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COMPARATIVE STUDY ON THE SYNTHESIS AND ACTIVITY OF METAL OXIDES CATALYSTS FOR PRODUCTION OF FAME VIA TRANSESTERIFICATION OF OILS

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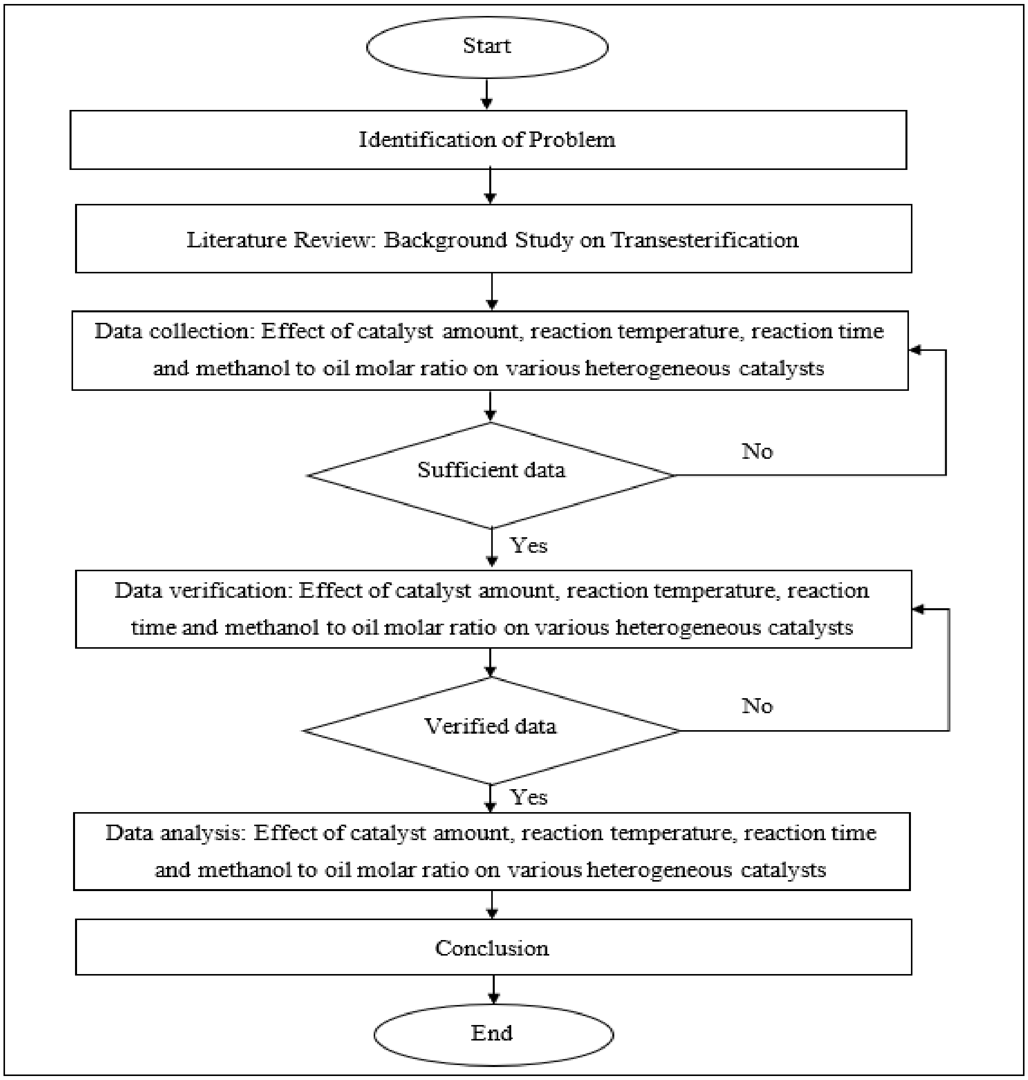
Abstract:
This paper reviews on the synthesis and activity of metal oxides catalyst for production of fatty acid methyl ester (FAME) via transesterification of oils. Transesterification process requires the presence of catalysts to react vegetables oils with methanol. Heterogeneous catalysts become the most prefer catalysts to be used due to the least problems to the overall reaction. Heterogeneous catalysts also can promote the best conditions to the operating systems compare to homogeneous catalyst and enzymes. However, catalytic activity of heterogeneous catalysts such as mixed metal oxides, sulphated metal oxides and sulphated zirconia can be influence by its reaction conditions. Paper gives a brief introduction on transesterification process and detailed review on the heterogeneous catalysts. It found that reaction conditions such as catalyst loading, reaction time, reaction temperature and methanol to oil molar ratio can give significant impact on the catalytic activity of the catalysts and thus, influence production of FAME. In addition, the effect of catalyst synthesis conditions such as calcination time, calcination temperature and metal ratio can give impact towards the catalytic activity and the FAME content. The work of many researchers on the effect reaction conditions and catalyst synthesis conditions based on various catalysts are reviewed, compared, and discussed.

