ABSTRACT

Increased consumption and energy security issues have led many developed and developing countries to seek methods to produce alternative fuels. Biodiesel is one such high-density alternative fuel that can increase the longevity of transportation fuels. Biodiesel can be produced from a wide range of feedstock using simple process schemes. In the past, edible oils were used as feedstock for biodiesel fuel production; however, use of non-traditional feedstock like waste cooking oil, non-edible oils, animal fats, and algae can make biodiesel production a sustainable process. The high free fatty acids content in the feedstock, longer reaction rates, high energy consumption, and the catalysts used in the conversion process pose some limitations for current biodiesel production. These limitations can be addressed by developing novel process techniques such as microwaves and ultrasound and by developing non-catalytic transesterification methods. Enhancing byproduct recovery seems to be an important strategy to improve the energy footprint and economics of current biodiesel production.
INTRODUCTION

The United States of America (USA) consumes over 50 billion gallons of diesel fuel per year for transportation purposes (Gallagher, 2011; Gude et al., 2013a) and about 65% of these fuels are imported from foreign countries. In 2007, the USA Government Accountability Office reported the need to develop a strategy for addressing a peak and decline in oil production (US Government Accountability Office, 2007). Declining oil production will cause oil and diesel prices to rise sharply creating a strong market for replacement fuels. Apart from this, increasing energy use, climate change, and carbon dioxide (CO₂) emissions from fossil fuels make switching to low-carbon fuels, also known as alternative fuels, a high priority (Fargioni et al., 2008). Alternative fuels are the fuels derived from sources other than petroleum. These are developed to extend the useful life and longevity of existing petroleum fuel sources that are depleting due to increased consumption and non-renewability. These alternative fuels include but not limited to biofuels, solar energy, wind energy, hydrogen and hydroelectric power. Biofuels can serve as ideal candidates to replace a part of petroleum based fuels in the transportation sector. Biofuels research has gained increasing attention in the past few years due to the limited availability of petroleum fuels and the environmental concerns associated with their use. Among the biofuels, bioethanol, biogas, and biodiesel are the most commonly used commodities in various sectors. These can be produced from various feedstock using different extraction and conversion processes. Biofuels can be produced from a variety of feedstock and are classified into three generations based on their relevance to human interests and environmental impacts. The first generation biofuels like bioethanol are produced from edible sources like starch, sugars, and vegetable oils. The second generation biofuels can be produced from non-edible oils like jatropha, waste cooking oil and lignocellulosic biomass like switch grass. The third generation biofuels are known as algae biofuels which are produced from algal biomass. All the three generation biofuels have their limitations such as fuel and food issue, larger land needs and high production costs. Therefore, careful utilization of combination of these three generations biofuels can address the current day fuel issue.

Among the biofuels, biodiesel is comparatively a high-density energy carrier which can be directly utilized as a fuel source in the transportation and other industrial sectors. Biodiesel is an alternative liquid fuel that can substantially replace conventional diesel and reduce exhaust pollution and engine maintenance costs. This renewable fuel can be produced from any feedstock that contains lipid/oil constituents. Biodiesel production has increased significantly over the past decade due to the aforementioned reasons as shown in Figure 1. The world biodiesel production has increased by more than 25 times over the past decade (between 2001 and 2012) while the USA biodiesel production has developed new trends in recent years (Gude et al., 2012). In addition, the USA biodiesel production increased by more than 27% from 2012 to 2013. This increase can be directly related to the escalating gasoline and diesel prices over the past decade which are expected to rise in the future (US EIA, 2009). Apart from that, local biofuel production may play a critical role in promoting economic, energy, and environmental security of the nation. In 2007, the U.S. government has committed to increase the renewable fuel production to 36 billion gallons per year by 2022 (EISA, 2007).

This chapter discusses the use of non-conventional feedstock and novel technologies for energy-efficient and sustainable biofuel production. Non-conventional and renewable feedstock include waste cooking oils and microalgae respectively. Novel process intensification techniques discussed here are microwaves and ultrasound. A detailed discussion on the development and production of microwave