UNIVERSITI PUTRA MALAYSIA

MODIFICATION OF NATURAL WASTE CLAMSHELLS BY HYDRATION-DEHYDRATION TECHNIQUE FOR TRANSESTERIFICATION REACTION OF PALM OIL TO BIODIESEL

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By

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Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

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MODIFICATION OF NATURAL WASTE CLAMSHELLS BY HYDRATION-DEHYDRATION TECHNIQUE FOR TRANSESTERIFICATION REACTION OF PALM OIL TO BIODIESEL

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Chair : Prof. Taufiq Yap Yun Hin, PhD
Faculty: Science

Utilization of catalyst from waste shell (clamshell) via modification of catalyst via hydration followed by thermal decomposition is not only economic and environmental friendly. The hydration-dehydration method is efficient and easy to manufacture. The clamshell-derived calcium oxide (CS-CaO) from hydration technique shows high basicity as well as high surface area that exhibited higher catalytic activity than CaO of commercial standard. The CS-CaO derived from clamshell was reflux continuously with water for 1,3,6,9 and 12 h and calcined at 600 ^{o}C for 3 h to produce heterogeneous catalyst with greater properties (stronger activity and better selectivity relatively due to high surface area and high basicity) that perform better in transesterification reaction. The clamshell was characterized by using X-Ray fluorescence spectroscopy (XRF) and thermogravimetric analysis (TGA). The synthesized catalyst was characterized by using several methods such as X-Ray diffraction (XRD) analysis, N_2 adsorption (BET), temperature-programme desorption of carbon-dioxide (TPD-CO_2), scanning electron microscopy (SEM). The synthesized biodiesel was characterized using gas chromatography (GC) and atomic absorption (AAS). Furthermore, the catalytic activity of the catalyst derived from clamshell; CS-CaO, CS-CaO $_{1h}$, CS-CaO $_{3h}$, CS-CaO $_{6h}$, CS-CaO $_{9h}$ and CS-CaO $_{12h}$ were investigated. Elongating the time during refluxing process in water resulted in high basicity of catalyst and surface area which leads to high catalytic activity (CaO $_{12h}$>CaO $_{9h}$>CaO $_{6h}$>CaO $_{3h}$>CaO $_{1h}$). The transesterification activity was greatly influenced by basicity of the active sites on the catalyst. The optimization study for palm-based biodiesel production using CS-CaO, CS-CaO $_{1h}$, CS-CaO $_{3h}$, CS-CaO $_{6h}$, CS-CaO $_{9h}$ and CS-CaO $_{12h}$ was conducted in this study. The effect of the variables including methanol and oil molar ration (5-17), catalyst loading (0.2-1 wt. %) and reaction time (1-5 h) was investigated. The results shows CS-CaO $_{9h}$ catalyst resulted in completed reaction (FAME > 98 %) at optimum condition of 2 h reaction time via catalyst loading equal to 1 wt.% with 9:1 methanol and oil molar ratio. Several physicochemical properties of palm-based biodiesel produced was tested and agreed

to ASTM D6751 (ASTM D445, ASTM D93, ASTM D97, ASTM D2500) and EN 14214 standard.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Master Sains

PENGUBAHSUAIAN SISA SEMULA JADI CENGKERANG KEPAH MELALUI TEKNIK PENGHIDRATAN-PENYAHIDRATAN UNTUK TINDAK BALAS TRANSESTERIFIKASI MINYAK SAWIT KEPADA BIODISEL

Oleh

NURUL ASIKIN BT MIJAN

Jun 2014

Pengerusi: Prof. Taufiq Yap Yun Hin, PhD
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Penggunaan pemangkin dari sisa cengkerang (cengkerang kepah) melalui pengubahsuaian penghidratan diikuti oleh penguraian terma bukan sahaja menjimatkan dan mesra alam sekitar. Kaedah penghidratan-penyahidratan juga efisien dan penghasilannya sangat mudah. Kalsium oksida (CS-CaO) yang diperbuat daripada cengkerang kepah melalui kaedah penghidratan menunjukkan darjah kealkalian dan luas permukaan yang tinggi, ia menunjukkan kadar aktiviti pemangkin yang tinggi lebih daripada pemangkin CaO komersial. CS-CaO daripada cengkerang telah direflukskan di dalam air untuk jangka masa 1,3,6,9, dan 12 jam dan dikalsin pada suhu 600 ºC untuk 3 jam bagi menghasilkan pemangkin heterogen dengan ciri-ciri lebih bagus (aktiviti yang lebih aktif dan pemilihan yang lebih baik, disebabkan luas permukaan dan kealkalian yang tinggi), ia akan menyebabkan tindak balas berlaku dengan berkesan. Cengkerang kepah tersebut dianalisa dengan menggunakan sinar-X pendarfluor spektroskopi (XRF) dan termogravimetri analisis (TGA). Pemangkin yang telah disintesis akan dicirikan dengan menggunakan beberapa kaedah seperti analisis belauan sinar-X (XRD), Brunauer-Emmet-Teller (BET), Program suhu peyahjerapan karbon dioksida (TPD-CO_2), pengimbas mikroskopi elektron (SEM). Biodiesel yang dihasilkan akan dicirikan menggunakan gas chromatogram (GC) dan spekroskopi penyerapan atom (AAS). Seterusnya, aktiviti pemangkin yang diperbuat daripada cengkerang kepah CS-CaO , CS-CaO $_{1\ h}$, CS-CaO $_{3\ h}$, CS-CaO $_{6\ h}$, CS-CaO $_{9\ h}$ dan CS-CaO $_{12\ h}$ disiasat. Pemanjangan tempoh masa semasa proses refluks dalam air akan menyebabkan peningkatan kealkalian dan luas kawasan permukaan yang tinggi sekaligus membawa kepada aktiviti pemangkinan yang tinggi (CS-CaO $_{12\ h}$ > CS-CaO $_{9\ h}$ > CS-CaO $_{6\ h}$ > CS-CaO $_{3\ h}$ > CS-CaO $_{1\ h}$ > CS-CaO). Transesterifikasi aktiviti dipengaruhi oleh kealkalian tapak aktif catalyst. Kajian pengoptimuman biodiesel daripada minyak sawit mengunakan CS-CaO , CS-CaO $_{1\ h}$, CS-CaO $_{3\ h}$, CS-CaO $_{6\ h}$, CS-CaO $_{9h}$ dan CS-CaO $_{12h}$ telah dijalankan dalam kajian kesan pemboleh ubah termasuk nisbah molar (5-17) metanol dan minyak, kuantiti pemangkin (0.2-1 wt.%) dan masa tindak balas (1-5 h) telah disiasat. Keputusan menunjukkan pemangkin CS-CaO $_{9h}$ menghasilkan tindak balas lengkap (FAME > 98 %) di dalam keadaan

optimum masa tindak balas 2 jam , kuantiti pemangkin 1 wt.% dan nisbah methanol dan molar minyak pada 9:1. Beberapa sifat fisikokimia biobahan api biodiesel minyak sawit yang dihasilkan telah diuji dan mematuhi ASTM D6751 (ASTM D445, ASTM D93, ASTM D97, ASTM D2500) dan EN 14214 standard.

