Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

# Production of Biofuel by Catalytic Cracking Process using Coal Ash Catalyst and its Effects on DI Diesel Engine

**Muthukumaran N**

Department of Mechanical Engineering Government College of Engineering,
Dharmapuri-636704, Tamil Nadu,
India. Email: muthukumar_nv@yahoo.co.in

## ABSTRACT

In this study, the biofuel produced from the Pongamiapinnata seed seed oil through catalytic cracking process. In this process the Coal Fly Ash (CFA) is selected as a catalyst material for cracking process and the cracking process was conducted on a fixed bed catalytic cracking reactor at the temperature range of 450-500$^{o}$C.the CFA analyzed through EDS (Energy Dispersive Spectroscopy), the resultsreveal the presence of oxide of aluminium, silicon and iron in it. The performance and emission characteristics of cracked oil are evaluated with diesel blends in single cylinder, four strokes, water cooled DI diesel engine. The results reveal that the Brake Thermal Efficiency (BTE) at B20 show the closer to neat diesel. The exhaust emission of oxides of nitrogen (NOx) and Smoke Density are decreased with increasing the maximum load for B100 than neat diesel. However, the emission of HC and CO slightly increasing with increasing the percentage of load than the neat diesel.

**KEYWORDS**: Pongamiapinnata seed, Catalytic cracking, Coal fly ash and EngineEmission

***Corresponding author**

**Dr. N. Muthukumaran**

Assistant Professor,

Department of Mechanical Engineering

Government College of Engineering,

Dharmapuri-636704, Tamil Nadu,INDIA.

Email:muthukumar_nv@yahoo.co.in, Mob No- 9894301560

# INTRODUCTION

Biofuels are non-fossil energy derived from organic materials such as vegetable oil or animal fat. Bio-fuel is defined as liquid or gaseous fuel that can be produced from utilization of bio mass substrates and can solve as a partial substitute for fossil fuels. Energy from renewable source is currently among the most researched topics around the globe because of the challenges that the world is facing. These challenges include high energy demand, especially in fast developing regions and depletion of fossil fuel reserves and environmental challenges. The effort to overcome these problems is increasing the production of bio-fuels. It is the fuel derived from vegetable oil, one of these is Pongamia Pinnata oil.

It is reported that biofuel leads to greenhouse gas reductions, on a well-to-wheel basis, of 40–60% when compared with conventional petroleum diesel[1]. In the USA alone, over 1.5 billion gallons of biofuel was produced from vegetable oils in past year[2]. Meanwhile, global biodiesel production and consumption is forecast to rise by 14% from 2016 to 2020, driven by the fulfillment of current biofuel policies in the US, Argentina, Brazil, Indonesia and the EU. At the meantime, the biodiesel from waste-based production was forecast to grow to 4.4 billion liters[3].

There are many processes for producing bio fuel such as esterification, transesterification, hydrocracking, catalytic cracking, pyrolysis, fermentation and etc. Among these, Catalytic cracking process is easy way to convert long carbon chain molecule into short carbon chain molecule and its temperature ranges between 450$^{o}$C-500$^{o}$C lower than pyrolysis which ranges from 500$^{o}$C-850$^{o}$C[4].

Catalytic cracking is a process widely used in petroleum refining for converting heavy portion into lighter products. Catalytic cracking of vegetable oil into green fuel is favourable as it does not require additional infrastructure to be build[5].

# MATERIALS AND METHODS

## *Vegetable*Oil (*PungamiaPinnata*)

Pongamiapinnata is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. here, the table1. The pongamia non-edible oil contains the following components by percentage.

**Table: 1 component of pongamiapinnata oil**

| Components | Percentage |
|---|---|
| Oil | 27 - 39% |
| Protein | 17 - 37% |
| Starch | 6 - 7% |
| Crude fiber | 5 - 7% |
| Moisture | 15 - 20% |
| Ash | 2 - 3% |

## Coal Fly Ash

Generally, Coal fly ash is collected from the Mettur thermal power plant, Salem, Tamilnadu. Fly ash is also known as "pulverized fuel ash" is a coal combustion product that is composed of the particulates (fine particles of fuel) that are driven of coal fired boilers together with the flue gases.

