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Enhanced Effectiveness of PyrolysedCardanol as Renewable Fuel

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ABSTRACT
Most importantproblem of currentdomain is to find an unconventionalcause for energy as conventional crude oil based petroleum is going to be exterminated. In accumulation to the contaminatingradiation, from themalso upsurges as the automobile density and inhabitants goes on upturns day by day.Biocorpusfoundation promises better skills to swap conventional fuel and lessen the polluting radiations while used for energy source. Most of the bio sources are mined from their spores and are endangered to trans esterification to be used in production of energy or impulsion of vehicles. In penetrating of new source, cardanol has been carefully chosen for the study of its practicability to be used in internal combustion engine in assortment with diesel fuel.Cardanol is one of the integral of cashew nut shell fluid (CNSF) oil, which is haul out from cashew nut shell and is a derivative for cashew treatingmanufacturing.It has some industrial solicitations like, brake lining, lacquer, rubber, etc. Physical and chemical properties of cardanol oil have been experienced and which evidences the capability of it could switch diesel fuel. Physical properties of this oil are in the tolerable range for the collection of biomass as ansubstitute fuel and are nearer to the vegetable oil. Chemical configuration of this oil shows that the nonexistence of triglycerides and hence transesterification process is not required. Furthermore, severalpossessions like flash point, fire point, molecular weight, corrosiveness, miscibility, etc are in the adequate range for the assortment of biofuel. Dissimilarassortments can be set by basically mixing it in diesel and experienced for its physical and chemical properties. Based on the test outcomes, biodiesel blend is augmented for its appropriateness to be used in compression ignition engine as ansubstitutebiofuel.

KEYWORDS: Vegetable oil; Cardanol; Transesterification; Properties; Biodiesel.

I. INTRODUCTION

Importance of nonrenewable fossil fuel goes on upsurges along with the rise in vehicle solidity and energy requirement which results to the formation of pollutant emission. This situation of present world emerges the researchers to find an alternative source for conventional fuel with either reduced or no pollutant without affecting the performance of conventional engine.There were many alternative sources have been found, among them, vegetable oil promises better ability to replace fossil fuel without any major modification in existing engines. Reduced hydrocarbon and other pollutants emitted during the combustion create a positive opinion on vegetable based biofuel and again it is renewable, non toxic and ecological. Most of the herbal oils are dig up from their spores and all vegetable oil has a chemical structure of triglycerides with longer carbon chain and higher molecular weight. Occurrence of longer carbon chain marks in higher viscosity and higher molecular weight. Hence, straight herbal oils show their incompetence to routine in internal combustion engine as it is. In order to use the vegetable oil in engines, it must undergo to the procedure known as transesterification. During this, triglyceride present in vegetable oil is made to react with an alcohol like methanol in presence of a catalyst like sodium hydroxide or potassium hydroxide, which producesglycerol and additionalmethod of aldehyde. The ultimate product acquired by this process is a blend of biofuel and glycerol. Additional they can be separated by gravity settling it in a separating funnel. Separated biofuel is to be underwent some washing process to remove the untreated catalyst. Washed biofuel will have reduced viscosity and lower molecular weight and again some physical and chemical properties very closer to the diesel fuel. In this article, cardanol, a major constituent of cashew nut shell liquid oil, extracted from the shell and separated by the pyrolysis process has been studied and tested for its properties. Study of physical and chemical properties and feasibility of cardanol as biofuel has been done in our previous work. With reference to that optimization has been carried out and reported in this article.

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II. MATERIALS AND METHODS

Cashew tree belongs to the family of *Anacardiumoccidentale L*, and has a native of north east Brazil. Portuguese travelers took the cashew tree to the colonies during sixteenth century. Presently, India is the second largest producer and first largest processor of cashew in the world with a production value of 860 kg hectare^{-1}.Cashew tree, fruit, nut and shell has many applications in different industries. Cashew nut shells are the byproduct obtained from cashew processing industries, which is about 67% of raw cashew by weight (AtulMohod, 2011). Structure of cashew nut shell is a soft honey comb with thick vesicant, dark reddish brown and high viscous oil known as cashew nut shell liquid oil (Tyman et al 1989). Various methods are available for the extraction of oil from the shell and are based on the origin, nature of nut, energy source available for processing industries. But mainly classified as mechanical, thermal, pyrolysis (Tsambaet al, 2006), solvent extraction (Senthil Kumar et al, 2009) and super critical fluid extraction (Patel, et al 2006).Quantity of oil obtained by each process varies and their composition also. Major constituents of CNSL oil are cardanol, cardol, 2-methylcardol and anacardic acid, their chemical structures are shown in figure 1.From their chemical structures and Gas chromatography studies, it can be concluded that all the constituent of CNSL oil has a benzene ring and posses the nature of phenolic substance. All the constituents have many applications in different kind of industries (Subbarao et al, 2011). Piyali Das et al, 2004; studied the properties of CNSL oil extracted by pyrolysis process and reported that CNSL oil has the ability of biofuel. This motivatesus to study about the properties of this oil and in our previous work, we have concluded the cardanol, one of the byproduct of CNSL oil can be used in diesel engine as an alternative fuel(Sivakumar S, et al, 2014). Since the remaining constituents are unstable at the temperature range of 220 °C – 230 °C.