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I certify that a Thesis Examination Committee has met on 19 June 2014 to conduct the final examination of Nurul Asikin binti Haji Mijan on her thesis entitled "Modification of Natural Waste Clamshells by Hydration-Dehydration Technique for Transesterification Reaction of Palm Oil to Biodiesel" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
EN	European Standard
JCPDS	Joint Committee on Powder Diffraction Standards
MPOB	Malaysian Palm oil Board
R&D	Research And Development
TGA	Thermogravimetry Analysis
XRD	X-Ray Diffraction Analysis
TPD-CO_2	Temperature Programmed Desorption of Carbon Dioxide
BET	Brennauer-Emmet-Teller
SEM	Scanning Electron Microscopy
XRF	X-ray Fluorescence Spectroscopy
GC	Gas Chromatography
AAS	Atomic Absorption Spectroscopy
FFA	Free Fatty Acid
TCD	Thermal Conductivity Detector
D2	Diesel Fuel
SNI	Shipp Non-ionic
EMA	Engine Manufacturers' Association
TCD	Thermal Conductivity Detector
FAME	Fatty acid methyl ester
CS	Raw fresh powder clamshell
CS-CaO	CaO derived from clamshell
CS-$CaO_{1 h}$	CaO derived from clamshell from 1 h water treatment
CS-$CaO_{3 h}$	CaO derived from clamshell from 3 h water treatment
CS-$CaO_{6 h}$	CaO derived from clamshell from 6 h water treatment
CS-$CaO_{9 h}$	CaO derived from clamshell from 9 h water treatment
CS-$CaO_{12 h}$	CaO derived from clamshell from 12 h water treatment

CHAPTER 1

INTRODUCTION

1.1 Fossil Fuel Energy

The world has recently been in trouble with energy crisis due to the depletion of fossil fuel (Ngamcharussrivichai *et al*., 2010). This fact also in agreement by Alba-Rubio *et al.*, 2010, which the exhaustion of the fossil source has provoked enormous problem of energy dependency in most countries. The world's oil reserves are located in certain location and extremely irregularly. The specific areas which have suitable geological features and allowed the creation along with accumulation of the oil. Figure 1 shows the current scene of the distribution of the oil reserves around the world. It found, that majority about 65 % of oil reserve possess by Middle East followed by Europe and Eurasia (11.7 %), Africa (9.5 %), Central and South America (8.6 %), North America (5 %) and Asia and The Pacific (3.4 %) (Escobar *et al.,* 2009)

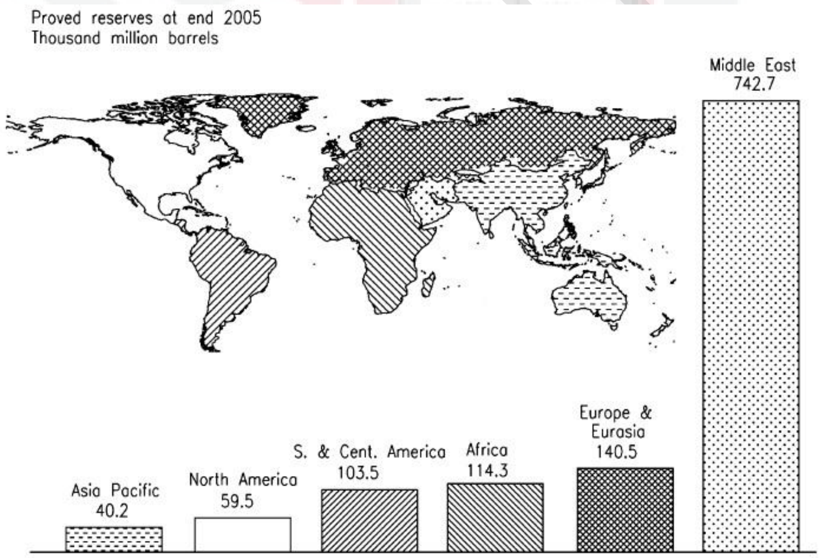

Figure 1. Current panorama and distribution of the oil reserves in the world (Source: Escobar *et al*., 2009)

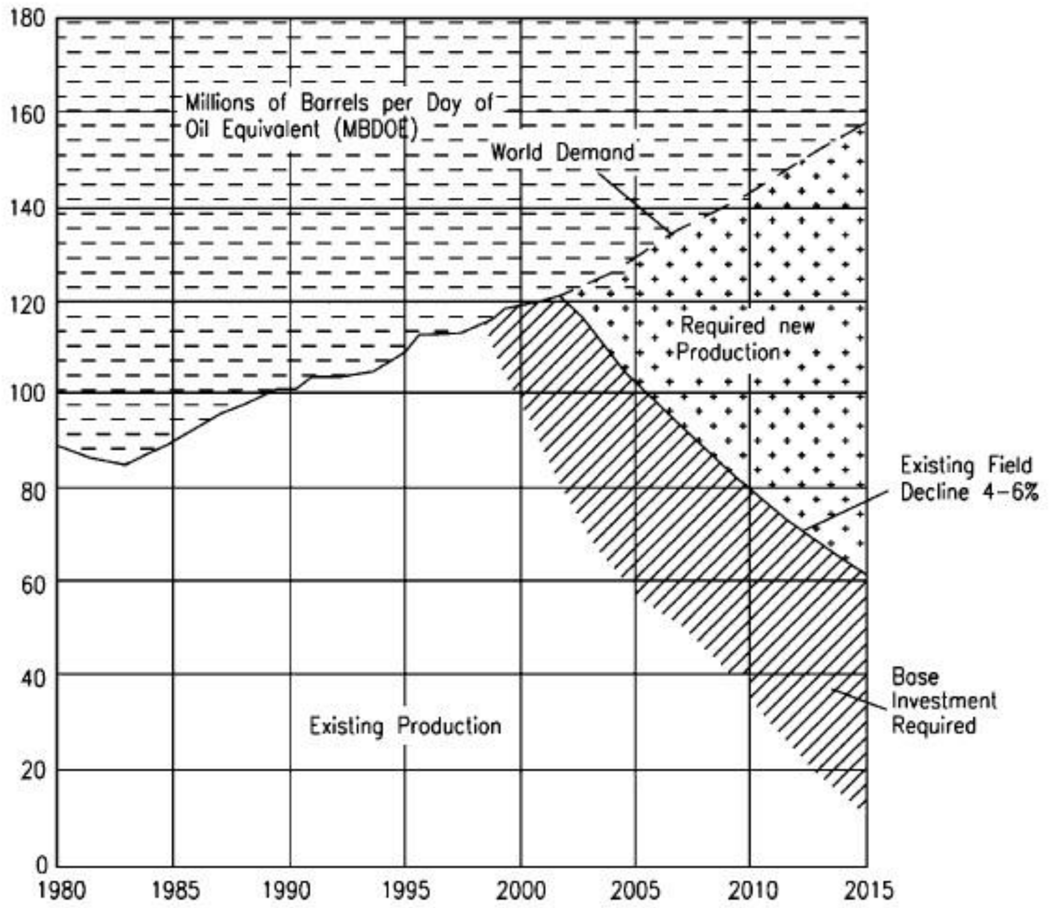

Figure 2. Projection of the energy demand from (1980-2015) (ExxonMobil)

Furthermore, Figure 2 shows projection of the world energy demands for near future. The forthcoming reduction of fossil fuel production along with the rapid growth of population and urbanization contributed to the rising of the petroleum derived fuels demand for daily necessities especially in transportation sector. In 2010, Rahman's stated that the growing consumption of energy resulted in the country's increasing dependent on fossil fuels such as coal, oil and gas. But, energy sources are limited and decreasing gradually. Therefore, limitability and unrenewability energy for fossil resources are the main reason to the rising of cost of petroleum-derived fuels. Hence, new energy sources which can contribute towards meeting the demands must be explored.

