WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 9, Issue 7, 1480-1486. Research Article ISSN 2277– 7105

SUSTAINABLE PRODUCTION AND CHARACTERIZATION OF CALCIUM BASED NANOCATALYST USING WASTE EGG SHELLS

Ambika Gaur*[1], Shivani Singhal[1] and Dr. Rohit Sharma[2]

[1]Scholar, B.Sc (H) Biotechnology, Department of Biotechnology, School of Applied and Life Sciences (SALS), Uttaranchal University.

[2]Assistant Professor, Department of Biotechnology, SALS, Uttaranchal University, Dehradun.

Article Received on 13 April 2020,
Revised on 04 May 2020,
Accepted on 25 May 2020,
DOI: 10.20959/wjpr20207-17756

***Corresponding Author**
Ambika Gaur
Scholar, B.Sc (H) Biotechnology, Department of Biotechnology, School of Applied and Life Sciences (SALS), Uttaranchal University.

ABSTRACT

Solid heterogeneous based catalysts are one of major materials for the transesterification and pyrolysis of edible or non edible oils because they are normally more reactive than solid acid based catalysts which require severe operating parameters. Calcium oxide based nanocatalyst has shown improved catalytic activity because of its high basicity as required during the transesterification reaction process of triacylglycerides (TAGs) and in pyrolysis process. In the present study, waste chicken egg shell based nanocatalyst derived from calcium oxides as a heterogeneous catalyst was synthesized and characterized using Fourier transformed infrared spectroscopy (FTIR) and X-ray based diffraction (XRD). The FTIR as well as XRD results have clearly shown the synthesis of heterogeneous based calcium oxide nanocatalyst from waste eggshell, which is normally composed of calcium carbonate. Therefore, waste eggshells can be considered as the promising technique and resource of calcium for the applications in various fields.

KEYWORDS: Nanocatalyst, Waste chicken egg shell, Calcium oxide, Heterogeneous catalyst.

INTRODUCTION

Large amounts of solid waste which include industrial, municipal, as well as major hazardous wastes is generating worldwide. Moreover, Food wastes are also a major source of solid waste which causes major problems in health as well as in the environment. It has been estimated that kitchen or food waste could increase the production from 44% from 2005 to

2025.[1] Rise in industrialization as well as population rise are the most important factors that increase the solid wastes in the nation. Eggshell is also one of the solid waste materials that contributes to the degradation of the environment. Restaurants, Domestic/households, as well as bakeries are major sources of waste eggshells.[2] The main constituent of pure eggshell is calcium carbonate ($CaCO_3$) which contains low porosity.[2] This egg shell waste could be easily transformed into various value added products. Waste eggshells could also be useful as the $CaCO_3$ source for other important applications in catalytic industries.[3,4] Moreover, the most common tool to manage and utilize waste eggshell is synthesis of chemicals based on Calcium sources. Utilization of waste eggshells could also provide benefits which is not only regarding the environmental concern but also for the freeing of size for landfill sites. Preparation of nanocatalyst is one of the attracting as well as more attentive processes because of its better production related to its improved yield and surface area. Calcium oxide based nanocatalysts have most applications in different fields. This product is also considered as the active nanocatalyst for diversified applications in oil sectors.[5] Calcium oxide based nanocatalysts have been produced and utilized as the source of adsorbents for removal of heavy metals in water during wastewater treatments[6–10], as source of CO_2 capture[11] in which CO_2 capturing capacity also increases with increase in surface area of the nanocatalyst[12], as well as heterogeneous nanocatalysts in production of biodiesel[13] with transesterification process and bio-oil with pyrolysis process. This type of nanocatalyst have also been synthesized by different methods like ultrasonic based method[14], hydrogen based plasma metal reaction[15], the biopolymer based method[16] microwave based method[17], calcination based[18], co-precipitation based[19], thermal decomposition based[20] and chemical based co-precipitation[21], etc. These methods are having various drawbacks like the use of costly additives, high pressure and temperature conditions, time consuming process, high cost and complicated process.

