Molecular Catalysis 545 (2023) 113162

Contents lists available at ScienceDirect

Molecular Catalysis

journal homepage: www.journals.elsevier.com/molecular-catalysis

An accelerated route for synthesis of Glycerol carbonate using $MgTiO_3$ perovskite as greener and cheaper catalyst

Gitanjali Pradhan [a,b], Sunita Maurya [b], Subhalaxmi Pradhan [c], Yogesh Chandra Sharma [b,*]

[a] Dept of Chemistry, REVA University, Bengaluru
[b] Department of Chemistry, Indian Institute of Technology BHU Varanasi 221005, India
[c] Dept of Basic Sciences, Galgotias University, Greater Noida, India

ARTICLE INFO

Keywords:
$MgTiO_3$ perovskite
Glycerol carbonate
Transesterification
Glycerol

ABSTRACT

Synthesis of glycerol carbonate from glycerol has gained major research attention because of its wide application in lithium-ion battery and pharmaceutical companies. Current study summarises the catalytic transformation of glycerol-to-glycerol carbonate using $MgTiO_3$ perovskite catalyst. Here,we have reported the synthesis of $MgTiO_3$ catalyst by simple co-precipitation route and investigated the catalytic activity in transesterification of glycerol. The physico-chemical properties of $MgTiO_3$ catalyst was successfully studied by XRD, SEM-EDX, XPS, Raman spectra, BET-surface area and TGA analysis. The designed catalyst possesses high catalytic efficiency and stability in transesterification reaction of glycerol. Depending upon its surface area and basicity many experiments were performed and observed that under optimized condition i.e., 12 wt.% catalyst loading, 6:1 molar ratio of DMC to glycerol, 90 °C and at 180 min highest conversion of glycerol 93% and 88% selectivity of glycerol carbonate was achieved. The reusability study also revealed that $MgTiO_3$ perovskite is highly efficient and stable catalyst to trans esterify glycerol with 88% selectivity towards glycerol carbonate up to sixth cycle.

1. Introduction

Energy consumption is rapidly increasing over worldwide as a result of technology advancements and human development. Basically, two types of energy sources like fossil fuels, as non-renewable energy and renewable sources like solar, wind, biomass are utilised in industrial, building and transportation sectors tremendously [1–5]. The burning of fossil fuel causes environmental degradation and the production of waste which are main factors for imbalance of atmospheric carbon dioxide (CO_2). As a result, biofuel like biodiesel, bio ethanol, biomethanol are extensively used worldwide to fulfil the energy demand. The enormous production of biodiesel causes large scale accumulation of glycerol as by-product [6,7]. In order to economize the biodiesel production process recent research attention has been focused towards the conversion of glycerol to several value-added product. Glycerol carbonate is one of the value-added product having water solubility and nontoxic properties mostly used in pharmaceuticals, beauty and personal care industries, agricultural industries, building and cement factories as well as lithium-ion batteries [8–11]. Depending upon the types of feed materials glycerol carbonate can be synthesized by various pathways like use of phosgene, carbon dioxide, carbon monoxide, urea, and dialkyl carbonate etc. [12–14]. The synthetic pathway of glycerol carbonate using phosgene, CO and CO_2 has been obsoleted due to unsafe and high toxicity properties of these chemicals. Although the use of CO and CO_2 provided relatively high yield but these processes are thermodynamically limited and requires high temperature and pressure [15–20]. Compared to all these process transesterification reaction of glycerol using dimethyl carbonate (DMC) is most promising and facile one. This method is environmental benign and greener for glycerol carbonate synthesis under mild reaction condition. A variety of heterogeneous, homogeneous and enzymatic catalysts have been used for synthesis of glycerol carbonate [21,22]. The enzymatic systems are highly sensitive to poisoning and requires long reaction time. Although homogeneous catalysts like NaOH, K_2CO_3, etc. shows high catalytic performance but suffered inconvenient separation process [23,24]. In order to overcome all these problems and achieving highest product yield numerous heterogenous catalysts have been explored. Heterogeneous catalysts like KNO_3/CaO [25], Mg- Ca [26], NaOH/ γ-Al_2O_3 [27], Li/ZnO [20], Ca/ZrO_2 [28], Ca/La [29], KF/Y-Al_2O_3 [30], Na modified zeolites [31] are used for synthesis of glycerol carbonate. Diverse application of Ca based mixed catalysts have been used for transesterification of glycerol. The disadvantages of such type of catalytic system includes prolonged

* Corresponding author.
E-mail address: ysharma.apc@itbhu.ac.in (Y.C. Sharma).

https://doi.org/10.1016/j.mcat.2023.113162
Received 18 February 2023; Received in revised form 23 March 2023; Accepted 17 April 2023
Available online 13 May 2023