Application of the petroleum-derived fuels is one of the reasons to the increasing emission of polluted gasses that lead to the global warming effect such as COx and NOx. It is terrified that global warming will lead to a serious climatic change and threatening human nature. Global warming is mainly caused by greenhouse gases, particularly CO_2 which are produced during the burning of fossil fuels which results in significant changes in the ecosystem. Over the past century, the atmospheric concentration of CO_2 reached its highest levels. As it can be observed in Figure 3. Escobar's reported, these problems happened due to unsustainable usage of fossil fuels product and the change in the use of land (Escobar *et al.*, 2009).

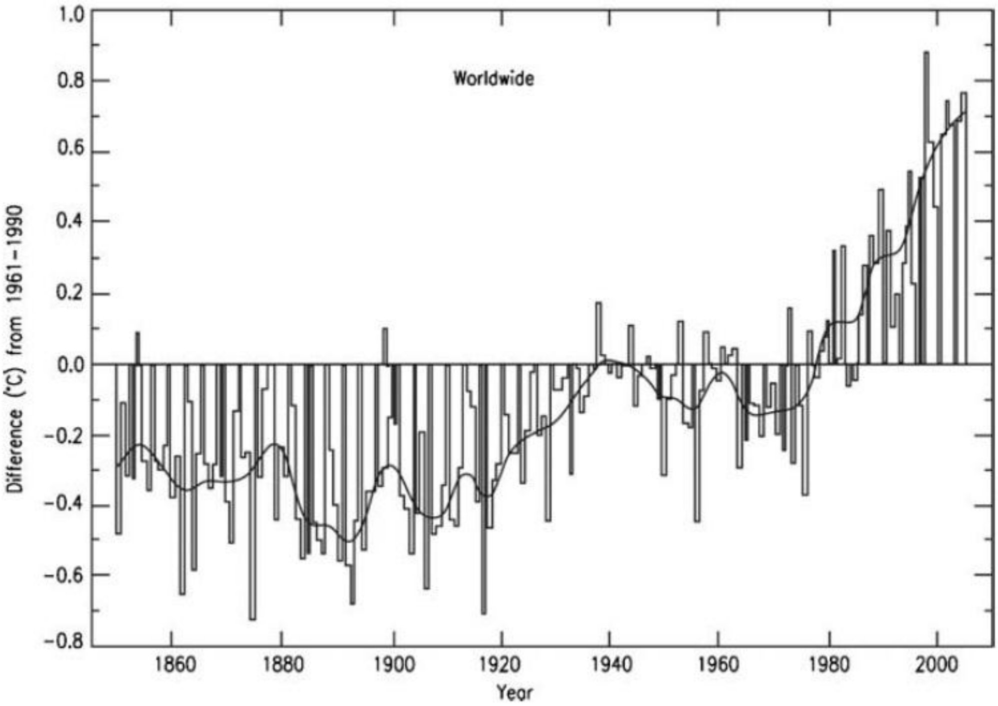

Figure 3. The variation of the concentration level of CO_2 in the atmosphere and the rise in the planet's global temperature
(source: Escobar *et al*., 2009).

In 2012, Kouzu and Hidaka reported the constant ascend of the earth's average temperature, threatens millions of people with growing risk of hunger, floods, water shortage and diseases such as malaria. Escobar's group agreed that the decreasing of the resources of the fossil energy and the accumulation of carbon dioxide and other greenhouse gases in the atmosphere are the main explanation for the change in climates, and will result in very bad consequences on human and other living organisms.

Therefore, it is necessary to solve this problem by making great effort in order to reduced the climate change and also reduce the level of greenhouse gas emission. Nowadays, all the developed countries are competing among themselves to create new alternative low cost fuel known as biodiesel which should be sustainable and also friendly to environment.

1.2 Problem Statements and Scope of Research

The increasing of crude oil petroleum prices, limited resources of fossil fuels and environmental concern have led to the search for new alternative fuels which are more sustainable, energy conservation, efficiency and environmental friendly. In this present study, biodiesel production from transesterification reaction are focussed by application of heterogeneous catalyst. Heterogeneneous catalyst attracted much attention due to the technological problems that are associated with the production of biodiesel when using homogeneous catalyst in which required extra purification or neutralization step. The neutralization step is non-friendly environmental process. It because of neutralization step will produced high amounts of waste water and caused water pollution. In addition utilization of homogeneous catalyst in vegetable oil transesterification, results in soap formation which is an undesirable side-reaction. Since the catalyst is consumed in the reaction, it will make separation process of ester and glycerol becomes very difficult and require more purification process which will lead to higher production cost. Besides, homogenous catalyst cannot be reused or regenerated.

Therefore, heterogeneous catalyst are very important for biodiesel production because it have many advantages over homogeneous catalysts. Generally, they are noncorrosive, environmentally friendly and less disposal problems. Application of heterogeneous catalyst will not cause soaps formation through fatty acid neutralization saponification. Moreover, it also easy to be separated from liquid product, reusable and can be designed to give higher catalytic activity, selectivity and longer catalyst lifetime.

Nowadays, biodiesel researches are directed towards the development of environment friendly and involved lower cost. Therefore, various of heterogeneous catalysts from different natural resources have been reported in previous studies such as eggshell, cockle shell, chicken bone, bovine bone, oyster shell and etc. Most of these waste material derived catalysts are coming from cheap waste resources for CaO production. The CaO is one of the highly effective base catalyst in biodiesel production other than MgO, BaO and SrO. Moreover, it normally show high performance when vegetable oils with high quality is used in the transesterification process. Application of natural CaO from waste materials has been considered as a new trend for biodiesel production. This catalyst considered as strong basic catalyst, it could produce high yield of biodiesel (> 98 %) at lower temperature (60-65 ^{o}C). Therefore, application CaO catalysts from waste shell have very high commercial prospects in biodiesel production and will costly effective because involved nominal cost as it coming from waste material.

The waste materials were not important and considered as waste, therefore introducing waste material in biodiesel production will make it competitive with petroleum diesel. This discovery and utilization as a catalyst means a value addition to the recycled waste. The catalysts are reusable for several reaction cycles. These catalysts are considered as green-catalyst which is derived from renewable biomasses and the production of biodiesel is also a promising green-process. Moreover, easy availability, biodegradability and environmental acceptability are other three factors in favour of the catalysts as their large scale use will pose no disposal. In this research, the heterogeneous catalyst made from waste shell of clamshell from *Meretrix meretrix sp.* like in Figure 4.