This method of calcium oxide based nanocatalysts synthesis overcomes most of these drawbacks from above mentioned protocols. This method of synthesis is very simple, low cost, less time consuming and moreover does not require any expensive equipment during production. This method of production is carried at lower temperature as well as with atmospheric pressure.

Due to this, this method can be the promising process for synthesizing calcium oxide based nanocatalyst. Today, waste eggshell is mostly utilized in various industrial applications.[3,4,10,22] This method of production can be shown as low cost, easy as well as eco-friendly.

2. MATERIAL AND METHODOLOGY

2. 1 Preparation of CaO based Nanocatalyst

Empty chicken egg shell waste was collected. Briefly, the egg shells were washed with warm tap-water to remove unwanted material adhered on the surface and rinsed thoroughly with distilled water and then dried in hot air oven at 120°C for 24 h. The chicken egg shells were finely crushed using a blender and passed through 60 mm sieve mesh. The powered egg shells were calcinated in a muffle furnace at 900°C for 3 h. above 800°C, calcium carbonate of the egg shells was decomposed to calcium oxide and carbon dioxide.

Figure 1: Preparation of catalyst.

The CaO obtained was refluxed in water at 60°C for 6 h, and dried in a hot air oven at 105°C overnight. The solid dried particles were further grounded using a blender and dehydrated by calcinations in furnace at 870°C for 3 h to convert hydroxide to oxide form and stored under vacuum in a desiccators. Therefore, highly active CaO nanocatalyst was synthesized from chicken egg shells.

2.2. Characterization

Characterization process of synthesized CaO based powders was tested by Fourier based transformed infrared spectroscopy (FTIR). The chemical analysis of raw eggshell and synthesized CaO nanoparticle was performed using X-ray fluorescence spectrometer (**Bruker**). The crystalline structure analysis of synthesized CaO nanoparticle was analyzed by X-ray based diffraction (XRD) with diffraction pattern angles of 2θ from 10° to 90°. The FTIR spectroscopy (Thermo Scientific) was used to determined the different functional groups present in the synthesized CaO based nanoparticle.

RESULTS AND DISCUSSION

FTIR spectrum graph of CaO based nanoparticle, is shown in Figure 2. This graph characterizes the CaO based synthesized nanoparticle which is prepared using waste eggshells.

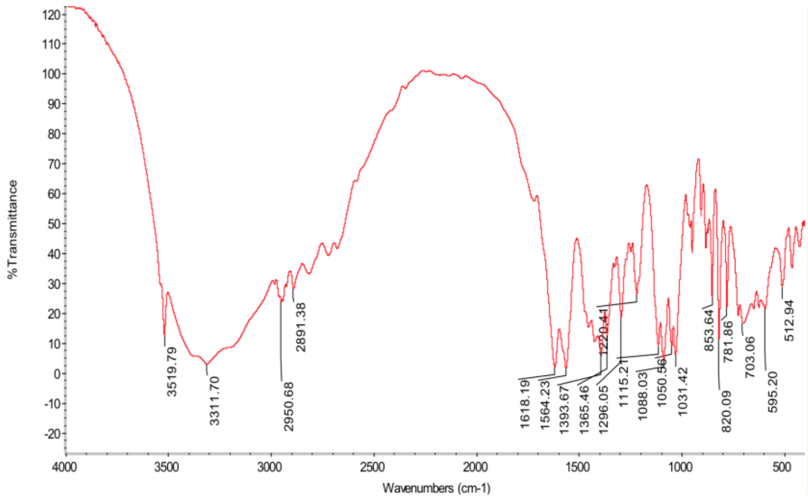

Figure 1: FTIR spectrum of CaO based nanocatalyst.