## Catalytic Cracking

In this process, the vegetable oil has the catalytic cracking reaction which carried out in catalytic cracking reactor. The reactor is made up of iron material and also it heated by the electric coil[7]. The temperature is measured by the thermocouple and the reactor has provided gas delivery system and provision for sampling. Here on/off temperature controller was used for controlling the temperature[8]. The catalytic cracking experiment is conducted in optimum temperature at different ratio. At the different ratio's catalyst analyzed for identifying the bio-fuel production[9]. This experimental section is not used indirect. It is a direct method without any treatment.

The coal fly ash and mahua oil is added thing make it as slurry with help of mechanical stirrer and fed into the reactor with the temperature of 450$^{o}$C-500$^{o}$C. On heating process the catalytic cracking reaction takes place due to the catalyst activity. From the vegetable oil, the gaseous hydrocarbon will release and it exists from the condenser. The existing gaseous hydrocarbon gets cooled and collected in the form of liquid hydrocarbon. There are collect from the collectors.

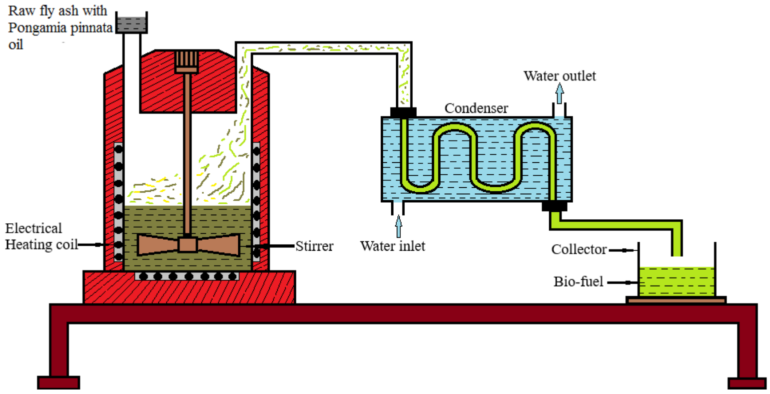



**Figure1. Catalytic cracking Reactor**

## EDS Analysis of Coal Fly Ash

It is an analytical technique used for the elemental analysis or chemical characterization (Figure 2) of a sample. It relies on an interaction of some source of X-ray excitation and a sample.Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum (which is the main principle of spectroscopy). The table 3. Show the presence of predominant elements

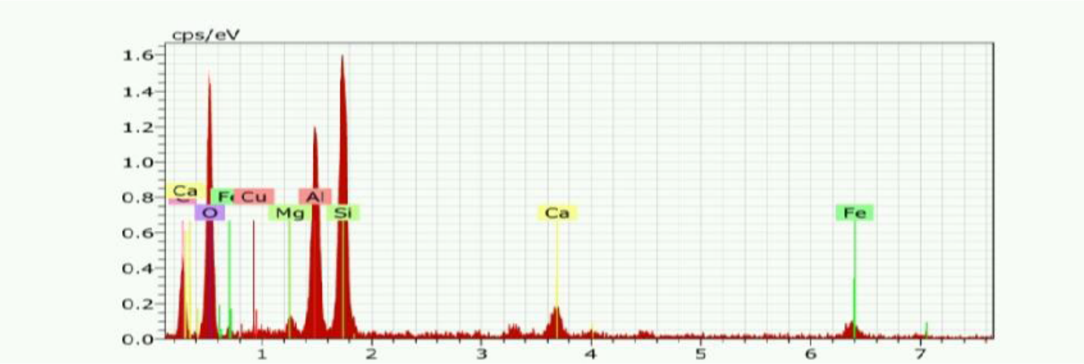



**Figure2. EDS analysis of Coal fly ash**

**Table: 3 properties of coal fly ash**

| El | AN | Series [wt.%] | unn.C [at.%] | Norm.C [at.%] | Atom Norm.C [at.%].C | Error | 1 Sigma) [wt%] |
|---|---|---|---|---|---|---|---|
| O | 8 | K-series | 64.36 | 46.63 | 48.51 | | 11.69 |
| C | 6 | K-series | 36.16 | 26.20 | 36.30 | | 9.27 |
| Si | 14 | K-series | 16.30 | 11.81 | 7.00 | | 0.81 |
| Al | 13 | K-series | 13.23 | 9.58 | 5.91 | | 0.76 |
| Ca | 20 | K-series | | 2.28 | 0.95 | | 0.21 |
| Fe | 26 | K-series | | 2.00 | 0.60 | | 0.22 |
| Mg | 12 | K-series | | 0.79 | 0.54 | | 0.15 |