Figure 4. Fresh clamshell (*Meretrix meretrix*)

The clamshell is non-toxic, biodegradable and environmentally friendly. Generally, application of CaO catalyst will take longer time in transesterification reaction compared to other base catalyst, attempt have been done in order to improve the catalytic activity and selectivity of using CaO catalyst by increasing its surface area and its basicity. Improving these two properties could result in maximum conversion of biodiesel in a shorter time. One of the method is through hydration-dehydration technique. This technique not only simple, easy to handle but also less costly. In the hydration-dehydration technique the CaO were react with hot water. In this research the hydration-dehydration technique were applied in different water treatment in order to investigate the effect of time on formation of hydroxide for increasing the basicity of catalyst.

Chapter 1 gives a brief introduction about fossil energy, problem statement and scope of research. While Chapter 2 is a review of previous literature to with biodiesel topic and background of the research. Chapter 3, it explained more details about materials, instruments and various method of characterizations to produce and characterized the catalysts and biodiesel including all experimental part of this research will be explained. Results is presented and discussed in Chapter 4. Finally is the comprehensive conclusion associates with overall study are in Chapter 5.

1.3 Objectives of Research

The objectives of this research are:

1. To synthesize CS-CaO derived from natural $CaCO_3$ waste shells from clam shell (*Meretrix meretrix*).

2. To enhance the CS-CaO catalyst by implementing the hydration technique via various time of water treatment process to produce $CS\text{-}CaO_{1\,h}$, $CS\text{-}CaO_{3\,h}$, $CS\text{-}CaO_{6\,h}$, $CS\text{-}CaO_{9\,h}$, $CS\text{-}CaO_{12\,h}$.

3. To screen and characterize the derived heterogeneous catalyst using several methods such as Thermogravimetry (TGA) Analysis, X-ray Flourescense Spectroscopy (XRF), X-Ray diffraction (XRD) Analysis, Temperature programmed desorption of carbon dioxide (TPD-CO_2), Brunauer-Emmett-Teller (BET) and Scanning electron microscopy (SEM).

4. To optimize the biodiesel production by manipulating its parameters (methanol and oil molar ratio, reaction time period and amount of catalyst).

REFERENCES

Alba-Rubia, A.C, Santamaria, G.J., Josefa, M., Merida-Robles, Ramon M.T., David, M.A., Antonio, J.L. and Pedro, M.T. (2010). Heterogeneous transesterification processes by using CaO supported on Zinc oxide as basic catalysts. *Catalysis Today*. 149: 281-287.

Aksoy, H.A., Kahraman, I., Karaosmanoglu, F. and Civelekoglu, H. (1988). Evaluation of Turkish sulphur olive oils as an alternative diesel fuel, *Journal of the American Oil Chemists' Society*. 65:936-938

Ali, A.J. and Sinha, H.P.A.S.K. (2013). Egg Shell as Eco-friendly Catalyst for Transesterification of Rapeseed Oil: Optimization for Biodiesel Production. *Special Issue of International Journal of Sustainable Development and Green Economics (IJSDGE, V-2, I-1,* : 2315-4721.

Ali A. Jazie and Sinha H.P.A.S.K. (2012). Egg Shell Waste-Catalyzed Transesterification of Mustard Oil: Optimization Using Response Surface Methodology (RSM). *2nd International Conference on Power and Energy Systems*. 56: 52-57.

Almeida De, E.F. and De Souza, J.V.B.C.M. (2007). The performance of Brazilian biofuels: an economic, environmental and social analysis. *Federal university of Rio de Janeiro, Brazil*. 5: 1-91

Aramendia, M.A., Benitez, J.A., Borau, V., Jimenez, C., Marinas, J.M., Ruiz, J.R. and Urbano, F. (1999) Charaterization of various magnesium oxides by XRD and H-1 MAS NMR spectroscopy. *Journal of Solid State Chemistry*. 144: 25-29.

Bacon, D.M., Brear, F., Moncrieff, I.D. and Walker, K.L. (1981). The use of vegetable oils in straight and modified form as diesel engine fuels. Beyond the Energy Crisis - *Opportunity and Challenge Volume III. Third International Conference on Energy Use Management. Berlin (West). Eds. R. A. Fazzolare and C. R. Smith, Pergamon Press, Oxford*. 1525- 33.

Barsic, N.J., and Humke, A.L. (1981) Vegetable oils: diesel fuel supplements. *Automotive Engineering*. 89(4): 37-41.

Baranescu, R.A. and Lusco, J.J. (1982). Performance, durability, and low temperature operation of sunflower oil as a diesel fuel extender. Vegetable Oil Fuels*: Proceedings of the International Conference on Plant and Vegetable Oils Fuels. St. Joseph, MI: ASAE*.

Bartholomew, D. (1981). Vegetable oil fuel. *Journal American Oil Chemist Society*. 58(4): 286-288.

Basumatary Sanjay. (2013). Heterogeneous catalyst derived from natural resources for biodiesel Production: A Review. *Research Journal of Chemical Sciences* Vol. 3(6):95-101.

Bettis, B.L., Peterson, C.L., Auld, D.L., Driscoll, D.J. and Peterson, E.D. (1982). Fuel characteristics of vegetable oil from oilseed crops in the Pacific Northwest. *Agronomy Journal*, 74:335-339.

Billaud, F., Dominguez, V., Broitin, P. and Busson, C. (1995) Production of hydrocarbons by pyrolysis of methyl esters from rapeseed oil. *JAOCS,*72:1149–54.

Birla, A., Singh, B., Upadhyay, S. N., and Sharma, Y. C. (2012). Kinetics studies of synthesis of biodiesel from waste frying oil using a heterogeneous catalyst derived from snail shell. *Bioresource Technology, 106*:95-100

Biodiesel 2020. Global Market Survey, Feedstock Trends and Forecasts. *Multi-Client Study, 2nd Edition Emerging Markets Online* 2000;685. Retrieved from 20 July 2013 from http://www.emerging-markets.com/biodiesel/

Borgas, M.E. and Diaz, L. (2012). Recent development on heterogenous catalyst for biodiesel production by oil esterification and transesterification reactions: A review. *Renewable and Sustainable Energy Reviews*. 2839-2849

Bojan, S. G., and Durairaj, S. K. (2012). Producing Biodiesel from High Free Fatty Acid Jatropha Curcas Oil by A Two Step Method- An Indian Case Study. *Journal of Sustainable Energy & Environment*, 3: 63-66.

Boey, P.L., Gaanty, P.M. and Shafida, A.H. (2009). Biodiesel production via transesterification of palm oil using mud waste mud crab (*Scylla serrata*) shell as heterogeneous catalyst. *Bioresource Technology* 100:6362-68

Boey, P.L., Gaanty, P.M., and Shafida, A.H. (2011). Performance of calcium oxides as a heteregeneous catalyst in biodiesel production: Review. *Chemical Engineering Journal* 168:15-22.

Boey, P.-L., Maniam, G. P., Hamid, S. A., and Ali, D. M. H. (2011). Utilization of waste cockle shell (Anadara granosa) in biodiesel production from palm olein: Optimization using response surface methodology. *Fuel, 90*(7): 2353-2358.

Boey, P.B., Maniam G.P., Hamid S.A. and Ali, D.M.H. (2011). Crab and cockle shells as catalysts for the preparation of methyl esters from low FFA chicken fat, *Journal American Oil Chemist Society*. 88:283–288

Boro, J., Ashim, J.T. and Dhanapati, D. (2011). Solid oxide derived from waste shells of Turbonilla Striatula as a renewable catalyst for biodiesel production. *Fuel Processing Technology* 92:2061-2067.

