**The Effect of Co-Solvent and Catalyst Type on the One-Step Supercritical Carbon Dioxide (*Trans*)esterification of *Swietenia Macrophylla* Seed**

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**Highlights**

* Utilizing co-solvent gave significant effect to the oil yield where methanol showed to be the best.
* Utilizing base-functionalized MWCNT as catalyst is still more practical rather than using KOH though it exhibited to make the highest yet at par %FAME Yield.
* Cetane number of the biodiesel used showed to be high which can provide short ignition delay in diesel engines when used.

**1. Introduction**

Mahogany (*Swietenia Macrophylla*) seed, a non-edible seed is not only abundant in most of the localities in the Philippines. It has been found out that the seed has a significant amount of oil of around 39-58% [1, 2]. Moreover, it was proven that Mahogany seed is a potential feedstock for biodiesel production which could meet biodiesel standards, comparable to petroleum-based diesel. However, issues on the presence of a significant amount of impurities like free fatty acid (FFA), moisture, waxes, and gums may arise. To resolve these issues the process may require additional processing steps before this feedstock can be used for biodiesel production using the conventional base-catalyzed process. Otherwise, a process requiring the use of a specific catalyst and /or solvent conditions may be needed to effectively utilize this feedstock. Until now, achieving the supposed potential of seed biofuels remains in the experimental lab scale due to the mundane cost of its production, making them less attractive for long-term operations in the industrial-scale [3].

One-step (*trans*)esterification using supercritical carbon dioxide and two-reactors in series of dried Mahogany seed creates interest and was studied since there is a significant reduction in the process supply chain by combining crucial steps and increasing the residence time which could improve the conversion of triglycerides to FAME. The effect of co-solvent and catalyst type on the relatively novel process was determined and quantified in order to determine their response on oil and FAME yield.

**2. Methods**

The experimental set-up include: (a) Liquid CO2 cylinder which provides the carbon dioxide in the process; (b) Micro filter which ensures that no contaminants could enter the system; (c) Chiller which brings down the temperature of the carbon dioxide to 2oC, thus in liquid state; (d) HPLC (High Performance Liquid Chromatography) pump which regulates the flow rate of the carbon dioxide of the system; (e) Oven with installed pre-heater (f) that controls the temperature for the extraction/(*trans*)esterification; (g) the reactors (approximately 10 and 50-ml capacity) where extraction and (*trans*)esterification are being held; (h) BPR (Back Pressure Regulator) which controls the pressure of the system; (i) Cyclone separator which separates carbon dioxide from the sample; and (j) is the sampler flask. The experiment was divided into two phases. First phase dealt with the effect of co-solvent type on oil yield while the 2nd phase studied on the effect of catalyst type on the FAME yield. All of these were subjected in supercritical carbon dioxide extraction/(*trans*)esterification at a pressure of 30 MPa and temperature of 90oC, and at CO2 influx of 10 g/min. N-hexane, methanol, mixture of n-hexane and methanol were among the co-solvents used. On the other hand, potassium hydroxide (KOH), acid-functionalized MWCNT (multi-walled carbon nanotubes) and base-functionalized MWCNT were the types of catalyst utilized in this study. One-factor completely randomized design was used as the basis in designing the experiments.

**3. Results and discussion**

The result has shown that utilizing a co-solvent could give significant effect to the oil yield where methanol showed to be the best. Utilizing n-hexane with methanol as co-solvent could have been a good alternative for it gave a close result to methanol. However, lots of impurities have been observed that 86% have been wasted. Moreover, using more co-solvent types could just make the separation complex. On the other hand, %FAME Yield was highest when OST was run with KOH as catalyst. The result is close to that of the base-functionalized MWCNT catalyst. However, utilizing KOH is cost intensive and will not pose an economic advantage to the process.

The %FAME could have been high enough to meet the European standard of at least 95%, however, optimum conditions for one-step supercritical fluid (trans) esterification could not be met due to the limited capacity of the reactors (e.g. allowable pressure, temperature). In effect of low %FAME important properties of the biodiesel obtained under the supercritical conditions failed to conform to the standards except for Cetane number (CN) which is high. This means that with high CN, the biodiesel produced can provide short ignition delay in diesel engines.

**4. Conclusions**

In conclusion, it is best to use methanol as co-solvent and base-functionalized MWCNT to obtain the most practical FAME yield. Moreover, the biodiesel produced can give the highest Cetane number which is relative to short ignition delay among the feedstock studied. However, reactors have yet to be upgraded with higher capacity, especially the maximum allowable temperature to possibly obtain higher %FAME and conform to all standards on biodiesel properties.

**References**

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