



Biodiesel production from neem towards feedstock diversification: Indian perspective

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ARTICLE INFO

Article history:

Received 6 January 2011

Received in revised form 2 September 2011

Accepted 4 October 2011

Available online 29 October 2011

Keywords:

Biodiesel feedstock

Neem

Transesterification

Sustainable development

Integrated approach

ABSTRACT

In developing countries like India where 70% of country's petroleum needs are met by import, energy security assumes significance in view of uncertainty of supply and increasing price of petroleum fuels. Fuels of bio origin not only provide energy security, but also reduce emissions of harmful pollutants and greenhouse gases and ensure rural upliftment by increasing employment in agricultural sector. India cannot afford to produce biodiesel from edible oil seeds as it is done in the American and European countries. Extensive focus has been given on producing biodiesel from non-edible sources, specifically from *Jatropha*. Discrepancies between the expectation and realities regarding *Jatropha* as a feedstock necessitate efforts for diversification of the feedstocks. Scientific research should therefore be directed towards oilseeds like Karanja, Sal, Mahua, Neem, etc. that are widely available and sustainable to the diverse socio-economic and environmental conditions of rural India. Among them the evergreen neem with its wide availability and various useful uses may be a potential feedstock for biodiesel production. In this paper attempts have been made to overview the morphology of neem tree, various useful uses, physical and chemical characteristics of neem oil and optimized production process for biodiesel production from neem oil.

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1. Introduction

Energy is the key input for technological, industrial and socio-economical development of any country or region. Petroleum oil, natural gas, electricity and coal are the major commercial sources of energy across the world. Most of the current energy requirements in India are fulfilled by fossil fuels – coal, petroleum-based products and natural gas. In India, 95% of transportation energy is provided by oil and the demand for diesel is five times higher than the petrol demand. It was estimated that for sustaining India's 8% average annual economic growth and to support its growing population, India needs to generate 2- to 3-fold more energy than the present [1]. Since these commercial sources are finite and continuous depletion of fossil fuels is taking place, energy supplies in the world are becoming unsustainable. Dependence on fossil fuels also causes environmental problems both locally and globally. India ranks fifth after USA, China, Russia and Japan in producing high rate of emission and creating environmental and ecological imbalances.

Despite awareness drives and governmental initiatives towards popularizing and production of non-conventional energy, petroleum remains the primary energy source in India as a preferred fuel. Its consumption has been increasing at a very steep rate from 3.5 MT in 1950–1951 to 84.3 MT in 1997–1998 and projected to reach 200 MT in 2011–2012. The need of the hour is to conserve petroleum by its judicious use and to substitute it by other renewable resources wherever feasible. Renewable energy sources provide several significant benefits such as energy security, reduced emission of pollutants, greenhouse gases and increased employment in the agricultural sector. In its fourth assessment report, the intergovernmental panel on climate change (IPCC) confirmed that climate change was accelerating and if current trends continued, energy-related emissions of carbon dioxide (CO₂) and other greenhouse gases will rise inexorably, pushing up average global temperature by as much as 6 °C in the long term [2]. Hence, to reduce emissions of harmful pollutants and to conserve the environment, biofuels are going to play an extremely important role in developing countries like India by meeting country's energy demands.

Bio-diesel is one of the candidates as an alternate to diesel and is being explored world over because of its properties like high cetane number, low sulfur content and better lubricity than petro-diesel, which makes it an excellent fuel for diesel engines [3]. The various engine and vehicle tests conducted so far indicate the vehicle performance to be satisfactory with blends up to 20% of bio-diesel in diesel. The emissions of carbon monoxide and particulates are also lower with bio-diesel and petro-diesel blends [4]. Benefits for carbon credits exist on account of lower carbon dioxide emissions with use of bio-diesel. While blends up to 20% are quite common abroad, the Indian vehicle manufacturers are initially apprehensive and recommend use of only 5% or 10% of bio-diesel in diesel.

Biodiesel is produced from biological sources such as vegetable oils or animal fats using a biochemical process known as

transesterification. The use of edible vegetable oils and animal fats for biodiesel production has recently been of great concern because they compete with food materials [5]. India is one of the leading importers of edible oils as demand exceeds the domestic production. As the demand for vegetable oils for food has increased tremendously in recent years, it is impossible to justify the use of these oils for fuel use purposes such as biodiesel production. Thus, the contribution of non-edible oils will be of great importance in the coming days as source for biodiesel production. It is estimated that the potential availability of such oils in India amounts to about 1 million tons per year, the most abundant oil sources are sal oil, mahua, neem oil and *Pongamia pinnata* [6].

In recent past, *Jatropha curcas* has been identified as major feedstock for biodiesel production in India because of its various speculated advantages such as wide adaptability, low requirement of water and fertilizers, pest resistance, low gestation period, high seed yield and oil content, easy propagation, and not browsed by cattle. But in practice, it shows wide variation in seed yield and oil content under different soil and agro-climatic conditions which present substantial risk and challenges that need to be addressed before huge monoculture plantation of this particular crop. Hence diversification of non-edible feedstocks is the call of the day towards ensuring sustainable supply of the renewable oil. This paper reviews the potential non-edible oil sources for production of biodiesel and focuses specifically on neem as a non-edible feedstock with an integrated approach for sustainability in renewable oil supply.

2. Energy security

2.1. India's energy outlook

India currently ranks as the world's 11th greatest energy producer, accounting for about 2.4% of the world's total annual energy production, while it ranks as the world's sixth greatest energy consumer, accounting for about 3.3% of the world's total annual energy consumption. India is one of the countries where the present level of energy consumption, by world standards, is very low. India, with over a billion people, today only produces 660 billion KWh of electricity and over 600 million Indians, a population equal to the combined population of USA and EU, have no access to electricity, and limited access to other clean, modern fuels such as LPG and kerosene [7]. Per capita energy consumption in India is less than 500 kgoe (Kilogram Oil Equivalent), compared to the global average of nearly 1800 kgoe.

It is estimated that India has only 0.4% of the world's proven reserves of crude oil. India meets about 70% of its petroleum requirements through imports which are expected to expand in coming years. During the last three decades, the production of crude oil in the country has increased from 6.82 million tons in 1970–1971 to 34.12 million tons in 2007–2008 [8]. In India, the

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