Boro, J, Dhanapati, D. and Ashim J. T. A. (2012). Review on solid oxide derived from waste shells as catalyst for biodiesel production. *Renewable and Sustainable Energy Reviews* 16:904–910.

Brito, A., Borges, M.E and Otero, N. (2007) Zeolite as a Heterogeneous Catalyst in Biodiesel Fuel Production from Used Vegetable Oil. *Energy & Fuels* 21: 3280–3283

Bruwer, J.J., Boshoff, B.D., Hugo, F.J.C., DuPlessis, L.M., Fuls, J., Hawkins, C., Vander Walt, A.N. and. Engelbert, A.(1980). The Utilization of sunflower seed oil as renewable fuel diesel engines. *In Agricultural Energy,Biomass Energy/Crop Production*. ASAE Publication 2:4-81.

Buasri, A. C. and N.Loryuenyong, V. orawanitchaphong, P.Trongyong, S. (2013). Calcium oxide derived from waste shells of mussel, cockle, and scallop as the heterogeneous catalyst for biodiesel production. *Scientific World Journal*, 460923.

Cantrell, D. G., Gillie, L. J., Lee, A. F. and Wilson, K. (2005) Structure-reactivity correlations in MgAl hydrotalcite catalysts for biodiesel synthesis, *Applied Catalysis* a-General, 287:183-90

Canakci, M. and Gerpen, J.V. (2001) Biodiesel production from oil and fats with high free fatty acid; *American Society of Agricultural Engineers ISSN* 0001–2351. 4:1429–1436.

Chen. H., Peng, B., Wang, D. and Wang, J. (2007) Biodiesel production by the transesterification of cottonseed oil by solid acid catalysts. *Frontiers of Chemical Engineering in China* 1:11-15

Chang, C.C. and Wan, S.W. (1947) Chinas motor fuels from tung oil. *Indrustrial and Engeenering Chemical*. 39 (12):1543–1548.

Chen, C.L., Chien-Chang, H., Dang-Thuan, T. and Jo-Shu, C.(2012). Biodiesel synthesis via heterogenous catalysis using modified stronstium oxides as the catalyst. *Bioresource Technology*. 113: 8-13.

Demirbas. A. (2008). New liquid biofuels from vegetable oils via catalytic pyrolysis. *Energy Education Science and Technology*. 21:1-59.

Demirbas. A. (2003). Biodiesel Fuels from Vegetable Oils via Catalytic and Non-Catalytic Supercritical Alcohol Transesterifications and Other Methods: A Survey. *Energy Conversion and Management.* 44:2093– 2109.

Demirbas. A. (2010). Tea *seed upgrading facilities and economic assessment of biodiesel production from tea seed oil ,Energy Conversion and Management*,51: 2595–2599

Demirbas. A. (2009) Progress and recent trends in biodiesel fuels. *Energy conversion management.* 50:14-34.

Diesel, R. (1913). Die Entstehung des Dieselmotors. Berlin: *Verlag von Julius Springer*.

Dossin, T. F., Reyniers, M. F., Berger, R. J. and Marin, G. B. (2006). Simulation of heterogeneously MgO-catalyzed transesterification for fine-chemical and biodiesel industrial production. *Applied Catalysis B: Environmental.* 67:136-148

Edgar, Lotero., Yijun, L., Dora, E., Lopez, Kaeta, S., David, A., Bruce, and James, G. Goodwin, Jr. (2005). Synthesis of Biodiesel via Acid Catalyst. *Ind. Eng. Chem. Res*. 2005;44:5353-5363.

Engelman, H. W., Guenther D. A. and Silvis T. W. (1978). Vegetable oil as a diesel fuel. SAE Paper 78 DGP 19

Endalew, A.K., Yohannes, K. and Rolando, Z.(2011). Heterogenous catalysis for biodiesel production from Jatropha curcas oil (JCO). *Energy*. 36:2693-2700.

Escobar, J.C., Lora, E.S., Venturini ,O.J., Yanez, E.E., Castillo,E.F. and Oscar, A. (2009) Biofuels: Environment, technology and food security. *Renewable and Sustainable Energy Reviews*. 13: 1275-1287.

ExxonMovil. A report in energy trends greenhouse gas emissions and alternative energy; 2004. Available in: http://www.esd.lbl.gov. Accessed July 2013.

Fazal, M.A Haseeb, A.S.M.A. and Masjuki, H.H. (2011). Biodiesel feasibility study: an evalution of material compatability, performance emission and engine durability . *Renew. Sustain. Energy Revision*. 15: 1314-24.

Felizardo, P., Correia, M., Raposo, I., Mendes, J., Berkemeier, R., & Bordado, J. (2006) Production of biodiesel from waste frying oil. *Waste Management*. 26:487-494.

Fort, E.F., Blumberg, P.N., Staph, H.E. and Staudt, J.J. (1982) Evaluation of cottonseed oils as diesel fuel. *SAE Technical Paper Series* 820317.

Freedman, B., Pryde, E.H. and Mounts, T.L.(1984)Variables Affecting the Yields of Fatty Esters from Transesterified Vegetable Oils. *Northern Regional Research Center*, *Agricultural Research Service, U.S. Department of Agriculture, Peoria*, I L 61604. 61:1638-1643

Freedman, B. and Pryde, E.H.(1982) Fatty esters from vegetable oils for use as a diesel fuel. *proceedings of International Conference on Plant & vegetable oils as Fuels*. ASAE, St. Joseph, MI: 1982 :17-122.

Goering, E., Schwab, W., Daugherty, J., Pryde, H. and Heakin, J. (1982). Fuel properties of eleven vegetable oils. *The American Society of Agricultural and Biological Engineers* Trans ASAE 25:1472–83.

Furuta, A., Matsuhashi, H. and Aratab, K. (2006). Biodiesel fuel Production with solid amorphous-Zirconia catalysis in fixed bed reactor. *Biomass Bioenergy*. 30: 870–873.

Giracol, J., Passarini, K.C., da Silva, S.C., Calarge, F.A., Tambourgi, E.B. and Santana, J.C.C. (2011). Reduction In Ecological Cost Through Biofuel Production From Cooking Oils: An Ecological Solution For The City Of Campinas, Brazil. *Journal of Cleaner Production* 19:1324-1329.

Giannakopouloua, K., Lukasb, M., Vasilievc, A., Brunnerb, C. and Schnictzer, H. (2010). Conversion of rapeseed cake into bio-fuel in a batch reactor: effect of catalytic vapour upgrading. *Microporous and Mesoporous Materials* 128:126-135.

Giri, B.Y., Rao, K.N., Devi, B.L.A.P., Lingaiah, N., Suryanarayana, I., Prasad, R.B.N. and Prasad, P.S.S. (2005). Esterification of palmitic acid on the ammonium salt of 12-tungstophosphoric acid: The influence of partial proton exchange on the activity of the catalyst. *Catalysis Communications* 6: 788-792.

Girish, N., Niju, S. P., Meera Sheriffa Begum, K. M. and Anantharaman, N. (2013). Utilization of a cost effective solid catalyst derived from natural white bivalve clam shell for transesterification of waste frying oil. *Fuel* 111: 653-658.

