

**Thesis Title**            Continuous Esterification of Crude Palm Oil with Ethanol  
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## **ABSTRACT**

Biodiesel is the most outstanding renewable energy, produced from several oils and fats through base catalyzed transesterification with an alcohol. If ethanol is used, ethyl ester, completely natural biodiesel, will be obtained. Crude palm oil (CPO) is the most potential raw material for biodiesel production in Thailand, but unfortunately it contains a high level of free fatty acid (FFA) content which should be reduced before conducting the transesterification. This research aimed to reduce FFA and phosphorus content of CPO using acid catalyzed esterification with ethanol; it is the optimized pretreatment process for CPO because the product is ethyl ester and degumming of phosphatide can be concurrent. This study investigated optimized conditions of the esterification using 3 experimental types i.e. batch (300 g/batch) and continuous (1.47 L) assisted by ultrasonic irradiation and also a continuous stirred-tank reactor (87 L), exploiting Taguchi method to design the experiments. The optimum conditions in descending order for batch and continuous ultrasonic methods are catalyst amount 60 wt% of FFA, molar ratio of ethanol to FFA at 30:1, temperature at 60°C (fixed for continuous experiments), reaction time of one hour and amplitude of acoustic power at 75% (for batch method only), consequently reduce FFA content (from 6 wt%) to 0.50 and 0.35 wt%, respectively. If water, by product of the reaction, can be abolished, the equilibrium will shift to the product side that be shown by FFA reduction to 0.22 wt% with 2 steps esterification. The optimum conditions in descending order of CSTR method (reacted at 60°C) are retention time of one hour, molar ratio of ethanol: FFA at 30: 1 and catalyst amount 60 wt% of FFA, obtaining final FFA content (from 7.5 wt%) of 0.81 wt%. As for energy consumption comparison shows that batch ultrasonic, continuous ultrasonic and CSTR experiments have an energy efficiency of 8.23, 6.85 and 79.70%, respectively. The obvious advantages of ultrasonic irradiation over the conventional method are that no external heating source is required for the reaction, resulting in saving the heating unit and a shorter time to achieve a lower FFA content and it can reduces FFA and phosphorus content from 6.26 to 0.35 wt% and from 11.24 to 1.46 mg/kg, respectively. This phosphorus content also meets the EN 14214: 2008.