The FTIR graph results of CaO based nanocatalyst showed various band centering at 1415.52 cm^{-1}; which is basically the characteristic of an C–O bond that shows a bond in between oxygen atom, carbonate & calcium atom.[23] Moreover, there are two more sharp bands as shown in spectrum at 711.62 as well as 875.54 cm^{-1} which is showing C–O bond.[23] These peaks of CaO based nanoparticles correspond with commercial $CaCO_3$ at 2360.48 cm^{-1} that represents the N–H bond which is caused by the amines as well as amides present fiber of the eggshell membrane.[23]

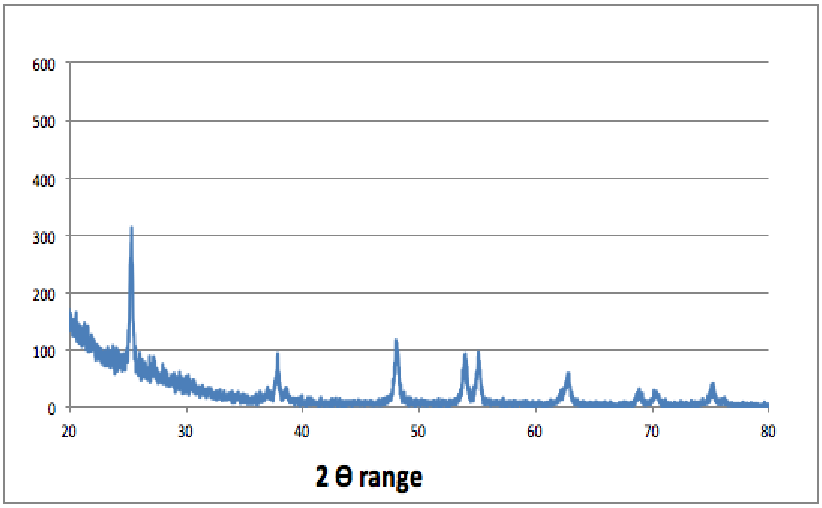

Figure 1: XRD pattern of CaO based nanocatalyst.

CONCLUSION

In the present study, calcium oxide based nanocatalysts were prepared from the waste eggshell. This technique has more advantages over other conventional methods or processes for synthesizing various metal oxides based nanocatalysts. This is such a simple, economic, with no expensive equipment, sustainable with low temperature and having no pressure requirements. The FTIR as well as XRD results have clearly reporsenting the synthesis of waste egg shells based calcium oxide nanocatalyst, which mainly consist of calcium carbonate.

ACKNOWLEDGEMENT

The authors thank the Chancellor, Vice Chancellor (Uttaranchal University) and Principal (SALS) for guidance and support.

REFERENCES

1. Mavropoulos, A.; Wilson, D.; Cooper, J.; Costas, V.; Appelqvist, B. Globalization and Waste Management; International Solid Waste association (ISWA): Vienna, Austria, 2012; 1–55.
2. Akbar, A.; Hamideh, F. Application of eggshell wastes as valuable and utilizable products: A review. Res. Agric. Eng., 2018; 64: 104–114.
3. Jose Valente, F.C.; Roberto, L.R.; Jovita, M.B.; Rosa María, G.C.; Antonio, A.P.; Gladis Judith, L.D. Sorption mechanism of Cd(II) from water solution onto chicken eggshell. App. Sur. Sci., 2013; 276: 682–690.
4. Duncan, C.; Allison, R. Sustainable bio-inspired limestone eggshell powder for potential industrialized applications. ACS Sustain. Chem. Eng. 2015; 3: 941–949.
5. Gerko, O. Metal oxide nanoparticles: Synthesis, characterization, and application. J. Sol. Gel Sci. Technol, 2006; 37: 161–164.
6. Ming, H.; Shujuan, Z.; Bingcai, P.; Weiming, Z.; Lu, L.; Quanxing, Z. Heavy metal removal from water/wastewater by nanosized metal oxides: A review. J. Hazard. Mater, 2012; 211–212: 317–331.
7. Lin, X.; Burns, R.C.; Lawrance, G.A. Heavy metals in wastewater: The effect of electrolyte composition on the precipitation of cadmium (ii) using lime and magnesia. Water Air Soil Pollut, 2005; 165: 131–152.