Goering, C.E., Camppion, R.N., Schwab, A.W. and Pryde, E.H. (1982). In: Vegetable oil fuels. Proceeding of the International Conference on Plant and Vegetable Oils as Fuels, Fargo, North Dakota. *American Society of Agricultural Engineers,* St Joseph, MI 4, MI4:279–86.

Goering, C.E., Schwab, A.W., Daugherty, M.J., Pryde, E.H. and Heakin, A.J.(1981) Fuel properties of eleven vegetable oils. *ASAE Paper* 81-3579.

Goering, C.E., Fry, B., (1984). Engine durability screening test of a diesel oil/soy oil/alcohol microemulsion fuel. JAOCS 61:1627-1632.

Granados, M.L, Poves, M.D.Z., Alonso, D.M., Mariscal, R., Galisteo,F.C and Moreno-Tost. (2007). Biodiesel from sunflower oil by using activated calcium oxide. *Appl Catal B Environment* 73: 317-26.

Gryglewicz, S. (1999). Rapeseed oil methyl esters preparation using heterogenous catalyst. *bioresour Tehnol* 70: 249-53.

Gryglewicz, S. (2000). Alkaline-earth metal compounds as alcoholysis catalysts for ester oils synthesis. *Appl. Catal. A Gen.* 192: 23-28

Gryglewicz, S. (1999). Rapeseed oil methyl esters preparation using heterogenous catalyst, *Bioresour. Technol.* 170:249-23.

Guzatto,R., Tiago, L.D.M. and Dimitrios, S. (2011). The use of a modified TDSP for biodiesel production from soysbean, linseed and waste cooking oil. *Fuel Processing technology* 92: 2083-2088.

Helwani,Z., Othman, M.R., Aziz, N., Fernando, W.J.N. and Kim, J. (2009). Technologies for production of biodiesel focusing on green catalytic techniques: a review *Fuel Processing Technology*, 90:1502–1514

Hideshi, H. (1995). Heterogeneous basic catalyst. *Chemical Reviews*. 95: 537-558

Hofman,V., Kaufman, D., Helgeson, D. and Dinusson, W.E. (1981). Sunflower for power. *NDSU Cooperative Extension Service Circular AE* 735.

Hsu, H.L., Osburn, J.O. and Grove, C.S. (1950). Pyrolysis of the calcium salts of fatty acids. *Ind. Eng. Chem.* 42 (10): 2141–2145

Hu, S., Wang Y. and Han H., (2011). Utilization of waste freshwater mussel shell as an economic catalyst for biodiesel production. *Fuel*.3627-3635

Ivanoiu, A., Schmidt, A., Peter, F., Rusnac, L.M. and Ungurean, M. (2011). Comparative Study on Biodiesel Synthesis from different Vegetables Oils.*Chem. Bull* 56: 94-98.

Janaun, J and Naoko, E. (2011). Perspectives on biodiesel as a sustainable fuel. *Renewable and Sustainable Energy Reviews*. 14:1312-1320.

Jacobson, K., Gopinath, R., Meher, L.C. and Dalai, A.K. (2008). Solid acid catalyzed biodiesel production from waste cooking oil. *Applied Catalysis B: Environmental*. 85:86–91

Jitputti, J., Kitiyanan, B., Rangsunvigit, P., Bunyakiat, K., Attanatho, L. and Jenvanitpanjakul, P. (2006). Transesterification of crude palm kernel oil and crude coconutoil by different solid catalysts. *Chemical Engineering Journal*. 116: 61-66

Karaosmonoglu, F.(1999). Vegetable oil fuels: a review. *Energy Sources* 21:221–31

Kawashima, A., Matsubara, K. and Honda, K. (2008). Development of heterogenous base catalyst for biodiesel production. *Bioresource Technology*. 99: 3439-3443.

Khemthong, P., Luadthong, C., Nualpaeng, W., Changsuwan, P., Tongprem, P., Viriya-empikul, N., and Faungnawakij, K. (2012). Industrial eggshell wastes as the heterogeneous catalysts for microwave-assisted biodiesel production. *Catalysis Today*, *190*(1): 112-116.

Kiss, A.A., Dimian, A.C. and Rothenberg, G. (2006). Solid acid catalysts for biodiesel production—towards sustainable energy. *Advance Synthesis and Catalysis*. 348: 75–81.

Kim, H.J., Kang, B.S., Kim, M.J., Park, Y.M., Kim, D.K. and Lee, J.S. (2004) Transesterification of vegetable oil to biodiesel using heterogeneous base catalyst. *Catalyst Today*. 93–95:315–20.

Kivevele , T.T., Mbarawa, M.M., Bereczky, A., Laza, T. and Madarasz, J. (2011). Impact of antioxidant additives on the oxidation stability of biodiesel produced from Croton megalocarpus oil. *Fuel Processing Technology*. 92:1244–1248.

Knothe, G. Jon-Van, G.J. and Krahl J.V. (2005).The biodiesel handbook. IL: *AOCS Publication*;

Knothe, G. (2010). Biodiesel and renewable diesel: A comparison. *Progress in Energy and Combustion Science*. 36: 364-373.

Kouzu, M., Kasuno, T., Tajika, M., Yamanaka, S. and Hidaka, J. (2008). Active phase of calcium oxide used as solid base catalyst for transesterification of soysbean oil with refluxing methanol. *Applied catalysis.* 34; 357-657.

Kouzu, M. and Hidaka, H. (2012). Transesterification of vegetable oil into biodiesel catalyzed by CaO : A review. *Fuel.* 93:1-12

Kulkarni, M.G. and Dalai, A.K. (2006). Waste Cooking Oils An Economical Source for Biodiesel: A Review. *Industrial and. Engineering Chemistry. Res.*45: 2901-2913

Lam, M.K., Keat, T.L. and Abdul, R.M. (2010) .Homogeneous, heterogeneous and enzymatic catalysis for transesterification of high free fatty acid oil (waste cooking oil) to biodiesel: A review *Biotechnology Advances* 28: 500–518

Lee, H.V., Yunus R., Juan J.C and Taufiq-yap Y.H. (2011). process optimization design for jathropha-based biodiesel production using response surface methodology. *Fuel Processing Tenchnology*. 92;2420-2428.

Lee, D.W., Young-Moo, Park. and Kwan-Young, L. (2009). Heterogenous base catalysts for transesterification in biodiesel synthesis. *Catalysis surveys from Asia* 13:63-77.

Liu, X., Piao, X., Wang, Y., Zhu, S. and He, H. (2008). Calcium methoxide as a solid base catalyst for the transesterification of soybean oil to biodiesel with methanol. *Fuel* 87: 1076–1082

Liu, Y., Lotero, E. and Goodwin, J.J.G. (2006). A comparison of the esterification of acetic acid with methanol using heterogeneous versus homogeneous acid catalysis, *Journal of Catalysis* 242: 278–286

Lopez, D.E., Goodwin, J.G.J., Bruce, D.A. and Lotero, E. (2005). Transesterification of triacetin with methanol on solid acid and base catalysts, *Appled. Catalysis.* 295: 97-105

Marchetti, J.M., Miguel, V.U. and Errazu, A.F. (2007). Possible method for biodiesel production. *Renewable and Sustainable Energy Reviews*.11:1300-1311.

