IN-SITU FATTY ACID ETHYL ESTER PRODUCTION FROM WET MAHOGANY (*SWIETENIA MACROPHYLLA*) SEED USING SUPERCRITICAL CARBON DIOXIDE AND AZEOTROPIC ETHANOL

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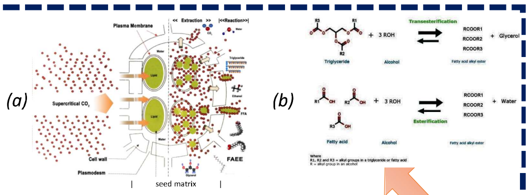
ABSTRACT

The issue on biodiesel production cost can be resolved using the novel technique employed in this study. The study involves the reactive-extraction process of seed oil from Mahogany seed using the synergy of in-situ formation of carbonic acid, and carbon dioxide-expanded ethanol-water system. This technique provides cheaper production cost since it eliminates the energy-intensive process which is the drying of seeds and utilizing cheap solvent, azeotropic ethanol and the recoverable co-solvent, carbon dioxide. It was observed that higher water loading provides better extraction efficiency and conversion when operated low conditions. The novel and simpler technique employed in this study transpired significant potential in producing fully renewable and cheap biodiesel which is due to the positive synergistic effect of the carbon dioxide-ethanol-water solvent system.

METHODOLOGY

Fig. 1. Theoretical illustration (*a*) & FAEE production pathways (*b*) using the proposed novel technique.



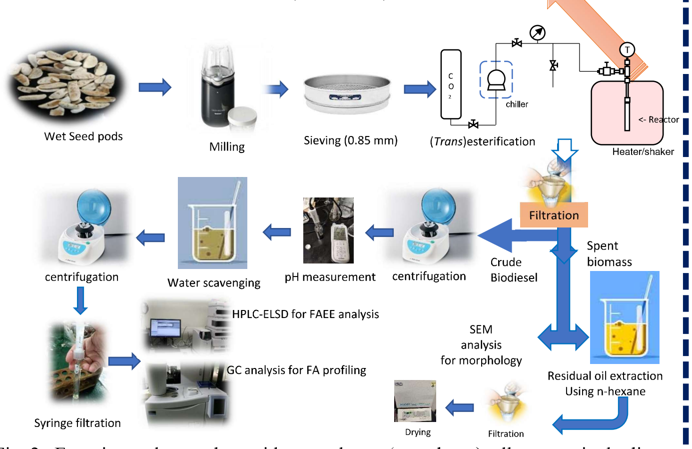


Fig. 2. Experimental procedure with control runs (no solvent); all were run in duplicates

CONCLUSIONS

Eliminating pre-treatments and utilizing azeotropic ethanol in supercritical carbon dioxide reactive extraction was found possible. It was found out that higher water loading of the proposed novel technique showed to be an advantage. The increase in volume expansion coefficient of the solvent resulted in an increase in recovery and yield. Further increase in the amount of H^+ via *pH* lowering led to a higher recovery and yield. With all these significant findings, it can be concluded that the synergy of *in-situ* formation of carbonic acid (via *pH* or H^+ production) and supercritical CO_2-expanded ethanol-water solvent system has a relative positive effect on the production of FAEE that introduces a novel technique that can be more economical, with low environmental impact, and sustainable. Further studies is recommended to improve the degree of conversion and yield.

INTRODUCTION

Biodiesel is an ester product composed of a mixture of alkyl esters. It is a renewable fuel that could serve as an alternative for fossil fuels. Among the promising feedstocks nowadays are from non-edible plants and microbial sources and waste oils. The major challenge in the widespread use of biodiesel lies primarily in its cost and current technology for processing a wide range of feedstocks.

In this work, we introduced a novel, simple, and economical technique to produce fatty acid ethyl esters (FAEE) by employing *in-situ* supercritical carbon dioxide ($scCO_2$) reactive extraction using wet Mahogany seeds as the feedstock and azeotropic ethanol (EtOH-H_2O) as the reactant.

This present work aims to investigate the viability of using $scCO_2$ in EtOH-H_2O solvent system in the *in-situ* reactive extraction of FAEE in Mahogany seeds. Specifically, the synergistic effect of the *in-situ* formation of carbonic acid (H_2CO_3) and the volume expansion, as an effect of the introduction of $scCO_2$ to EtOH-H_2O system was thoroughly investigated.

RESULTS AND DISCUSSIONS

Conventional versus the novel technique

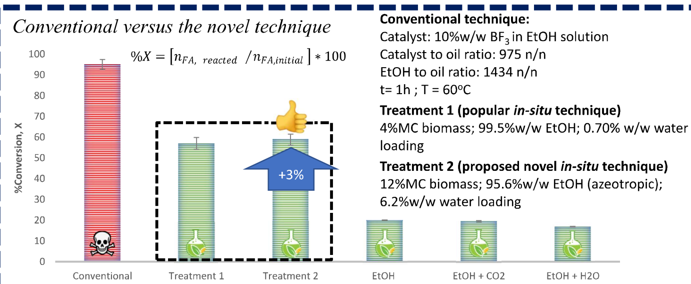
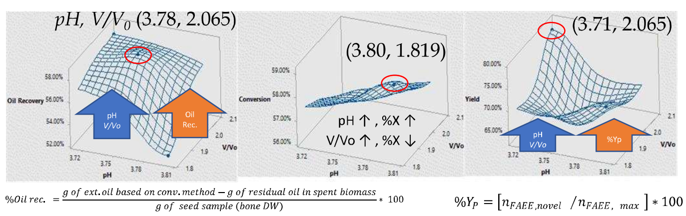


Fig. 3. Degree of conversion (*%X*) comparison using different methods & co-solvents.

Synergistic effect of in-situ H_2CO_3 formation and CO_2-expanded ethanol (T2)



$$\%Oil\ rec. = \frac{g\ of\ ext.oil\ based\ on\ conv.method - g\ of\ residual\ oil\ in\ spent\ biomass}{g\ of\ seed\ sample\ (bone\ DW)} * 100$$

$$\%Y_P = [n_{FAEE,novel} / n_{FAEE,\ max}] * 100$$

Fig. 4. Synergistic effect of volume expansion and *pH* on extraction efficiency (*a*), conversion (*b*), and yield (*c*).

Morphological analysis of biomass

Compact & smooth cells | Sharp cavities & thin flakes | Sharp cavities & thinner flakes

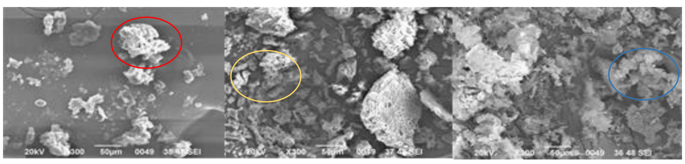


Fig. 3. SEM micrographs of fresh sample (*a*), Treatment 1 (*b*), and Treatment 2 (*c*).

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