilseeds (camelina, carinata, pennycress) and four conventional (soybean, canola, sunflower, corn) biofuel feedstocks. Our fuel property evaluation compares the more traditional biofuel pathways of straight vegetable oil (SVO), biodiesel (B100), and renewable diesel (R100) [14,15] with the less known triglyceride blends (TGB) pathway. A triglyceride-blend (TGB) is formed when SVO is mixed with another less viscous fuel (other than petroleum diesel), and the resulting solution used as a petroleum diesel substitute [1]. E10 gasoline was used to form the TGBs in this study unless otherwise noted. Peer reviewed literature found on this type of blend is extremely limited, although several U.S. farmers have been successfully using SVO–gasoline blends for several years [16]. Using E10 gasoline as a blending agent has several benefits: it is readily available, has high energy content, inexpensive, and has shown complete miscibility and stability with SVO during EECL testing. Like other blends/emulsions of this nature, as compared to biodiesel, producing TGBs is fast, requires low energy inputs, does not create waste products, and does not require a catalyst [1,17]. They can be splash blended, and do not need changes in temperature, pressure, or large amounts of agitation to form a solution. TGBs change the physical properties of SVO to be more similar to petroleum diesel; the recent engine testing at the EECL has found this type of blend compatible with modern direct injection (DI) engines without modification [1].

Fuel property evaluations for these industrial oilseed feedstocks have been completed for the biodiesel (B100) fuel pathway [18–22], but not for the R100 and TGB pathways. TGB fuel property data has also not been reported for the conventional oils of this study. This research explores how several key fuel properties of industrial oilseeds compare to conventional biofuel feedstocks. There is no ASTM standard for TGB fuels, so the results of the properties tested are directly compared to petroleum diesel and to the other renewable fuel pathways. This paper will concentrate on TGBs since it is a fuel conversion method that is easily adaptable by farm-scale producers. The previously mentioned engine testing used TGBs formed using a 75% SVO to 25% E10 gasoline volumetric ratio. This fuel property study also explores how other blend ratios affect fuel properties.

2. Materials and methods

2.1. Test fuel preparation

Oil extraction and fuel preparation methodologies for SVO, B100, and TGB fuels were kept consistent with typical farm-scale fuel procedures. Since most farm-scale producers do not have access to large scale refining, crude (unrefined) vegetable oil was used as the biofuel feedstock unless otherwise noted. To evaluate the effect of oil feedstock refinement on fuel properties, biofuels produced from both crude and refined, bleached, and deodorized (RBD) soybean and corn oil were used in testing. The sources of oil and other testing materials are shown in Table 1.

The TGBs used in the evaluation were formed by initially filtering the SVO with a 10 μm polypropylene filter, then blending with E10 gasoline at various volumetric ratios. The resulting TGB was transferred to a high-density polyethylene (HDPE) container, then agitated by manually shaking the container for ~30 s to ensure adequate mixing before filtering again to 1 μm.

Table 1
Source of testing materials.

Material	Source	Location
Carinata oil	Agrisoma Bioscience, Inc.	Saskatoon, SK, Canada
Camelina oil	ClearSkies, Inc.	Bozeman, MT, USA
Pennycress oil	Arvens Technology, Inc.	Peoria, IL, USA
Soybean oil	South Dakota Soybean Processors, LLC	Volga, SD, USA
Corn oil	Glacial Lakes Energy	Watertown, SD, USA
Canola oil	Painted Rock Farms	Stratton, CO, USA
Sunflower oil	Prairie View Farms	Penokee, KS, USA
Carinata R100, ReadiDiesel®	Applied Research Associates, Inc.	Panama City, FL, USA
Camelina R100, hydrotreated renewable diesel	Chevron Corporation	Richmond, CA, USA
Diesel fuel, Grade No. 2-D S15	Team Petroleum, LLC	Fort Collins, CO, USA
Ethanol, ACS/USP grade	Pharmco-Aaper	Brookfield, CT, USA
E0 gasoline, 87 octane	Hill Sinclair	Greeley, CO, USA
E10 gasoline, 87 octane	Agfinity Cooperative	Eaton, CO, USA

Download English Version:

https://daneshyari.com/en/article/6635497

Download Persian Version:

https://daneshyari.com/article/6635497

Daneshyari.com