Musa "*PisangAwak*" (Banana Peel) – A Novel Renewable Heterogeneous Catalyst for Biodiesel Production

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Energy becomes an inevitable part of a nation's development and its requirement is increasing at a faster rate due to the urbanisation, industrialisation and transportation sectors. Till date, this huge energy demand in India is predominantly met by utilising fossil-derived fuel resources such as coal, crude oil, and natural oil, which are non-renewable in nature. Extreme utilisation of these fossil reserves results in the emission of harmful greenhouse gases and hence, India stands third in the liberation of CO_2in 2016 (2431 Mt CO_2) preceded by China (First, 10151 Mt CO_2) followed by USA (Second, 5312 Mt CO_2) (Source: Global Carbon Atlas [http://globalcarbonatlas.org/en/CO2-emissions]).A huge share of transportation fuel demand in India was met by employing diesel (72%), petrol (23%) while the CNG and LPG account for the rest (National Policy on Biofuels, 2018).Presently, 210MMT of crude oil is needed for petroleum products based consumption. However, the domestic production entails only 17.9% while the rest is met through imports. This heavy exploitation of imported non-renewable oil sources will tremble nation's energy security and therefore, it forced the researchers, industrialists, and government to search and to develop different alternative renewable fuels in order to minimise the exploitation of fossil fuel reserves.

Biofuels are renewable fuels, which are derived from lignocellulosic biomass, municipal and industrial waste materials.Biodiesel is a biofuel, which is chemically mono-alkyl esters of long chain fatty acids developed from renewable lipid based feed stocks, has commanded immense attention in the field of renewable fuel research due to its characteristics such as biodegradability, renewability,

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* Mr. Balajii Muthusamy, Ph.D. Scholar from PSG College of Technology, Tamil Nadu, is pursuing his research on "A Novel Study on Biodiesel Production from Non-Edible Oils using Heterogeneous Catalytic System." His popular science story entitled "Musa "PisangAwak" (Banana Peel) – A Novel Renewable Heterogeneous Catalyst for Biodiesel Production" has been selected for AWSAR Award.

non-explosive, non-toxicity, no or less emissions, nonflammable, and its direct application in diesel engines without any major alterations. The physico-chemical properties of biodiesel are analogous to conventional petro-diesel and making it appropriate for commercialisation.

The four main methods appliedfor biodiesel production are (i) pyrolysis process, (ii) micro-emulsification, (iii) blending of oil with diesel fuels, and (iv) transesterification process. Among these methods, the most widely employed method was transesterification, which is basically the chemical reaction between oil and short chain alcohol in the presence of an acid or alkali catalyst to produce fatty acid methyl esters (biodiesel) and glycerol.

Additionally, a major problem associated with biodiesel production is the availability of feedstock. The lipid feedstock utilised for biodiesel production can be majorly categorised as vegetable oil (edible oil and non-edible), animal wastes and recycled oil. During the past few decades, non-edible oils were utilised as an alternative low-cost renewable feedstock to decrease the biodiesel production cost and to overcome the conflicts possessed by edible oils.*Ceibapentandra*, a non-edible plant which is native to India, Sri Lanka and Southeast Asia, belongs to the Malvaceae family. Kapok tree bears pendulous, oblong-ellipsoid shaped capsules containing numerous brown seeds entrenched in silky hair. The seeds of *C. pentandra* contain 25-28% of oil in each fruit and is used for fuel and in the manufacture of ointments, paints, soaps, and as a substitute or adulterant for several edible oils such as olive oil and cotton seed oil. Several researchers have reported that it exhibits huge potential as a feedstock for biodiesel production.

The catalyst used for biodiesel production can majorly be classified as homogeneous and heterogeneous catalyst. The choice of catalyst depends on the amount of free fatty acid (FFA) present in the raw material. The conventional catalyst utilised for biodiesel production is homogeneous catalyst (includes acid and alkali). Homogeneous alkali catalysts such as potassium hydroxide, sodium hydroxide are widely used for large-scale production of biodiesel owing to its advantages such as shorter reaction time, high catalytic activity, modest operating conditions, abundant availability and low cost. Besides several advantages in using homogeneous catalyst, the major limitation relies on the purification of biodiesel, which requires an enormous amount of water invariably leading to the generation of a large amount of waste water. Moreover, the catalyst cannot be recovered and reused.

