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# Production of Biodiesel from *Zygnema carinthiacum* Using Eggshell as a Catalyst and Impregnation with Green Produced Silver Nanoparticles

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## ABSTRACT

Biodiesel is a promising renewable fuel that can be used as an alternative to fossil fuels. In this study, biodiesel was produced from *Zygnema carinthiacum* green algae by extracting oil and then converting the oil in two steps (esterification and transesterification) using two types of catalysts: calcium oxide (CaO) produced from eggshells and calcium oxide impregnated with silver nanoparticles (CaOAgNPs) produced from the same algae *Z. carinthiacum*. The properties of algal oil and biodiesel produced were investigated using Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier Transform Infrared Spectroscopy (FTIR). The AgNPs were synthesized and characterized using a UV-visible Spectrophotometer, (FTIR), X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM), which confirmed the synthesis of mostly spherical nanoparticles with sizes ranging from 19.92-52.38 nm. Fuel properties, including density, kinematic viscosity, cloud point, pour point, and acid value were determined and their values were 0.877 g/cm$^3$, 4.71 mm$^2$/s, 3°C,-4°C, 0. 34 mg KOH/g, respectively, for biodiesel produced by used CaO catalyst, as for the biodiesel produced using CaOAgNPs catalyst their values were 0.867 g/cm$^3$, 4.12 mm$^2$/s, -2°C, -7°C, 0.46 mg KOH/g., respectively. The results also revealed that a biodiesel yield of approximately 78% was obtained using CaO and nearly 80% using CaOAgNPs. In conclusion, the production of biodiesel from *Z. carinthiacum* oil as an alternative feedstock using an AgNPs-impregnated CaO catalyst made from eggshell waste was discovered to be an environmentally-friendly and promising technique.

**Key words:** Biodiesel, transesterification, eggshells catalyst, *Zygnema*, calcination, AgNPs green synthesis

## INTRODUCTION

It is well known that fossil fuels pollute the air, and that global energy consumption is constantly increasing, which has resulted in dwindling fuel resources, leading to an increase in studies aimed at producing alternative fuels and renewable energy sources around the world (Deshmukh *et al.*, 2021). Biofuel produced from biomass, the most important of which include biodiesel, bioethanol, biohydrogen, biomethane and biogasoline, is currently one of the most important sources of sustainable and renewable energy (Sharma *et al.*, 2020). Biofuels are separated into three generations. The first generation is produced from food crops rich in sugars, starches and oils, such as corn, wheat, sugarcane, barley, sorghum and sunflower; the second generation is produced from cellulosic materials derived from plant residues such as wheat straw, grass and others (Leong *et al.*, 2018), while the third generation is produced from algae (Leong *et al.*, 2018).

Biodiesel is one of the most important types of biofuels, chemically is monoalkyl esters of long chain fatty acids derived from renewable feed stock such as vegetable oils (Shaah *et al.*, 2021), fish oils (Kadhim *et al.*, 2020), animal fats (Hasan and Ratnam, 2022), fungal oils (Alrubayae and Kadhim, 2020), as well as algal oils (Alwan and Al, 2021). It is produced by transesterification in which the oil or fat reacts with alcohol in the presence of a catalyst to give the corresponding monoalkyl esters (Mishra and Goswami, 2018).

It is a renewable and biodegradable fuel that is environmentally safe for use and provides energy needs, so it represents a practical solution to the crisis of depletion of fossil fuels on the one hand and the crisis of environmental degradation on the other (Bhatt *et al.*, 2018). It has been identified as a potential alternative fuel for diesel engines

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