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Experimental studies on nanocomposites to catalyze fructose sources for the synthesis of dimethylfuran as a promising alternate fuel using coil reactor

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Abstract

The world acclaims crude sources as 'black gold' owing to its potency and market value. However, it makes itself in-feasible, in terms of renewability and quick recoverability. There is a high demand for alternative fuel sources at present to replace the current conventional sources. Fructose sources are modestly available sugar derivatives and have endless applications. The coil-reactor is fabricated to actualize the reaction and the nanocomposites were prepared and interpreted by XRD and SEM analysis. The product to be recovered entails two-step process. The formal step involves Acid dehydration process, where the raw fructose sources are dehydrated by concentrated hydrochloric acid. An unstable intermediate named Hydroxymethylfurfural (HMF) will form and arrested by organic solvents, which then distilled to its pure form. The latter stage involves Hydrogenolysis process, where the formed HMF is hydrogenated by hydrogen donors and catalyzed in the presence of monometallic and bimetallic nanocatalysts (Cu/Al_2O_3 and $Cu\text{-}Zn/Al_2O_3$). The hydrogenation reaction is carried out at 80 °C–120 °C and (1–2) atm pressure in the coil-reactor at definite time intervals. The desired end

product named Dimethylfuran (a bio – derivative fuel) is recovered and distilled to its pure form. Its other potential uses are as a resin, polymeric binder. The product samples are then analyzed in Gas Chromatography–Mass Spectrometer (GC–MS) and checked for desired product implication and other components compositions. After the recovery of the product, kinetic studies, energy barrier relations and feasibility studies were performed to determine the Order of the reaction (n), Reaction rate (rA), Volume of the reactor (V_o), Frequency factor (A), Activation energy (Ea), Conversion (X_A), Yield (Y), Selectivity (S) and Final product concentration C_{Af} (t).

Introduction

Crude sources are perceived as the core of the economy for its tendency to produce different products ranging from oil to tar [1]. The world faces a deficit of crude sources and so there is a great demand for crude fuels ever. Experts predict that existing crude sources will get exhausted by the end of this century [2]. The crude prices are hiking in the world trade market steadily [3]. It directly affects the economy of crude dependent countries [4]. Simultaneously, the emissions from the burning of crude sources result in the release of greenhouse gases, misleading the nature cycle by global warming and climate change [5]. So, the world is in requisite of an alternative that could replace them with better efficacy.

In this circumstance, one of the promising fuels named Dimethylfuran could be a better alternative to existing fuel sources [6]. This furan compound can be produced from the waste fructose sources, catalyzed by nanocomposites [7]. They possess high Research Octane Number (RON) and has high energy density than bio-ethanol and crude sources. They also emit less greenhouse gases, diminishing global warming [8]. Since these fructose sources are abundant in nature, they can be easily renewed and makes it as efficient and cheaper [9]. Thus, these furan sources will act as a promising alternative to existing fuel sources [10].

Section snippets

Design of coil-reactor

A Coil reactor is fabricated to recover our product. The material used for the construction of the reactor is stainless steel. Since the reactor walls get contact with certain fluids, it must resist corrosion. The Chromium content present in the stainless steel on corrosion forms chromium oxide (Cr_2O_3) which acts as a stable passive layer, thus retarding the corrosion. A length of 20 cm, a diameter of 4 cm and a capacity (volume) of 5 L is designed. An Anchor impeller is coupled with motor and …

Morphological characterization of nanocatalysts

The prepared monometallic and bimetallic nanocatalysts are characterized by SEM analysis. All the nanocatalysts are morphologically studied. Graphical analysis is also done by plotting graph between Frequency (%) Vs Particle size (nm). Same magnification of 500 nm is kept for both the catalytic samples.

Fig. 1 (a) represents the SEM image of monometallic Cu/Al_2O_3 nanocatalyst and (b) represents the SEM image of bimetallic catalyst $Cu\text{-}Zn/Al_2O_3$ nanocatalyst. The Average size of the monometallic …

Conclusion

The produced Dimethylfuran fuel finds exceptional advantage over the other crude fuel sources. This Dimethylfuran fuel has high Research Octane Number (RON) which contributes less emission of COx, NOx, SOx, gases. In addition to that, it is highly insoluble in water and has high energy density. Electric engines cannot be employed for heavy load vehicles. So, because of its high energy density, this fuel can be used for high locomotives engines. The product composition analysis is done for both …

CRediT authorship contribution statement

Bharathan G.: Conceptualization, Methodology, Validation, Writing - original draft, Funding acquisition. **Selvi P.P.:** Formal analysis, Investigation, Supervision, Project administration. **Arunprasad R.K.:** Software, Writing - review & editing, Funding acquisition. **Gokulkumar M.:** Resources, Visualization, Funding acquisition. …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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