DEVELOPMENT OF HETEROGENEOUS PHOTOCATALYTIC METHOD FOR BIODIESEL PRODUCTION

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Keywords:

Terminalia catappa, photocatalyst, $CaTiO_3$, biodiesel

Introduction:

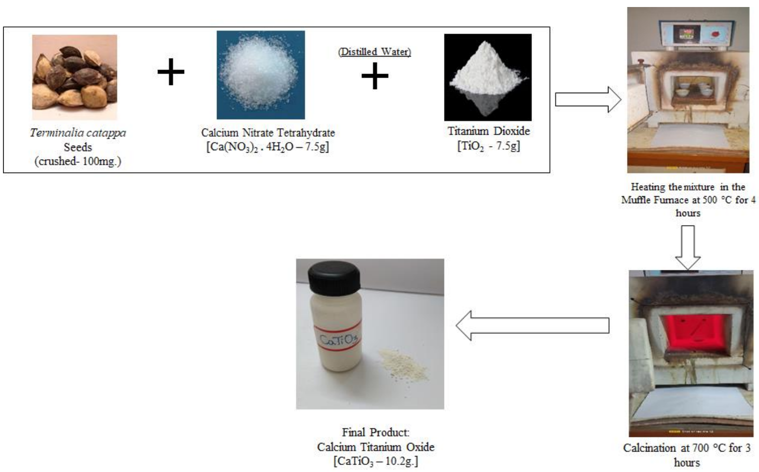
The crisis of oil and global warming are some of the major issues in today's world. So, researchers have been experimenting to find befitting substitute fuels to petroleum oil. Biodiesel can be used as a substitute to fossil fuels which is blended with diesel for running diesel engines. Biodiesel is usually produced by the combination of any natural oil or fat with an alcohol such as methanol or ethanol chemically by esterification and transesterification. Methanol is the most often used alcohol in the producing commercial biodiesel. It is produced from plant oil such as soybean oil and the combination of methanol *via* the process of transesterification in the process of acid catalysts. Biodiesel has many benefits such as high fire and flash point, pollution would be reduced from machines when biodiesel is used compared to pure diesel and petrol. The greenhouse gas emissions from biodiesel are also less. But parallelly, there are several challenges i.e., the exorbitant cost of highly refined oils will be needed that will be used as a feedstock for the production. This brings a drawback in its economic competitiveness in comparison with inexpensive diesel that is obtained from petroleum. Next is the arrangement of catalysts that is the preparation of a photocatalyst. The technology known as Photocatalysis is a green technology to use intermittent sunlight which is found everywhere. Heterogeneous photocatalyst is a nanoparticle which absorbs light as a source and gives output as high energy. The energy obtained aids the solution to produce the chemical reactions. Calcium Titanate is a nanoparticle that is a heterogeneous mixture of Calcium Nitrate Tetrahydrate and Titanium Dioxide (TiO_2) The characteristics of the synthesised $CaTiO_3$ were obtained from Scanning Electron Microscope (SEM), X- Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and Transmission Electron Microscope (TEM). The $CaTiO_3$ nanoparticles showed excellent yield and great stability up to 5 cycles. The kinetic study of biodiesel production fits well to pseudo-first order reactions.

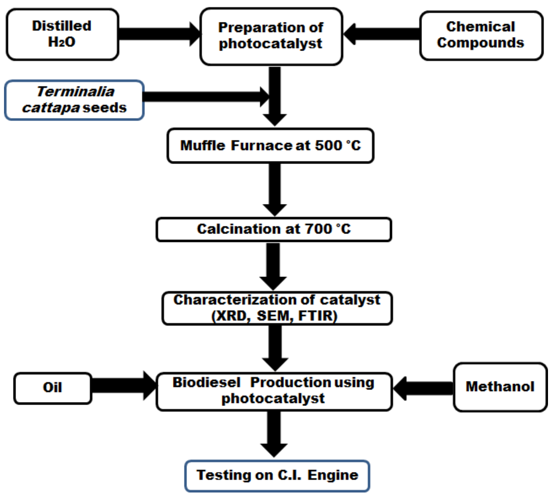
Objectives:

Green synthesis of heterogeneous photocatalyst for the simultaneous esterification-transesterification of oil. Characteristic study of the obtained photocatalyst. Optimizing the Bio-Diesel production process parameters using synthesized photocatalyst. Study of physio-chemical properties of obtained biodiesel. Real time testing of produced biodiesel on Compression Ignition Engine.

Methodology:

Terminalia Catappa seeds are collected from the campus of Siddaganga Institute of Technology, Karnataka, India. This was used as a fuel for the preparation of the photocatalyst. Methanol, Calcium nitrate tetrahydrate along with Titanium isopropoxide chemicals were purchased from a store known as Veeresh Scientifics, Tumakuru, Karnataka, India. Used cooking Oil (UCO) was collected from various hotels and restaurants in the surrounding locality. The FFA (Free Fatty Acid) value of the oil is tested by titration method and then the oil is subjected to esterification or transesterification process accordingly. The $CaTiO_3$ photocatalyst catalyst was synthesized using a solution-combustion synthesis process. To prepare the photocatalyst the raw materials required were Calcium Nitrate Tetrahydrate ($Ca(NO_3)_2.4H_2O$) and Titanium Dioxide (TiO_2). 7.5 grams of each were taken into a beaker along with 400 ml of distilled water. This solution was kept for stirring in a magnetic stirrer for about 30 minutes. After stirring, the solution is transferred to crucibles made of silica. Now crushed *Terminalia catappa* seeds are sprinkled into the crucible filled with the solution. The Muffle furnace is preheated to 500 °C and the crucibles are kept in the furnace one by one so that the solution does not spill out due to excess heat. After water evaporates the muffle furnace is closed and the crucibles are kept inside for about 4 hours. The crucibles are then taken out and the white powder is scraped out and transferred to a single crucible. The crucible is kept for calcination at 700 °C for 3 hrs in a preheated furnace. After calcination the final product is transferred to an airtight container for further application