8. El-Dafrawy, S.M.; Youssef, H.M.; Toamah, W.O.; El-Defrawy, M.M. Synthesis of nano-CaO particles and its application for the removal of Copper (II), Lead (II), Cadmium (II) and Iron (III) from aqueous solutions. Egypt. J. Chem., 2015; 58: 579–589.
9. Oladoja, N.A.; Ololade, I.A.; Olaseni, S.E.; Olatujoye, V.O.; Jegede, O.S.; Agunloye, A.O. Synthesis of nano calcium oxide from a gastropod shell and the performance evaluation for Cr (VI) removal from aqua system. Ind. Eng. Chem. Res., 2012; 51: 639–648.
10. Setiawan, B.D.; Oviana, R.; Fadhilah Brilianti, N.; Wasito, H. Nanoporous of waste avian eggshell to reduce heavy metal and acidity in water. Sus. Chem. Phar. 2018, 10, 163–167. Sustainability, 2019; 11: 3196 9 of 10.
11. Wenqiang, L.; An, H.; Qin, C.; Yin, J.; Wang, G.; Feng, B.; Xu, M. Performance enhancement of calcium oxide sorbents for cyclic CO2 capture-A review. Energy Fuels, 2012; 26: 2751–2767.
12. Nikulshina, V.; G´alvez, M.E.; Steinfeld, A. Kinetic analysis of the carbonation reactions for the capture of CO2 from air via the Ca(OH)2–CaCO3–CaO solar thermochemical cycle. Chem. Eng. J., 2007; 129: 75–83.
13. Boeya, P.L.; Pragas Maniama, G.; Abd Hamid, S. Performance of calcium oxide as a heterogeneous catalyst in biodiesel production. A review. Chem. Eng. J., 2011; 168: 15–22.
14. Alavi, M.A.; Morsali, A. Ultrasonic-assisted synthesis of Ca(OH)2 and CaO nanostructures. J. Exp. Nano Sci., 2010; 5: 93–105.
15. Liu, T.; Zhu, Y.; Zhang, X.; Zhang, T.; Zhang, T.; Li, X. Synthesis and characterization of calcium hydroxide nanoparticles by hydrogen plasma-metal reaction method. Mater. Lett., 2010; 64: 2575–2577.
16. Darroudia, M.; Bagherpour, M.; Ali Hosseinie, H.; Ebrahimic, M. Biopolymer-assisted green synthesis and characterization of calcium hydroxide nanoparticles. Ceram. Int., 2016; 42: 3816–3819.
17. Roy, A.; Bhattacharya, J. Microwave assisted synthesis of CaO nanoparticles and use in waste water treatment. Nano Technol, 2011; 3: 565–568.
18. Roy, A.; Gauri, S.S.; Bhattacharya, M.; Bhattacharya, J. Antimicrobial Activity of CaO Nanoparticles. J. Biomed. Nanotechnol, 2013; 9: 1–8.
19. Ghiasi, M.; Malekzadeh, A. Synthesis of CaCO3 nanoparticles via citrate method and sequential preparation of CaO and Ca(OH)2 nano particles. Cryst. Res. Technol, 2012; 47: 471–478.

20. Sadeghi, M.; Husseini, M.H. A Novel Method for the Synthesis of CaO Nanoparticle for the Decomposition of Sulfurous Pollutant. J. Appl. Chem. Res., 2013; 7: 39–49.
21. Mirghiasi, Z.; Bakhtiari, F.; Darezereshki, E.; Esmaeilzadeh, E. Preparation and characterization of CaO nanoparticles from Ca(OH)2 by direct thermal decomposition method. J. Ind. Eng. Chem., 2014; 20: 113–117.
22. Arul, E.; Raja, K.; Krishnan, S.; Sivaji, K.; Jerome, D.S. Bio-Directed synthesis of calcium oxide (Cao) nanoparticles extracted from limestone using honey. J. Nanosci. Nanotechnol, 2018; 18: 5790–5793. [PubMed]
23. Ferraz, E.; Gamelas, J.A.F.; Coroado, J.; Monteiro, C.; Rocha, F. Recycling waste seashells to produce calcitic lime: Characterization and wet slaking reactivity. Waste Biomass Valoriz, 2018; 1–18.