## EXPERIMENTAL SETUP

The test engine used in the current study is a stationary single cylinder diesel engine, used mainly for agricultural application and in industries for generating electricity.The engine is coupled with an eddy current dynamometer for applying loads by adjusting the current supplied to it and while doing this; the fuel pump rack position is adjusted so as to maintain a constant speed of 1500 rpm. Piston with hemispherical bowl, 3 hole mechanical injector and inline fuel pump have been the integral key components of the engine and the fuel injection system. All other engine specifications are listed in table and the arrangement of engine setup has been depicted in schematic diagram as shown in figure 3.

**Table: 4 specification of the test engine**

| Type | Vertical, water cooled, four stroke |
|---|---|
| Number of cylinders | One |
| Bore | 87.5mm |
| Stroke | 110mm |
| Compression ratio | 17:5:1 |
| Maximum power | 5.2kW |
| Speed | 1500rpm |
| Dynamometer | Eddy current |
| Injection timing | $23^{o}$ before TDC |
| Injection pressure | $220kgf/cm^2$ |

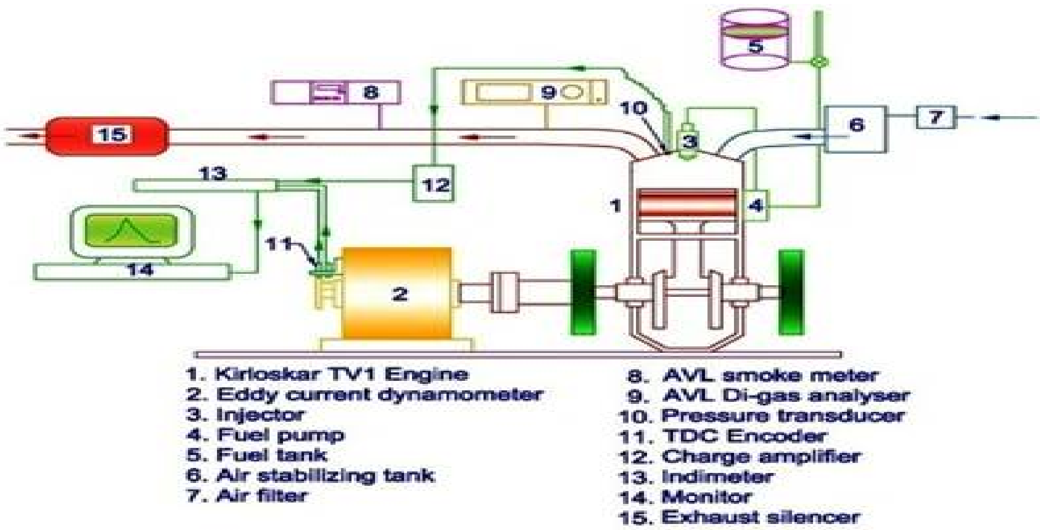
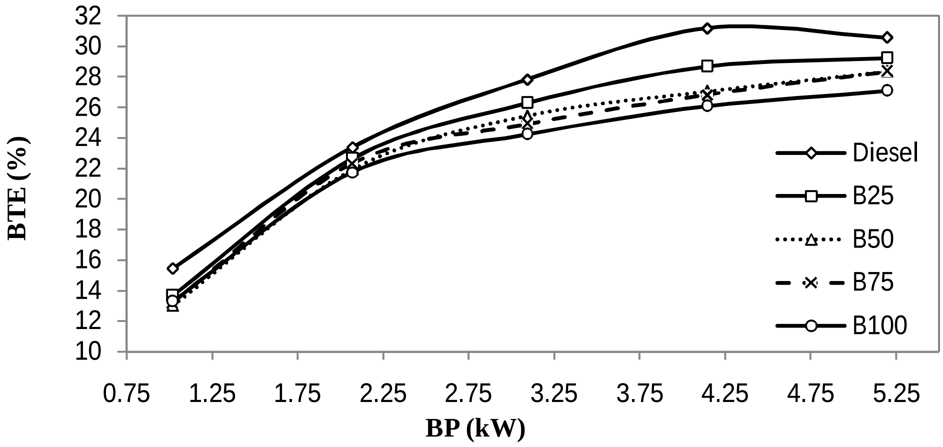