***Keywords*:**
Metal oxide, Heterogeneous catalyst, Transesterification, Biodiesel, Methyl ester

Objectives:

- To perform comparative study on the synthesis and activity of metal oxides catalysts for production of FAME via transesterification of oils.
- To study the metal oxide catalysts activity based on several effects such as catalyst loading, reaction time, reaction temperature and methanol to oil molar ratio for production of FAME.

Methodology:



Results:

Table 3.1: Summary on the effect of catalyst loading based on various catalysts

Catalyst	Feedstock	Catalyst loading (wt%)	FAME yield (%)	Reference
Bi_2O_3-La_2O_3	*Jatropha curcas* oil	2.0	93.0	[1]
Sr-Ce	Waste cooking oil	2.5	91.0	[2]
Ca-La	*Jatropha curcas* oil	3.0	99.8	[3]
La_2O_3	*Jatropha curcas* oil	10.0	97.6	[4]
La_2O_3/ZrO_2	Sunflower oil	21.0	84.9	[5]
Sr/MgO	Soybean oil	5.0	95.0	[6]
CaO-SiO_2	Palm oil	5.0	90.0	[7]
K_2CO_3/Al-Ca-25-650	Soybean oil	2.0	93.4	[8]

Table 3.2: Summary on the effect of reaction time based on various catalysts

Catalyst	Feedstock	Reaction time (h)	FAME yield (%)	Reference
CaO-TiO_2	Palm oil	1	76.7	[9]
CaO-TiO_2	Palm oil	2	84.0	[10]
Sr-Mg	Palm oil	0.5	90.0	[11]
CuO-CaO	*Moringa oleifera* oil	3	87.0	[12]
CaO-ZrO_2	Waste cooking oil	2	88.0	[13]
CaO-SnO_2	Soybean oil	6	89.3	[14]
Cs-Zr	Waste cooking oil	3	90.0	[15]
KNO_3/Al_2O_3	Jatropha oil	4	82.0	[16]

Table 3.3: Summary on the effect of reaction temperature based on various catalysts

Catalyst	Feedstock	Reaction temperature (ºC)	FAME yield (%)	Reference
β-cyclodextrin	*Xanthium sibiricum Patr* oil	140	90.0	[17]
SO^{2-}_4/ZrO_2	Soybean oil	150	99.8	[18]
$TiO_2/PrSO_3H$	Used cooking oil	60	98.3	[19]
CaFeAl	Soybean oil	60	89.0	[20]
LaMg	Cotton seed oil	65	96.0	[21]
CaO-CeO_2	*Pictacia chinensis* oil	110	93.0	[22]
Ca/Zr	Rapeseed oil	120	92.6	[23]
WO_3/SnO_2	Soybean oil	180	79.2	[24]

Table 3.4: Summary on the effect of methanol to oil molar ratio based on various catalysts

Catalyst	Feedstock	Methanol to oil ratio (wt./wt.%)	FAME yield (%)	Reference
$Mg_3Zn_1CO_2$	Soybean oil	20:01	90.0	[25]
Fe_2O_3-TiO_2	Soybean oil	40:01	96.0	[26]
TiO_2-MgO	Waste cooking oil	50:01	85.6	[27]
SO^{2-}_4/ZrO_2	Rapeseed oil	10:01	83.0	[28]
SO^{2-}_4/ZrO_2	Palm oil	10:01	76.2	[29]
WO_3/SnO_2	Soybean oil	30:1	79.0	[24]
Sr-Ti	Soybean oil	15:1	98.0	[30]
Li/Ca-La	Canola oil	15:1	96.3	[31]

Conclusion:

This study found that heterogeneous catalyst could give the most significant effect on overall reaction to produce biodiesel. However, the performance of heterogeneous metal oxide catalysts can be manipulated due to the conditions of the system. Reaction conditions such as catalyst loading, reaction time, reaction temperature, and methanol to oil molar ratio and catalyst synthesis conditions such as calcination time, calcination temperature and metal ratio can influence the performance of catalysts. An optimum condition of these parameters will eventually enhance the catalytic activity of the catalysts prior to the maximize the yield of FAMEs. Further exploration and development of the catalysts are necessary to improve the catalytic performance as well as the overall process for transesterification. In addition, application of heterogeneous catalysts in transesterification system should be upgrade from laboratory scale to industrial scale for biodiesel production.