Ma, F. and Hanna, M.A. (1999). Biodiesel production: a review. *Bioresource Technology*. 70:1-15.

McCormick, R. and Westbrook, S. (2007). Biodiesel and Biodiesel Blends. ASTM Standardization news.

Mirante, F. I. C. and Coutinho, J. A. P. (2001). Cloud point prediction of fuels and fuel blends. *Fluid Phase Equilibria*, *180*, 247–255.

Morin, P., Hamad, B., Sapaly, G., Rocha, M.G.C., De Oliviera, P.G.P., Gonzalez, W.A., Sales, E.A. and Essayem, N. (2007). Transesterification of rapeseed oil with methanol: I. Catalysis with homogenous keggin heteropolyacids. *Applied Catalysis.* A Gen. 330:69-76.

Mustakimah Mohamed, S. Y. and Saikat, M. (2012). Decomposition Study of Calcium Carbonate Cockle Shell. *Journal of Engineering Science and Technology,* 7:1-10.

Nakatani, N., Takamori, H., Takeda, K. and Sakugawa, H. (2009). Transesterification of soybean oil using combusted oyster shell waste as a catalyst. *Bioresource Technology*, *100*: 1510–1513.

Nam, L. T. H., Vinh, T. Q., Loan, N. T. T., Tho, V. D. S., Yang, X.-Y. and Su, B.-L. (2011). Preparation of bio-fuels by catalytic cracking reaction of vegetable oil sludge. *Fuel,* 90: 1069-1075.

Nair, P., Singh, B., Upadhyay, S.N. and Sharma, Y.C. (2012). Synthesis of biodiesel from low FFA waste frying oil using calcium oxide derived from the *Mereterix* as a heterogeneous catalyst. *Cleaner Production* 82-90.

Ngamcharussrivichai. C., Wipawee, W. and Sarinyarak, W. (2007) Modified dolomites as catalysts for palm kernel oil transesterification. *Journal of Molecular Catalysis A: Chemical* 276 : 24–33.

Ngamcharussrivichai, C., Nunthasanti, P., Tanachai, S. and Bunyakiat, K. (2010). Biodiesel production through transesterification over natural calciums. *Fuel Processing Technology,* 91: 1409-1415.

Obadiah, A., Swaroopa, G. A., Kumar, S. V., Jeganathan, K. R. and Ramasubbu, A. (2012). Biodiesel production from palm oil using calcined waste animal bone as catalyst. *Bioresource Technology,* 116: 512-516.

Ozbay, N. Oktar, N. and Tapan, N.A. (2008). Esterification of free fatty acid in waste cooking oil (WCO): role of ion-change resins. *Fuel*. 87:1789-1798.

Patil, P.D. and Deng, S. (2009) Optimization of biodiesel production from edible and non-edible vegetable oils, *Fuel*. 88:1302-1306.

Peng, B.X., Shu, Q., Wang, J.F, Wang, J.R., Wang, D.Z. and Han, M.H. (2008). Biodiesel production from waste oil feedstocks by solid acid catalysis. *Process safety and environment protection* 86:441–447

Pereira, R., Valdir D.J.L. and Silvano, V. Biodiesel production and consumption; a decade of comparison, from 2000 to 2010. *International conference on Renewable Energies and Power Quality (ICREPQ'13)*

Peterson, C.L., Auld, D.L., Korus, R.A. (1983). Winter rapeseed oil fuel for diesel engines*: Recovery and utilization.* 6:1579-1587.

Peterson, C.L., Auld, D.L., Thomas, Withers, V.M., Smith, S.M. and Bettis, B.L. (1981) Vegetable oils as an agricultural fuel for the Pacific Northwest. *University of Idaho Experiment Station Bulletin.* Moscow, ID: University of Idaho. 598.

Ping, B. T. Y., and Yusof, M. (2009). Characteristic and properties of fatty acid distillates from palm oil *oil palm bulletin,* 59: 5-11.

Patil, P.D. and Deng, S. (2009). Transesterification of camelina sativa oil using heterogenous metal oxide catalyst. *Energy fuels* 23: 4619-24.

Pioch, D., Lozano, P., Rasoanatoandro, M.C., Grailla, J., Geneste, P. and Guida, A. (1993) Biofuels from catalytic cracking of tropical vegetable oils. *Oleagineux* 48:289–91.

Popescu, F. and Ioana, I. (2011). Waste Animal Fats with High FFA as a Renewable Energy Source for Biodiesel Production - Concept, Experimental Production and Impact Evaluation on Air Quality. *"Politehnica" University of Timisoara Romania* 5:94-108.

Quick, G.R. (1980). Developments in use of vegetable oils as fuel for diesel engines. *ASAE Paper Number.* . St. Joseph, MI: ASAE. 80-1525

Rahman, K.M., Mashud, M., Roknuzzaman, M. and Galib, A.A. (2010). Biodiesel from Jatropha Oil as an Alternative. *Fuel for Diesel Engine.* International J. Mech. Mechatronics, 10(3):1-6.

Reddy, C., Reddy, V., Oshel, R. and Verkade, J.G., (2006). Room-temperature conversion of soybean oil and poultry fat to biodiesel catalyzed by nanocrystalline calcium oxides. *Energy Fuels* 20, 1310–1314.

Roschat, W., Mattana. K., Boonyawan. Y., Taweesak. S. and Vinich, P. (2012). Biodiesel production based on heterogenous process catalyzed by solid waste coral fragment: *Fuel.* 92: 194-202

Robert, S., Watkins, A., Lee, F. and Karen, W.(2004). Li-CaO catalysed tri-glyceride transesterification for biodiesel applications. *Green Chemistry*. 6: 335-340.

Ryan III, T.W., Dodge, L.G. and Callahan, T. J. (1984). The effects of vegetable oil properties on injection and combustion in two different diesel engines. *Journal American Oil Chemistry Society*. 61: 1610-1619.

Sharma, Y. C., Singh, B. and Korstad, J. (2010). Application of an Efficient Nonconventional Heterogeneous Catalyst for Biodiesel Synthesis from Pongamia pinnata Oil. *Energy & Fuels, 24*(5): 3223-3231.

Schlautman, N.J., Schinstock, J.L. and Hanna, M.A. (1986). Unrefined expelled soybean oil performance in a diesel engine. *Trans.* 29: 70-73.

Schwab, A.W., Bagby, M.O. and Freedman, B. (1987). Preparation and properties of Diesel fuels from vegetable oils. *Fuel* 66:1372–8.

Seki, T., Kabashima, H., Akutsu, K., Tachikawa, H. and Hattori, H. Mixed Tishenko (2001).
reactions over solid base catalysts. *Journal Catalysis.* 204:393–401

Serfor-Armah, Y., Amoah, C.M., Odamtten, G.T., Opata, N.S. and Akaho, E.H.K. (2010). Determination of elemental and nutrient composition of water, clam mantle and shell of the
Volta clam (Galatea paradoxa) using neutron activation analysis. Journal of Radioanalytical and Nuclear Chemistry.

Sing, S.P and Sing, D. (2010). Biodiesel production through the use of different sources and characterization of oils and their esters as the substitute of diesel: A review. *Renewable and Sustainable Energy* . 14: 200-216.