**Figure 3. Schematic view of test engine**

## RESULTS AND DISCUSSIONS

### *Brake Thermal Efficiency*

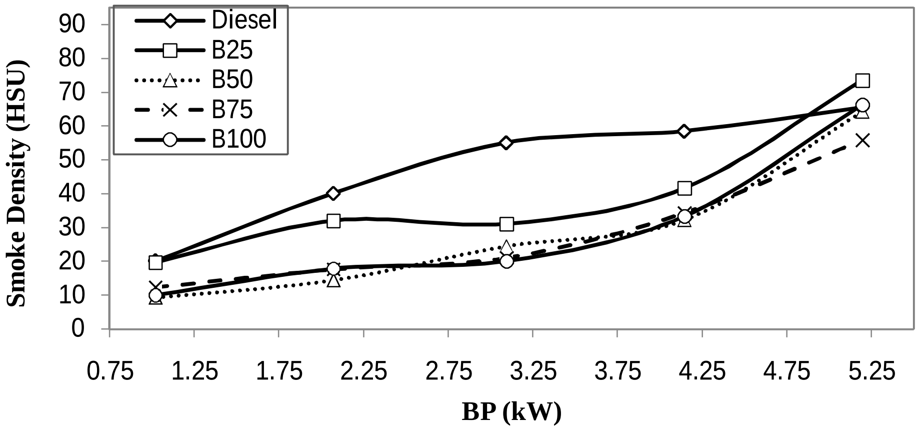
The variation of BTE with brake power for various blends are shown in Graph.1. In general brake power is directly proportional to the brake thermal efficiency, because the heat loss is minimized at peak load thus it increases the brake thermal efficiency. At maximum loads the BTE of the blends slightly lower than the diesel. This is due to the presence of oxygen content in the biofuel and also the rate of combustion is low due to the higher viscosity and lower heating value of the biofuel than the neat diesel[10]. The BTE of B25 blends show the closer efficiency to neat diesel than other blends.




**Graph.1: The variation of BTE with BP**

### *Smoke Density*

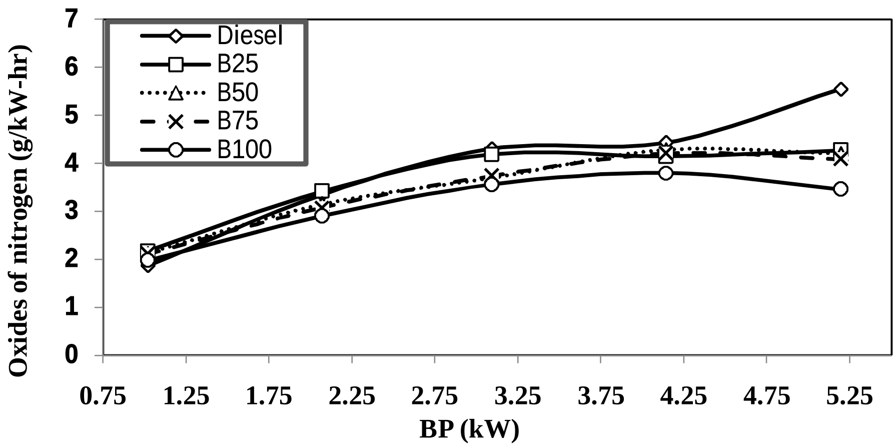
The variation of smoke density with respect to brake power for diesel and biofuel blend is shown in Graph.2 From the graph it is observed that the opacity is increased with increase in load for biofuel blends. The smoke capacity of biofuel blends is lower than diesel at initial load. But in peak load all the blends except B25 shows the highest smoke density than diesel.This is due to incomplete combustion of biofuel blends caused by poor vaporization, air-fuel mixing and higher viscosity of biofuel[11].