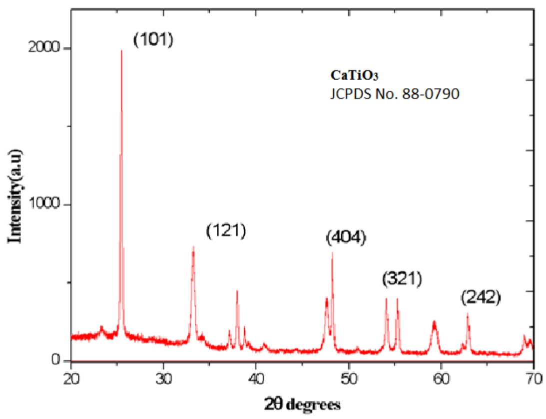


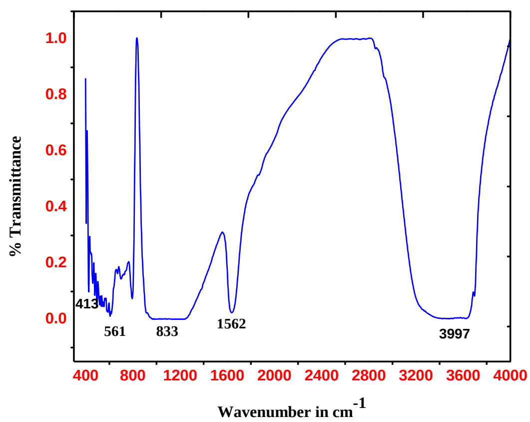
Conclusion:

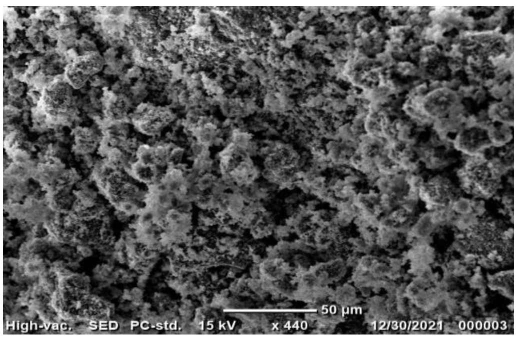
The first figure depicts the X Ray Diffraction pattern of $CaTiO_3$ Nanoparticles that was synthesized through solution-combustion method using Terminalia *catappa* seed extract as a fuel source. The synthesized $CaTiO_3$ NPs shows pure single orthorhombic phase. All the diffraction peaks at (101), (121), (404), (321) and (242) were well indexed and matched with the standard JCPDS card No. 88-0790. Extra diffraction peaks are absent which in turn indicates the absence of impurities in the material. The size of the synthesized crystallite $CaTiO_3$ Nanoparticles was evaluated using Debye-Scherer's formula. The crystallite size was found to be 37.19 nm (average).

The second figure shows the Fourier Transform Infra-Red (FTIR) spectrum of $CaTiO_3$. Absorption peaks are strong at 561 cm^{-1} and 413 cm^{-1} which shows the stretching vibration of the Ti–O bond. The peak observed at 561 cm^{-1} shows the Ti-O-Ti bridge stretching modes. The peak which is observed at 1562 cm^{-1} attributed to the O-H band of hydroxyls and water surface on the $CaTiO_3$ NPs.

The third figure shows the SEM $CaTiO_3$ photocatalyst. The material has clustered structures with small bead like and flaky morphologies. The energy dispersive X-ray spectrum **(Fig 6)** of $CaTiO_3$ sample assures the existence of Ca, Ti and O_3 at appropriate concentrations. The atomic % of Ca, Ti and O_3 element in CaTiO3 is found to be 14.83, 15.50 and 69.87 respectively. The output signals obtained from Energy dispersive X-ray spectroscopy (EDX) is referred as EDX plot. The synthesized nano $CaTiO_3$ crystals were exposed to EDX analysis, significant peaks for Ca, Ti and O_3 ensures the existence of these elements and mark no remains of impurities.







Scope for future work:

Biodiesel is a green fuel produced through various methods and producing biodiesel is the need of the hour due to rising fuel demand along with the limited resource of the fossil fuels. Introducing Biodiesel along with diesel would cut down fuel demand by some margin.

Currently Biodiesel is being prepared using homogeneous catalyst such as NaOH for the reaction between the methanol and oil to take place. Our project is to produce Biodiesel using a heterogenous catalyst so that the catalyst can be reused as it does not mix with mixture of methanol and oil.

Currently we have synthesized the heterogenous catalyst for the production of biodiesel. The process parameters have to be optimized so that the quantity of biodiesel produced is increased.