SCALE-UP, CHARACTERIZATION AND EFFICACY OF BIODIESEL FROM WASTE SLUDGE PALM OIL

COLLEGE : SIR M.VISVESVARAYA INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT : BIOTECHNOLOGY ENGINEERING
GUIDES : MR. MANJUNATH R
MR. SRINIVAS B V
STUDENT : MR. DEEPAK BAJANTRI

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Introduction:
Ever increasing fuel prices and the global uproar about the declining reserves have prompted research on eco-friendly; commercially viable alternative fuels like Biodiesel. Biodiesel is one of the most promising alternative fuels for transportation. In the present study, the focus is to reduce the production cost of biodiesel by utilizing low cost feedstock like Waste Sludge Palm Oil (SPO). It is a by-product of the milling process and its global annual production reaches 41 million tons. The SPO usually contains high amounts of free fatty acid (FFA) which reacts with alkali and results in the formation of soap. Hence, the alkali or acid based catalyzed transesterification method to produce biodiesel which gives low yield. Therefore, a two-step process was selected, where in, firstly, FFA content was reduced by esterification using pTSA catalyst, and the second step comprised of alkali catalyzed transesterification process for production of biodiesel from waste Sludge Palm Oil. We successfully produced biodiesel from waste SPO comparable in physico chemical property to that of virgin vegetable oil biodiesel with ASTM standards and in this studies have also focused on determining some parameters such as density, kinematics viscosity, calorific value, flash point, cloud point, pour point and acid value is comparing it to Diesel fuel, and determined the Engine performance and Emission characteristics of the biodiesel produced from our feedstock comparing it to diesel emission.

Objectives:
Therefore, The objectives of this study is to investigate the potential of Sludge Palm Oil (SPO) as a low-cost feedstock in biodiesel production by a two step process which include conversion of FFA into Fatty Acid Methyl Ester (FAME) by an organic acid such as PTSA followed by transesterification to obtain biodiesel.

- Scale-up of Biodiesel from SPO by acid catalyzed trans-esterification –scale up to 50Ltr per batch.
- Characterization of the Biodiesel produced in terms of physico-chemical parameters.
- Determination of the engine performance and emission characteristics of engine fueled with various blends of biodiesel produced from Waste Sludge Palm Oil.

Methodology:
Materials: The materials used for the present investigation purpose are Sludge Palm Oil (SPO), Methanol, NaOH, pTSA, Phenolphthalein indicator, 1N H₂SO₄ and Ethanol.
The main prospect of the present study is the production of biodiesel from waste sludge Palm oil. The proposed methodologies are given below.

1. Extraction of oil from Oil Palm Sludge
2. Qualitative & quantitative analysis of Sludge Palm Oil
3. Production of Biodiesel from Sludge Palm Oil by a 2-step catalyzed process:
   - Pretreatment to reduce FFA by using catalyst pTSA (P-toluene 4-sulfonic monohydrate acid)
   - Trans-esterification process
   - Separation and purification of Biodiesel
   - Characterization of the Biodiesel produced based on physico-chemical parameters
4. Determination of the Engine Performance and Emission Characteristics with Blend SPO Biodiesel

**Experimental Setup:** The experiments were carried out in a batch stirred tank reactor of 1L capacity, equipped with a reflux condenser, a mechanical stirrer, and a stopper to remove samples. Later the process was scaled up to 2 liter for bench scale production.

**Results:**

**Table 1:** Physico Chemical parameters of waste SPO Biodiesel compared with Std. diesel and Petro diesel.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Waste SPO Biodiesel</th>
<th>Std. Biodiesel (ASTM)</th>
<th>Petro Diesel</th>
<th>ASTM Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorific value</td>
<td>MJ/Kg K</td>
<td>39.5(MJ/kg)</td>
<td>37 to 42.5</td>
<td>43.5</td>
<td>ASTM D 613</td>
</tr>
<tr>
<td>Flash point</td>
<td>°C</td>
<td>179°C</td>
<td>130</td>
<td>54</td>
<td>ASTM D 2500.(≥130)</td>
</tr>
<tr>
<td>Cloud point</td>
<td>°C</td>
<td>20°C</td>
<td>-3 to 12</td>
<td>-28 to -7</td>
<td>ASTM D 287</td>
</tr>
<tr>
<td>Density at 15 °C</td>
<td>Kg/m³</td>
<td>900 kg/m³</td>
<td>870-900</td>
<td>820</td>
<td>ASTM D 445</td>
</tr>
<tr>
<td>Viscosity at 40 °C</td>
<td>Cst</td>
<td>8.92 Cst</td>
<td>1.9-6.0</td>
<td>2.54</td>
<td>ASTM D 97</td>
</tr>
<tr>
<td>Pour point</td>
<td>°C</td>
<td>8°C</td>
<td>-15 to 10</td>
<td>5.6 to 11.1</td>
<td>ASTM D 613</td>
</tr>
</tbody>
</table>

All properties of waste SPO biodiesel are tabulated in above Table 1. Properties of SPO biodiesel, which satisfy the ASTM standards of fuel properties. By considering these factors we can use this waste SPO biodiesel with different blends as a fuel for diesel engines.

**Engine Performance and Emission characteristics:**

Engine performance and emission characteristics of biodiesel from waste SPO for its various blends (B10, B20, B30 and B40) are carried out in direct CI engine at a rated speed of 1500 rpm by varying parameters of engine like injection pressure and timing. The engine was allowed to run till the steady state is reached. Then the engine was loaded in terms of 0,2,4,6,8,10 and 12kg, by electrical loading with an interval of every 30 seconds.

The **Engine Performance** like Mechanical Efficiency (ME), BP, BTE and BSFC characteristics for various blends are being compared with standard petro diesel in below Figures.
The emission details of biodiesel of different blends have been analyzed by multi gas analyzer (SGT-G-05). The details have been mentioned in Table
Conclusion:
The results indicate that SPO can be an attractive alternative as a feedstock for biodiesel production with
the development of a pre-treatment method using a pTSA as a most effective catalyst which accelerates
the reduction of FFA content.
The optimum conditions for esterification process was found to be 1.5 wt% pTSA, the optimal ratio of oil : methanol was found to 5:1.6 (w/w), The ideal reaction temperature was found to be 60°C, the ideal reaction time was found to 60 minutes and 400 rpm stirrer speed. The properties of Biodiesel such as Flash point (179°C), Calorific value (39.5 MJ/kg), Cloud point (20°C), Pour point (8°C), Viscosity(8.92 Cst), Density(900 kg/m³) and Acid value(1.5 mg of KOH/g),which meets the ASTM standards for biodiesel.

The engine performance and emission gas analysis was highly comparable with the petroleum diesel. The engine performance with different ratios of biodiesel blends such as B10, B20, B30 and B40 were studied and the most ideal blend was found to be B40.

It was interesting to note that as the blending level increased the emission the smoke density seems to be reduced, indicating the clear combustion of blends of biodiesel. However in contrast with normal petro diesel, the % of CO increased by 1.1 times, CO₂ increased by 0.68 times, HC reduced by 1.37 times and NOₓ emissions were found to be reduced by 1.06 times for B40 blend at maximum loads.

Scope for Future Work:
Further it would of economic interest to explore alternative uses of various homogeneous and heterogeneous catalysts including enzymes to increase the yield of the biodiesel and reduce the cost of production. Also it could be recommended to adopt visbreaking techniques to reduce viscosity of the biodiesel which improves the properties of biodiesel prior to the confirmation of biodiesel stability towards high temperature and pressure.