Chemical structure of cardanol shows the absence of triglycerides and presence of alcohol in it. Cardanol is the major product of CNSL oil extracted by pyrolysis process, has higher calorific value, higher flash and fire point than other constituents.Additionally other constituents of CNSL oil can also converted into cardanol by the decarboxylation process. Cardanol oil has higher calorific value and closer molecular weight motivated to select it as a source of alternative fuel.Copper corrosiveness and no presence of sulphur are another reason for the selection of this oil as a source for alternative to diesel fuel. From the chemical structure, it has been observed that there is no sulphur content and presence of alcohol, which ensures the complete combustion and reduces the formation of polluting hydrocarbon, carbon monoxide and sulphur oxides during combustion. Cardanol is completely miscible in diesel and alcohol which again upsurges the hope on this oil. It was stated by Siriornpuangmalee*et al*, 2009; that cardanol oil can be used as a diesel fluorescent marker.In addition to the comparison of properties of cardanol with diesel, we had compared Jatropha and Pongamia oil for our further reference. In table 1 we presented the compared result of some important properties different oils.Some important fuel properties has been studied from the reports of Rengasamy M, et al, 2014; Bobade S N, et al, 2014; Pramanik K, et al, 2003; Senthilkumar M, et al,2003.

Experimental procedure: Different blends of cardanol and diesel can be prepared by simply mixing them in a batch reactor, followed by a stirring of about 10 minutes. Different fuel blends has been prepared on mass basis and the blend range varies from 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 % cardanol with diesel respectively. Blends has been tested and the report was studied for its physical and chemical properties. The test has been performed under the standard conditions mentioned by ASTM method. Among number of tests, the basic properties like viscosity, density, calorific value, flash point and fire point, sulphur content, corrosive nature and molecular weight were tested for selecting suitable biofuelblend.

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Property	Diesel	Cardanol oil	Jatropha oil	Pongamia oil
Viscosity(cSt) at 30 °C	3.9	31.9	52.76	40.2
Calorific Value ($kJkg^{-1}$)	44800	40660	38200	36100
Molecular weight ($g\ mol^{-1}$)	≈ 200	298	900	886
Flash Point (°C)	58	208	210	225
Fire Point(°C)	64	220	238	230
Specific Gravity	0.804	0.909	0.932	0.925

III. RESULT AND DISCUSSION

I. Properties ofcardanol:

Viscosity: Viscosity of different oil blends are measured by using ostwalt viscometer at room temperature and as per the testing procedure. Measured viscosity values for different blends are plotted in graph and is shown in figure 3. From the viscosity graph it is clearly evident that lower blend ratios have the viscosity value in the acceptable range for the selection of biofuel. Further, from the measured viscosity values, it can be optimized that the maximum blend ratio of cardanol 40% and diesel 60% was selected and the ultimate aim of our study is to reduce the diesel usage in compression engine.

Calorific value: Calorific value of pure cardanol oil is in the acceptable range for biodiesel and further different blends value is also calculated and are shown in figure 4. It is clearly observed that as the blend ratio goes on upsurges, calorific value reduces slightly due to lower value of cardanol oil when compared with diesel.But calorific value of pure cardanol oil is higher than any other kind of biofuel produced from vegetable oils. Finally, optimization of blend can be in any ratio and even pure cardanol can alsoselected.

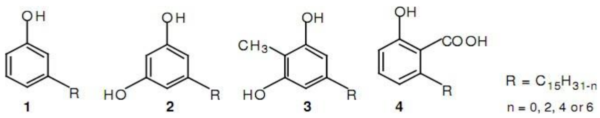
Molecular weight: It is the important property to be find out for the selection of biofuel, whether the biomass is to undergo the transesterification process or not. Diesel fuel has the value of approximately 200 g mol^{-1} and pure cardanol oil has a molecular weight of 298g mol^{-1}. In general most of the feedstockshas more than 800 g mol^{-1} before the transesterification and after that the biofuel may have some closer value. Again, this property is also closer to diesel fuel, so any blend ratio can be optimized.

Flash point and fire point: Tested flash and fire point of pure cardanol oil is 208 °C and 220 °C.It gets reduces while making the blends and is higher than the pure diesel and again it is a good reason for selection of cardanol diesel in any blend ratio.Higher value of flash and fire point ensures the safety of handling and operating conditions of different blends at hightemperatures.

Density: Cardanol has the density value of 0.909 g $cc^{-1}$and is slightly higher than diesel. There is no direct impact of this value of the selection, but slightly reflects in handling, storage and transportation.

Copper corrosion: While conducting copper corrosion test there is no change in color of copper strip at a specified testing temperature ranges. This ensures that the ability of usage of cardanol blend in the existing fuel flow passage without any modification. **Sulphur content:** From the chemical structure of cardanol oil it is evident that there is absence of sulphur content. This also reduces the polluting emittant during the combustion process.

Table: 1 Fuel Properties



IV. CONCLUSIONS

In this study both physical and chemical possessions of dissimilar blends of cardanol – diesel fuel has been experiencedand deliberated. From the verified and discussed information it can be determined that blend cardanol 40% and diesel 60% can be carefully chosen for the additional studies without any revisions in hardware of the appliance. As stickinessvalue of this blend drops under the normaldescription accounted by both ASTM and ISO for biofuels. The calorific value and flash and fire point also sophisticated than the obligatorystate for biofuel. With the above deliberated points, blend B40 can be designated as finestprime blend proportion. In supplementary studies, complex blends like B50 and B60 can be carefully chosen, by making ansupplementary blend with 5% or 10% of ethanol or diethyl ether to diminish the viscosity as the vital goal is to diminish the diesel percentage in incineration.In our upcoming work, we will contemporary the investigation of incineration, performance and emanation in the diesel engine with dissimilar loading circumstances like no load, part load and full load for the augmented blendproportion.

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