Supplementary Material

Microwave-Assisted Noncatalytic Esterification of Fatty Acid for Biodiesel Production: A Kinetic Study

Hoang Chinh Nguyen [1], Fu-Ming Wang [2], Kim Khue Dinh [1], Thanh Truc Pham [3], Horng-Yi Juan [3], Nguyen Phuong Nguyen [1], Hwai Chyuan Ong [4,*] and Chia-Hung Su [3,*]

[1] Faculty of Applied Sciences, Ton Duc Thang University, Ho Chi Minh City, Vietnam
[2] Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taipei, Taiwan
[3] Graduate School of Biochemical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
[4] School of Information, Systems and Modelling, Faculty of Engineering and Information Technology, University of Technology Sydney, NSW 2007, Australia
* Correspondence: ong1983@yahoo.com (H.C.O.); chsu@mail.mcut.edu.tw (C.-H.S.)

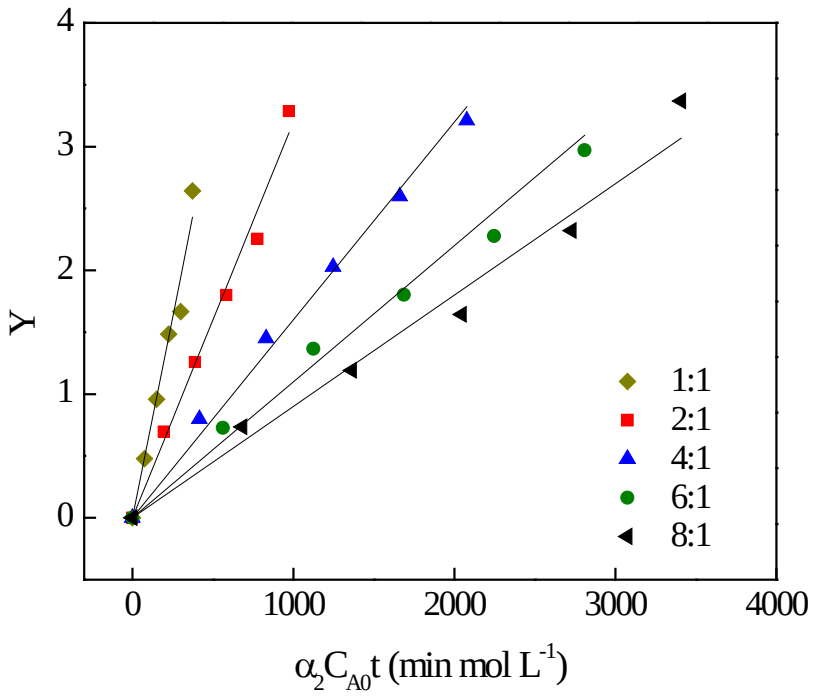

Figure S1. Kinetic model for calculating forward reaction rate constant of esterification of oleic acid with ethanol at different reactant molar ratios. Y denotes $ln\left[\frac{\left(-1-\theta_B-\frac{\theta_D}{K_e}+\alpha_2\right)X+2\theta_B}{\left(-1-\theta_B-\frac{\theta_D}{K_e}-\alpha_2\right)X+2\theta_B}\right]$.

