Mechanochemistry for a smart and sustainable biodiesel production under heterogeneous catalysis

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Abstract

Fatty acid methyl esters (FAME) produced from vegetable oil by transesterification, labeled as "Biodiesel", is industrially accomplished in the presence of a homogeneous basic catalyst, such as alkali hydroxide or methoxide dissolved in methanol. This process requires a large excess of methanol (methanol:oil molar ratio> 6), temperature around 60 °C and 1-2 h of reaction [1]. However, this process suffers from important drawbacks: low FFA and water tolerance, generation of process wastewater, etc. To overcome them, different approaches have been proposed: such as the use of heterogeneous catalysis, CO_2 under supercritical conditions or enzymes; coupled to microwave and ultrasonics systems as an alternative to conventional heating [2-3]. Among all the researches, heterogeneous catalysts show potential in the transesterification reaction. Unlike homogeneous catalysts, heterogeneous ones are environmentally benign and can be reused and regenerated. Nevertheless, higher catalyst loading and alcohol:oil molar ratio are required for biodiesel production in the presence of solid catalysts [4].

Methodology & Results: A new mechanochemical reactor is used for the transesterification reaction to promotes the reactants mixing, minimizing mass transfer limitations associated to the inmiscibility of reactants. This solution allows to reduce the methanol need to an amount close to the stoichiometry (methanol:oil molar ratio= 4:1), and at room temperature after less than one minute, more than 90 wt% FAME is reached [5].

Findings: Glycerol, obtained as by-product in the transesterification reaction is used to prepare calcium diglyceroxide by mechanosynthesis, and is used as heterogeneous catalyst. A new and more efficient mechanochemical synthesis of FAME is proposed, with shorter reaction and lower temperature [6], compared to other synthesis proposed in literature [7].

Significance: A new, smart and efficient process for biodiesel production was developed, without waste generation (no water, nearly no excess of methanol), with valorization of glycerol for catalyst synthesis, under very low energy consumption conditions.

Image

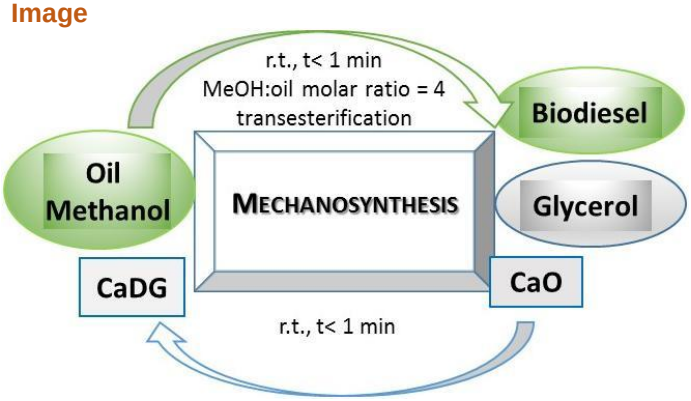

Figure 1: Scheme of the sustainable biodiesel production and heterogenous catalysis synthesis.

Recent Publications

1. B. Freedman, E.H. Pryde, T.L. Mounts, Variables affecting the yield of fatty esters from transesterified vegetable oil, JAOCS 61 (1984) 1638–1643.
2. Juan Miguel Rubio-Caballero, Jose Santamarıa-Gonzalez, Josefa Merida-Robles, Ramon Moreno-Tost, Antonio Jimenez-Lopez, Pedro Maireles-Torres, Applied Catalysis B: Environmental 91 (2009) 339–346.
3. Ana C. Alba-Rubio, Jose Santamarıa-Gonzalez, Josefa M. Me rida-Robles, Ramon Moreno-Tost, David Martın-Alonso, Antonio Jimenez-Lopez, Pedro Maireles-Torres, Catalysis Today 149 (2010) 281–287
4. Ferenc E. Kiss, Milenko Jovanovi, Goran C. Bošković, Fuel Processing Technology 91 (2010) 1316–1320
5. Patent new biodiesel process - WO2018002559: Method for producing fatty acid esters and glycerol at low temperature.
6. Patent CaDG synthesis (complete by Deasyl) – PCT/FR 2017 052675 : Procédé de fabrication de diglyceroxide de calcium
7. León Reina L. et al., Journal of Catalysis Journal of Catalysis (2013) 300, 30-36.

Biography

Irene Malpartida has her expertise in heterogeneous catalysis and biodiesel production for more than 15 years. She has worked in design, processing and evaluation of novel catalysts and processes for applications in the automobile industrial market to achieve the future European Standards for the air quality; Hydrogen production; oxidation of HCs and Biodiesel production. She develops the reactivity Set-up to work in real conditions and novelty work conditions to join fundamental research with the needs of industrial partners as Renault, PSA, Ford. Nowadays, she joins a research of valorization of Biomass developing sustainable industrial production of biofuels, biogas and other products from microalgae and residual oils in collaboration with Dr. Pedro Maireles (University of Málaga) and DEASYL S.A. DEASYL is a Swiss company based in Geneva; it is an international supplier of technologies and catalysts for petrochemical industry. Our mission is to provide innovative solutions to produce eco-responsible green biodiesel.

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