**Graph.2: The variation of Smoke with BP**

### *Oxides of Nitrogen*

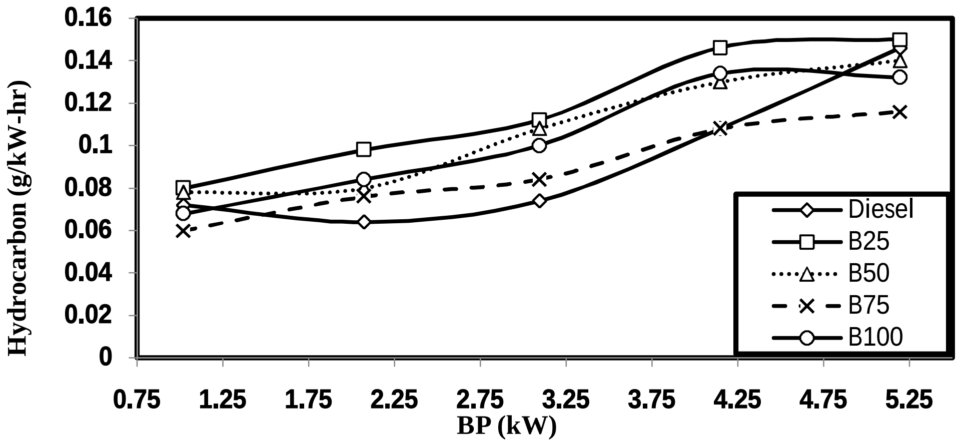
The variations of oxides of nitrogen with respect to the brake power for diesel and biofuel are shown in the Graph 3. It is observed that various blends of biofuel show the lower NOx emissions with increase in biofuel blends when compared to diesel fuel. The result shows the lower NOx emission occurs due to less burning rate of biofuel blends, less atomization and lower cetane index[12].




**Graph.3:The variation of NOx with BP**

### *Hydrocarbon*

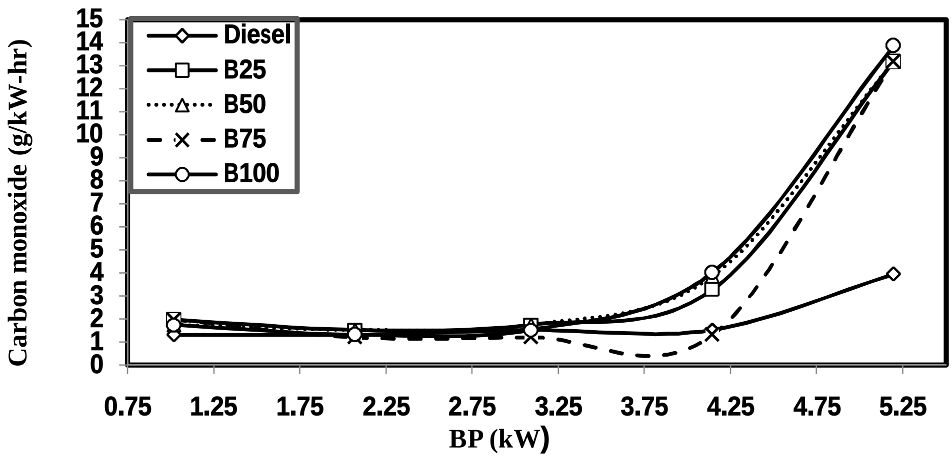
The variation of hydrocarbon with respect to the brake power as shown in Graph 4. The hydrocarbon emission indicates the act of incomplete combustion in the combustion chamber. The HC emissions increased with increase in load, this is due to engine operating condition, properties of fuel and spray formation were the major factors influencing the Hydrocarbon emissions[13]. The B25 shows the higher hydrocarbon emissions when compared to that of diesel fuel at initial load. However, the hydrocarbon emission of B100 is predominantly higher in comparison with diesel at peak load.




**Graph.4 The variation of HC with BP**

## *Carbon Monoxide*

The Graph 5. shows the variation of CO emission with respect to brake power. Generally, the CO emission is affected by air-fuel equivalent ratio, fuel type, combustion chamber design and start of ignition timing. It is observed that CO emission of all biofuel blends consistently increases with increasing biofuel blends. The low injection pressure and atomization rate affects primary combustion processes and subsequently generate high concentration of CO emission with proportion of Pongamiapinnata seed biofuel blends increasing[14]. The CO emission of B25 almost nearest to sole fuel up to part load condition. The blend B100 shows the higher CO emission than other blends however, diesel fuel shows the lowest CO emission.