Singh, A., Nigam, P.S. and Murphy, J.D. (2010).Mechanism and challenges in commercialisation of algal biofuels. Bioresource *Technology.* 102:26-34.

Smith, S. M., Oopathum, C., Weeramongkhonlert, V., Smith, C. B., Chaveanghong, S., Ketwong, P., and Boonyuen, S. (2013). Transesterification of soybean oil using bovine bone waste as new catalyst. *Bioresource Technology.* 143: 686-690.

Sonntag NOV. In: Swern D, editor. (1979). Structure and composition of fats and oils. 4th ed. Baileys industrial oil and fat products, vol. 1. New York: John Wiley and Sons; p. 1

Srivastava, A. and Prasad, R., (2000). Triglycerides-based diesel fuels. *Renewable Sustainable Energy Rev*iews 4 (2):111–133.

Strayer, R.C., Blake, J.A., Craig,W.K. (1983). Canola and high erucic rapeseed oil as substitutes for diesel fuel: *Preliminary tests.* 60:1587-1592.

Suarez, P. and Meneghetti, S.M.P.(2007). 70th anniversary of biodiesel: historical evolution and current situation in Brazil. *Quim Nova* 30:2068–71.

Suppess, G.J., Bockwinkel, K., Lucas, S., Botts, J.B., Mason M.H. and Heppert, J.A. (2001)"Calcium carbonate cata- lyzed alcoholysis of fats and oils," *JAOCS,*78:139-146

Suryaputra, W., Winata, I., Indraswati, N. and Ismadji, S. (2013). Waste capiz (Amusium cristatum) shell as a new heterogeneous catalyst for biodiesel production. *Renewable Energy,* 50: 795-799.

Tahir, A. R., Lapp, H.M. and Buchanan, L.C. (1982). Sunflower oil as a fuel for compression ignition engines. Vegetable Oil Fuels*: Proceedings of the International Conference on Plant and Vegetable Oils Fuels.*

Taufiq-Yap, Y.H., Lee, H.V., Hussein, M.Z. and Yunus, R. (2011). Calcium-based mixed oxide catalysts for methanolysis of *Jatropha curcas* oil to biodiesel**.** *Biomass and Bioenergy* 35: 827‑834

Taufiq-Yap, Y.H,Lee, H.V and Lau, P.L. (2012). Transesterification of jatropha curcas oil to biodiesel by using short necked clam (orbicularia orbiculata) shell derived catalyst. *Energy Exploration & Exploitation*. 30: 853-866.

Talebian-Kiakalaieh, A., N.A.S, A., Zarei, A., & Jaliliannosrati, H. (2013). Biodiesel production from high free fatty acid waste cooking oil by solid acid catalyst. *Proceedings of the 6th International Conference on Process Systems Engineering (PSE ASIA)* 571-576.

Viriya-empikul, N., Krasae, P., Nualpaeng, W., Yoosuk, B. and Faungnawakij, K. (2012). Biodiesel production over Ca-based solid catalysts derived from industrial wastes. *Fuel, 92*(1): 239-244.

Viriya-empikul, N., Krasae, P., Puttasawat, B., Yoosuk, B., Chollacoop, N. and Faungnawakij, K. (2010). Waste shells of mollusk and egg as biodiesel production catalysts. *Bioresource Technology*, *101*(10):3765-3767.

Wan, Z., Grisso, R., Arogo, A. and Vaughan, D. (2013). Biodiesel Fuel. *Virginia cooperation extension;* 2013:442-880.

Wang, Y., Shiyi, O., Pengzhan, L., Feng, X. and Shuze, T. (2006). Comparison of two different processes to synthesize biodiesel by waste cooking oil. *Journal of Molecular Catalysis A: Chemical* 252:107–112

Wang, Y., Ou, S., Pengzhan, L. and Zhang, Z. (2007). Preparation of biodiesel from waste cooking oil via two-step catalyzed process. *Energy Conversion and Management* 48:184–188

Wei, Z., Xu, C. and Li, B. (2009). Application of waste eggshell as low-cost solid catalyst for biodiesel production. *Bioresource Technology*. *100*(11): 2883-2885.

Weisz, P.B., Haag, W.O. and Rodewald, P.G. (1979). Catalytic production of high-grade fuel (gasoline) from biomass compounds by shape-selective catalysis. *Science*. 206:57–58.

Wen, Z., Yu, X., Tu, S.T, Yan, J. and Dahlquist E. (2010). Biodiesel production from waste cooking oil catalyzed by TiO2-MgO mixed oxides. *Bioresource Technology*.101:9570-9576.

Wen, Z., Robert, G., Jactone, A. and David, V. (2009). Biodiesel Fuel. *Virginia cooperation extension*; 442-880.

Xie, W., Peng, H. and Chena, L. (2006).Transesterification of soybean oil catalyzed by potassium loaded on alumina as a solid-base catalyst. A*pplied Catalysis* A: General 300:67–74.

Yan, S., Mohan, S., DiMaggio, C. and Kim, M., (2010). Long term activity of modified ZnO nanoparticles for transesterification. *Fuel*. 89:2844–2852.

Yoosuk, B., Udomsap, P., Puttasawat, B. and Krasae, K.(2010). Improving transesterification acitvity of CaO with hydration technique. *Bioresource Technology*. 101:3784–3786

Yoosuk, B., Udomsap, P. and Puttasawat, B. (2011). Hydration–dehydration technique for property and activity improvement of calcined natural dolomite in heterogeneous biodiesel production: Structural transformation aspect. *Applied Catalysis* A: General 395:87–94

Yoosuk, B, Udomsap, P., Puttasawat, B. and Krasae, P. (2010). Modification of calcite by hydration–dehydration method for heterogeneous biodiesel production process: The effects of water on properties and activity. *Chemical Engineering Journal* 162:135–141

Yusuf, N.N.A.N., Kamarudin, S.K., and Yaakub, Z. (2011). Overview on the current trends in biodiesel production. *Energy Conversion and Management.* 52: 2741-2751.

Yu, X., Wen, Z., Li, H., Tu, S.H. and Yan, J. (2011). Transesterification of Pistacia chinesis oil for biodiesel catalyzed by CaO-CeO2 mixed oxides. *Fuel,* 90:1868-1874.

Zabeti, M, Wan, M.A., Wan, D. and Mohammed, K.A. (2009). Activity of solid catalysts for biodiesel production: A review. *Fuel Processing Technology* 90:770-777.

Zhang, Y., Dubé, M.A., McLean, D.D. and Kates, M. (2003). Biodiesel production from waste cooking oil: Economic assessment and sensitivity analysis *Bioresource Technology,* 90: 229–240

Ziejewski, M. and Kaufman, K.R. (1982). Endurance test of a sunflower oil/diesel fuel blend. *SAE Technical Paper Series* 820257.

Ziejewski, M.Z., Kaufman,K.R. and Pratt, G.L. (1983). In: Vegetable oil as diesel fuel, USDA, Argic, *Rev. Man.,* 28: 106-111.

Ziejewski, M., Kaufman, K.R., Schwab, A.W. and Pryde, E.H. (1984). Diesel engine evaluation of a nonionic sunflower oil-aqueous ethanol microemulsion. *Journal of the American Oil Chemists Society* 61:1620-1626.