Green Synthesis and Characterizations of Flower Shaped CuO Nanoparticles for Biodiesel Application

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Abstract: Nanomaterials are primary candidates to play a key role in energy future. In this work, plant-mediated green synthesis of CuO nanoparticles was studied. The CuO nanoparticles were used as the catalysts for the production of biodiesel from coconut oil. An aqueous extract of Centella Asiatica leaves was used as a bio-reducing agent for the synthesis of CuO nanoparticles. This biocatalyst was characterized by using different techniques (FTIR, UV-Vis spectroscopy, XRD, FESEM with EDX) which were confirmed the formation of CuO nanoparticles. Further, the presences of FAME (Fatty Acid Methyl Ester) groups at the produced biodiesel were confirmed using both the GC-MS and FTIR analysis. From this work, it has been concluded that the plant extract mediated synthesis of CuO nanoparticles is quite simple, cost-effective and environmentally friendly. The produced biodiesel from coconut oil is considered to be a potential source for alternative conventional fuel.

Keywords: Green synthesis, Biodiesel, GCMS, Nanoparticles.

1. Introduction

Recently researchers are very much interested in producing biofuel, using nanomaterials as catalysts in an efficient way [1-3]. Nanomaterials have high catalytic activity, large specific surface area, high resistance to saponification reaction and good rigidity when compared with their bulk counterpart [4-7]. The available reports on biodiesel production using nanomaterials are relatively few [8-11].

The plant extract mediated synthesis of CuO nanoparticles is cost effective and eco-friendly [12-15]. Moreover, the plant extracts are possibly enriched with the presence of broad ranges of biomolecules such as alkaloids, terpenoids, phenols, and flavonoids etc. which were considered as bio-reducing agent [16-20]. Centella Asiatica is an important medicinal plant in Siddha and Ayurveda [21-23].

In the present work, the synthesized bio CuO nanoparticles were used as catalysts for the production of biodiesel. All the characterization studies clearly proved the formation of nanoparticles. The presence of methyl ester groups in the produced biodiesel was confirmed using both gas chromatography-mass spectrometry (GC-MS) and infrared spectroscopy (FTIR).

2. Materials and Methods

2.1. Materials

All the reagents were of analytical grade and they were used without further purification. Copper acetate [Cu(CH₃COO)₂] and Methanol (99.9 % purity) were obtained from Merck, Germany. The plant Centella Asiatica has been collected from remote villages of
Trichy. Coconut oil was purchased from a local market.

2.2. Preparation of CuO Nanocatalyst

The leaves (20 g) collected have been washed and boiled with de-ionized water for 15 minutes. The sample was taken out and kept in a place to attain the room temperature. Again it was filtered successively through filter paper and stored at 4 °C. The aqueous copper acetate and leaf extracts were taken in 4:1 ratio and the solution was exposed to sunlight for 3 hours. After the completion of the reaction, the precipitate was centrifuged (8000 rpm) and dried in hot air oven at 80 °C.

2.3. Transesterification Procedure

The flask was filled with the reaction mixture (1:3 oil/methanol and 1 wt. % of CuO) and mixed thoroughly at a constant temperature of 60 °C with the help of a magnetic stirrer. After the completion of the reaction, the mixture was cooled to room temperature and the top layer of the biodiesel phase has been separated.

3. Results and Discussion

3.1. UV-Vis Analysis

In Fig. 1 an observed peak at 393 nm is assigned to the surface plasmon resonance band of the CuO nanoparticles. This is analogous with the existing literature values [24].

![UV-Vis graph of CuO nanoparticles.](image1)

3.2. FTIR Analysis

In the Fig. 2 the peak at 1079 cm⁻¹ indicates the presence of C-O stretching and the peak at 1618 cm⁻¹ represents ketone group suggesting the presence of flavonones. The C-H stretches of alkanes appear at 2934 cm⁻¹ and the peak at 3430 cm⁻¹ mainly corresponds to the O-H groups.

![FTIR pattern of CuO nanoparticles.](image2)

3.3. XRD Analysis

No impurity peaks other than CuO were observed in the XRD pattern in Fig. 3. The major peaks at 32.4°, 35.5°, 38.7°, 48.8° and 66.2° are incomparable with JCPDS card no (65-2309). The average crystallite size of the CuO nanoparticles calculated by Debye–Scherer’s formula is 40 nm.

![XRD pattern of CuO nanoparticles.](image3)

3.4. FESEM with EDX Analysis

The surface morphology of the nanoparticles was obtained by Field Emission Scanning Microscopy (FESEM). The bio-reduced CuO nanoparticles resemble small spherical flower shape (Fig. 4). The EDX result of Fig. 5 shows the elemental composition of Cu, O along with some C and P.

![XRD pattern of CuO nanoparticles.](image4)
3.5. GCMS Analysis

The composition of coconut oil and the biodiesel were determined using GC-MS analysis. The chemical composition of coconut oil and biodiesel is briefly listed in Table 1. The maximum FAME conversion calculated is 78.58%. The most abundant FAME found in the coconut oil biodiesel is 10-Bromodecanoic acid methyl ester.

Table 1. GC-MS composition analysis.

<table>
<thead>
<tr>
<th>Type of fatty acid (FA)</th>
<th>Composition analysis</th>
<th>Total weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coconut oil biodiesel</td>
<td>coconut oil biodiesel</td>
</tr>
<tr>
<td>Saturated</td>
<td>12:0 14:0 8:0 16:0 10:0 18:0</td>
<td>94.15 18.21</td>
</tr>
<tr>
<td>Unsaturated</td>
<td>18:1 18:2 11:1 16:1 18:1</td>
<td>5.85 78.58</td>
</tr>
</tbody>
</table>

3.6. FTIR Analysis

The FTIR spectrum of produced biodiesel from coconut oil is shown in Fig. 6. From the literature, coconut oil biodiesel samples are very much similar to that of standard petrodiesel and biodiesel sample [20]. The two bands observed at 1459.56 cm\(^{-1}\) and 1748.33 cm\(^{-1}\) in sample indicate the presence of two groups namely methyl (CH\(_3\)) and ester respectively.

Fig. 6. FTIR spectra of biodiesel from coconut oil.

4. Conclusion

The production of biodiesel from coconut oil with methanol was successfully synthesized using CuO nanocatalyst. The biocatalyst was characterized using different techniques which confirm the formation of CuO nanoparticles. The presence of FAME groups at the produced biodiesel also confirmed by using GC-MS and FTIR analysis. The study demonstrates that the leaves of Centella Asiatica are content-rich and good sources for the fabrication of CuO nanoparticles. In conclusion, the biodiesel synthesized from coconut oil can be considered as the potential source of energy which can easily replace all the other conventional fuels.

References


