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A comprehensive review on properties of edible and non-edible vegetable oil-based biodiesel: Composition, specifications and prediction models

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ABSTRACT

In recent decades, the concern over depletion of the world's petroleum reserves and environmental pollution has increased the demand to develop a renewable and environmental friendly fuel. Biodiesel, which mainly consists of Fatty Acid Methyl Esters (FAME) is one of the best substitutes for diesel fuel. Currently, vegetable oils, edible or non-edible, are the main resources of biodiesel. This review aims at providing comprehensive information and analyzes on biodiesel produced from edible and non-edible vegetable oils, their composition and specifications. Accordingly, the Fatty Acid (FA) profiles of 28 edible vegetable oils and 40 non-edible vegetable oils were collected. Their main specifications including sulfur content, density, viscosity, flash point, cloud point, pour point, cold filter plugging point, cetane number, iodine number, heating value, acid value and carbon residual before and after transesterification (vegetable oil and biodiesel, respectively) were analyzed in detail.

Many researchers have developed prediction models to quantify biodiesel specifications to optimize its manufacturing and obtain biodiesel with the best specifications. Three factors that are especially influential are the fatty acids profiles, the degree of unsaturation within the FA structures and molecular weight. Accordingly, many models have been constructed on these features. There are also models that quantify the relationship between the biodiesel specifications and its thermodynamic properties or other specifications. Accordingly, the second part of this work was conducted on the existing prediction models. All the models were discussed along with their deviation in prediction.

Contents

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1. Introduction

Since the industrial revolution, global energy consumption has increased dramatically due to economic development, industrial/technological development and rapid population growth. Depletion of natural resources, waste disposal, environmental pollution (air, water and soil), global warming, climate change, deforestation and ozone layer depletion are a few examples of degraded environmental quality due to industrial growth. In fact, these problems are linked to a wide range of predictable and unpredictable disasters i.e. economic crisis, human health issues, etc. This has made human being to search for green technologies to generate clean, safe, sustainable and renewable energy resources for future generations on top of eliminating the existing harms caused by environmental degradation. Besides, at the consumption rate of 11 billion tones yearly, fossil fuel will soon be depleted. Developing an alternative energy is an inevitable choice for harmonious coexistence of environment and human as well as for sustainable economic growth in the human society. Accordingly, renewable energy sources, i.e. biofuels, have gained much attention. Biofuel is gaseous or liquid fuels such as bioethanol, ethanol, methanol and biodiesel generated from biomass.

Fig. 1 shows the global energy consumption by source from year 1990 to 2015 and its prediction till 2035 [1]. In 2015, 85.76% of the global energy consumption came from natural gas (24.36%), coal (28.93%) and liquids (32.45%, mainly oil, biofuels, gas-to-liquids and coal-to-liquids). Although the global energy consumption will keep rising till 2035, it is predicted that the use of these resources will reduce to 81.27%, among which 26.11% is supplied by natural gas, 26.14% by coal and 29.01% by liquid sources. However, it should be noted that the use of biofuel will increase from 5.26% in 2015 to 13.02% in 2035 (Fig. 2) [2]. Among the biofuel, biodiesel fuels, mainly the mixtures of fatty acid methyl or ethyl esters (FAMEs or FAEEs), will become the most popular alternative energy resource. According to International Energy Agency's (US EIA, Eurostat), global biodiesel production has increased ten folds in the last decade [3].

Non-toxicity, renewability, biodegradability, inherent lubricity, low or no sulfur content, high flash point, domestic origin and also contributes to the reduction of most regulated exhaust emissions are the main advantages of biodiesel. However, it faces to some technical challenges regarding its specifications which are note comparable with those of petroleumbased-diesel i.e. oxidative stability, cold flow properties, viscosity [4]. To ensure the satisfactory use of biodiesel, it should be provided with the best