CHAPTER 5
CONCLUSIONS

5.1 Two-Stage Process

The biodiesel production from un-degummed MCPO having high FFA content was investigated. Due to its high FFA contents and un-degumming, MCPO was processed in a two-stage process (Esterification (the first-stage process) followed by transesterification (the second-stage process)). The optimization of the two-stage process in this thesis, which could reduce FFA to less than 0.1%wt in first 30 seconds and convert the product of the first-stage process into ME to more than 97%wt in five minutes, was used 36 %vol methanol base on oil (12%vol methanol (a 10:1 molar ratio of methanol to FFA) was used in the first-stage and 24%vol methanol (a 6:1 molar ratio of methanol to TG) was used in the second-stage) and catalyzed by H_2SO_4 and NaOH at 0.8 and 0.5%wt, respectively, at 60 degree Celsius. In addition, a 95 %vol yield of biodiesel production from un-degummed MCPO, which contained high FFA, was observed in the optimal condition of the two-stage process.

In the optimization of esterification, the reaction was half-order with respect to FFA, MeOH, ME and WT, and pseudo-first order overall. Rate coefficients for the FFA forward and the reverse reaction were 1.834 and 0.682 min^{-1}, respectively. In addition, rate coefficients for the forward reactions of TG, DG, and MG in the optimal condition of transesterification were 2.600, 1.186, and 2.303 litre mol^{-1} min^{-1}, respectively and for the reverse reactions of theirs were 0.248, 0.227, and 0.022 litre mol^{-1} min^{-1}, respectively. Activation energies of this investigation ranged from about 250 to 22,000 cal/mol for the Arrhenius model, which is a sufficient to produce biodiesel from MCPO by using the two-stage process.

Properties of biodiesel produced from MCPO exceeded the levels prescribed by the standard of biodiesel for agricultural engines in Thailand, except some conditions such as viscosity and total glycerine. There were higher and methyl ester was lower than the fuel properties requirement of commercial biodiesel.

5.2 Two-Stage Process Modeling

Two-Stage Process Modeling was installed in MATLAB7 by using Rung-Kutta method, and the kinetics of the two-stage process (rate laws, reaction orders and rate coefficients). The biodiesel production from MCPO could be predicted and the concentrations of TG, FFA, DG, MG, ME, GL, and WT under process conditions were set in this model.

The comparison between predicted results and experimental data indicated in high % data error mean and standard deviation in categories. However, the FFA conversion in esterification and the ME conversion in transesterification from calculated data, which used rate coefficients and reaction orders of the two-stage process from curve-fitting of MATLAB7, were broadly in agreement with data obtained the experiments. Therefore, this model could be used to predict biodiesel production from MCPO by the two-stage process.

5.3 Recommendations

1. In the experimental work, some conditions of the two-stage process for producing biodiesel from MCPO might be improved to meet the standard of commercial biodiesel.

2. Further experiments should be carried out to study the effect of gum in the MCPO on the reaction rate of the two-stage process.

3. MCPO, which contain high FFA content (>30%wt), will be required for reducing the raw material cost to produce biodiesel by the two-stage process in further experiments.

4. Further experimental work on the two-stage process will be required to complete the model of two-stage process.