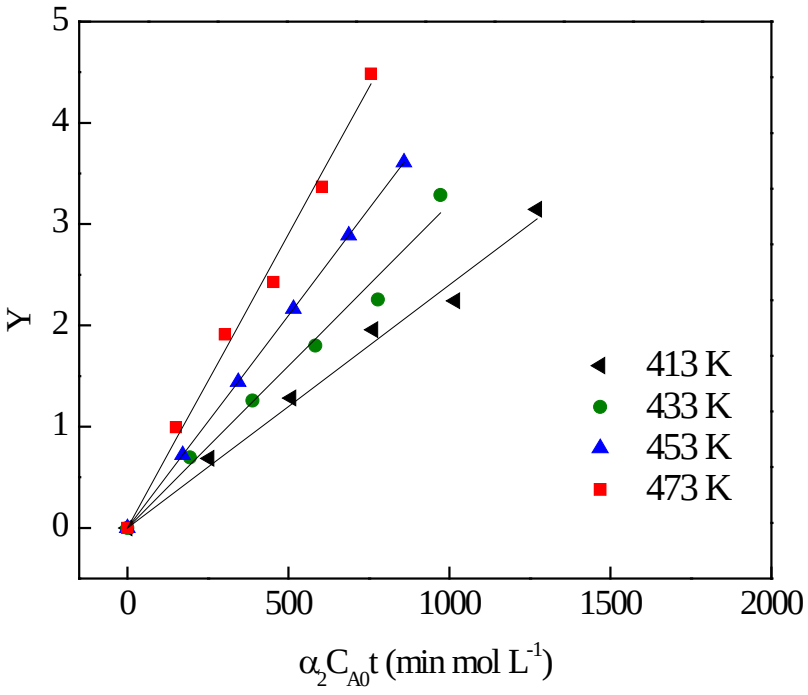

Figure S2. Kinetic model for calculating forward reaction rate constant of esterification of oleic acid with ethanol at different temperatures. Y denotes $ln\left[\frac{\left(-1-\theta_B-\frac{\theta_D}{K_e}+\alpha_2\right)X+2\theta_B}{\left(-1-\theta_B-\frac{\theta_D}{K_e}-\alpha_2\right)X+2\theta_B}\right]$.

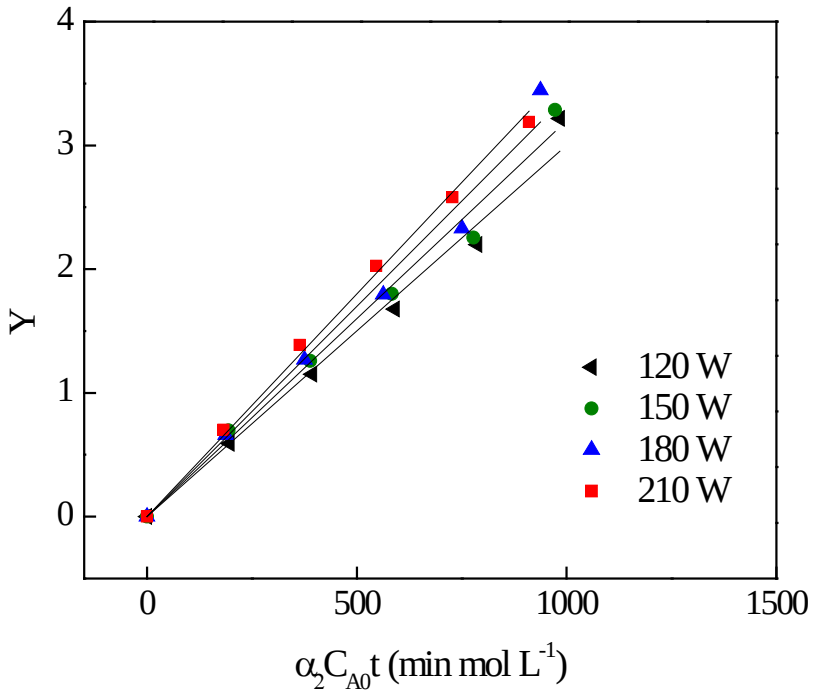

Figure S3. Kinetic model for calculating forward reaction rate constant of esterification of oleic acid with ethanol at different microwave power levels. Y denotes $ln\left[\frac{\left(-1-\theta_B-\frac{\theta_D}{K_e}+\alpha_2\right)X+2\theta_B}{\left(-1-\theta_B-\frac{\theta_D}{K_e}-\alpha_2\right)X+2\theta_B}\right]$.

Table S1. Forward reaction rate constant k_1 and equilibrium rate constant K_e for esterification using conventional heating.

Run	Molar ratio of ethanol to oleic acid	Temperature (K)	Equilibrium constant, K_e	Forward reaction rate constant, k_1 (L mol^{-1} min^{-1})	R^2
1	1:1	433	2.4213	2.2×10^{-3}	0.988
2	2:1	433	1.5584	1.5×10^{-3}	0.996
3	4:1	433	0.7237	0.8×10^{-3}	0.988
4	6:1	433	0.5484	0.5×10^{-3}	0.963
5	8:1	433	0.2980	0.5×10^{-3}	0.952
6	2:1	413	1.0501	1.0×10^{-3}	0.989
7	2:1	433	1.5584	1.5×10^{-3}	0.996
8	2:1	453	3.6264	1.9×10^{-3}	0.978
9	2:1	473	5.4830	2.4×10^{-3}	0.975

© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).