**Graph.5 The variation of CO with BP**

## CONCLUSIONS

The emission characteristics of Pongamiapinnata seed biofuel and diesel blends were evaluated in single cylinder, four stroke, water cooled diesel engine. The cracked biofuel has been produced by catalytic cracking process using coal fly ash as a catalyst. From this experimental investigation the following conclusion were made,

- The Pongamiapinnata seed biofuel can be directly used as a fuel in an unmodified diesel engine.
- ii) The BTE of B25 blend show closer to neat diesel than other blends. iii) At peak load condition the emission of HC and CO were increased with increasing the biofuel blends.
- iv) The NOx emission shows the reducing trend of biofuel blends and B100 produce lowest $NO_X$ emission than neat diesel
- v) From the above conclusion, B25 blend can be used as a better alternative for the diesel engine application.

## REFERENCES


1. Dos Anjos JS, De Araujo GW, Lam YLand Frety R et al. Catalytic decomposition of vegetable oil. *Applied Catalysis*.1983; 5(3): 299-308.
2. AyhanDemirbas, Bio diesel production from vegetable oil via catalytic and non-catalytic supercritical methanol tranesterification methods. Energy and Combustion Science.2005; 31: 466-487.
3. Muthukumaran N. “The influence of Coal fly ash as a catalyst on production of bio fuel from *Mahua* oil on DI Diesel Engine: A review” [online]. 2006 [cited 2006 Dec14] Available from: URL:https://www.irjet.net/archives/v1/i1/IRJET-V1I109.pdf /2014/vol-1-issue-1.
4. Ramya G, Sudhakar R,Amala Infant Joice J, Ramakrishnan R, Sivakumar T et al. Liquid hydrocarbon fuels from jatropha oil through catalytic cracking technology using AIMCM-41/ZSM-5 composite catalysts. Applied Catalysis. 2012; 433:170-178.
5. AbbasovV, MammadovaT, AliyevaN., Abbasov M, MovsumovN, Joshi A, Lvov Y. and Abdullayev E et al. Catalytic cracking of vegetable oils and vacuum gasoil with commercial high alumina zeolite and halloysite nanotubes for biofuel production,*Fuel*.2016; 181: 55–63.
6. Syed AmeerBashaa K and Raja Gopalet al. A review of the effects of catalyst and additive on biodiesel production, performance, combustion and emission characteristics. Renewable and Sustainable Energy Reviews.2012; 16: 711– 717.
7. Shelly Biswas and D.K. Sharma et al.Studies on cracking of Jatropha oil. Journal of Analytical and Applied Pyrolysis. 2013; 99: 122–129.
8. Muthukumaran N, Saravanan C.G,Prasanna Raj Yadav S, Vallinayagam R, Vedharaj S, and Roberts W.L et al.Synthesis of cracked Calophylluminophyllum oil using fly ash catalyst for diesel engine application. Fuel. 2015; 155: 68–76.

9. Oi L. E, Choo M-Y, Suraya Z, Lee H.V. and Juan J. C et al. Mesoporous TiO2: Potential catalyst for deoxygenation of triglyceride to hydrocarbon-like biofuel. *Malaysian Journal of Catalysis.*2017; 2(2): 53-56.
10. Doronin,V. P, Potapenko O. V., LipinP. V. and SorokinaT. P et al. Catalytic cracking of vegetable oils and vacuum gas oil. *Fuel.*2013; 106: 757–765.
11. Yee Kang ong andSubhash Bhatia et al. The current status and perspectives of bio-fuel production via catalytic cracking of edible and non-edible oils. Energy. 2010; 35:111-119.
12. Danilina, N., Krumeich, F., Castelanelli, S. A. and van Bokhoven, J. A et al. Where are the active sites in zeolites? origin of aluminum zoning in ZSM-5. *Journal of Physical Chemistry C.* 2010; 114 (14): 6640–6645.
13. Chiam, L. T. and Tye, C. T et al. Deoxygenation of plant fatty acid using NiSnK/SiO2 as catalyst. *Malaysian Journal of Analytical Sciences.*2013; 17(1): 129 – 138.
14. Syed AmeerBashaa K and Raja Gopalet al. A review of the effects of catalyst and additive on biodiesel production, performance, combustion and emission characteristics. Renewable and Sustainable Energy Reviews.2012; 16: 711– 717.