To overcome the above-mentioned problems, our research group has developed an eco-friendly, highly active heterogeneous catalyst derived from the banana peel (*Musa* "PisangAwak) for biodiesel production.

Banana has been widely cultivated in more than 26 states of India which includes Gujarat, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Maharashtra, Karnataka, Madhya Pradesh, Bihar, Kerala, West Bengal, Assam, Chhattisgarh, Odisha, Tripura, Telangana, Mizoram, Nagaland, Meghalaya, Manipur, Arunachal Pradesh, Jharkhand, Punjab, Sikkim, Rajasthan, Himachal Pradesh, and other few states. Among these states, Gujarat, Andhra Pradesh, and Tamil Nadu occupy the top three places in banana production (Source: Horticulture Statistics at a glance 2017, Government of India).The banana *Musa* "PisangAwak" (Cultivar Name: Karpooravalli or Karpuravalli, Cultivar Group: ABB) is a popular banana variety cultivated widespread in Southern

and Central parts of Tamil Nadu and Kerala. In Bihar, it is cultivated under the name "Kanthali". This banana variety is the sweetest banana in India and is suited for marginal lands with low input conditions (Source: http://nhb.gov.in/pdf/fruits/banana/ban013.pdf). The ash coated golden yellowish colouredpeelwhich comprises 18-33% of the whole fruit has been regarded as waste and thrown to garbage in several places after using the banana pulp. Furthermore, the peel is rich in minerals such as sodium, potassium, calcium, magnesium and other trace elements. This peel upon calcination at a particular temperature over a particular time period yielded a highly efficient catalyst.

To test the effectiveness of the developed catalyst, M. Balajii and S. Niju performed a number of experiments in the laboratory to determine the maximum conversion of biodiesel. Non-edible *Ceibapentandra*oil was utilised as a feedstock and a biodiesel conversion of above 90% was observed by the authors.Biodiesel produced from non-edible *Ceibapentandra* oil using the banana peel ash derived catalyst was shown in Fig.1.

We found the purity of biodiesel and quality of glycerol to be good while using banana peel ash as a catalyst and the reaction conditions used in transesterification process was in comparable with the commonly used heterogeneous catalyst and possesses better catalytic activity. This catalyst is recyclable and can provide a sustainable solution to the waste water disposal problemarised by homogeneous catalyst in biodiesel process industries.

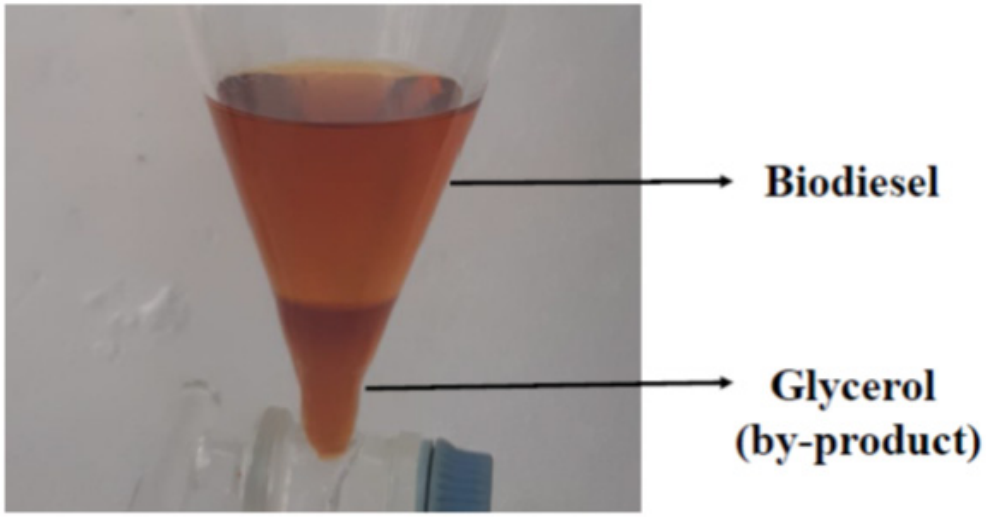

Fig. 1. Separated biodiesel and glycerol layers