Supplementary Materials for

Co-transesterification of waste cooking oil, algal oil and dimethyl carbonate over sustainable nanoparticle catalysts

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Table A. 1. The performance of nanoparticle catalyst on oil transesterification process

Feedstock	Nano-catalyst	Particle size (nm)	Condition	FAMEs yield (%)	Ref.
WCO	Fe_2O_3-MnO-SO_4^{2-}/ZrO_2	14.0-25.5	180 °C, 4 h, 600 rpm, methanol ratio of 20:1 and catalyst ratio 3%	96.5	[1]
WCO	Copper doped zinc oxide nanocomposite	80	55 °C, 50 min, methanol ratio of 8:1 and catalyst ratio 12%	97.71	[2]
Palm oil	TiO_2-ZnO mixed oxide	28.4-34.2	60 °C, 5 h, methanol ratio of 6:1 and catalyst ratio 1%	92	[3]
Soybean oil	$Ni_{0.5}Zn_{0.5}Fe_2O_4$	31.1-42.6	180 °C, 1 h, alcohol ratio of 12:1, catalyst ratio of 2%	99.54	[4]
Castor oil	Ni doped ZnO	1.68-35.1	55 °C, 60 min, methanol ratio of 6:1 and catalyst ratio of 11%	95.2	[5]
WAO	CM-derived ash	100-800	80 °C, 20 min, DMC ratio of 6:1, catalyst ratio of 3% and methanol addition of 3%	95	This study
WAO[a]	CM-derived ash	90-106 µm	80 °C, 60 min, DMC ratio of 15:1, catalyst ratio of 9% and methanol addition of 9%	89	This study
WAO[b]	-	-	90 °C, 90 min, DMC ratio of 18:1, methanol addition of 9%	80	This study

Note: [a]Non-nanoparticle catalyst; [b]Non-catalytic transesterification.

Table A. 2. Different reaction conditions in oil transesterification process

Feedstock	Catalyst	Solvent	Condition	FAMEs yield (%)	Ref.
WCO	CM-derived ash 850°C	Methanol	65 °C, 6 h, 1400 rpm, methanol ratio of 15:1 and catalyst ratio of 7.5%	91	[6]
WCO	CM-derived biochar 500°C	Methanol	350 °C, methanol ratio of 20:1 and catalyst ratio of 5%	95	[7]
WCO	Waste eggshell 1000°C	Methanol	65 °C, 120 min, methanol ratio of 9:1 and catalyst ratio of 5%	87.8	[8]
AO	CaO-based heterogeneous catalysts 700°C	Methanol	50 °C, 8.5 h, methanol ratio of 15.68 and catalyst ratio of 5.12%	86.4	[9]
Olive oil	Maize residue-derived biochar 450°C	DMC	380 °C, 2 h, 500 rpm and DMC ratio of 36	95.4	[10]
Canola oil	Triazabicyclodecene catalyst	DMC	60 °C, 2 h, DMC ratio of 6:1 and catalyst ratio of 3%,	80	[11]
Soybean oil	Potassium methoxide	DMC	80 °C, 15 min, DMC ratio of 6:1, and catalyst ratio of 2%	91	[12]
WAO	CM-derived nanoparticle ash 850°C	DMC	80 °C, 20 min, 1400 rpm and DMC ratio of 6:1, catalyst ratio of 3% and methanol addition of 3%	95	This study

Table A. 3. The conversion efficiency for WAO co-transesterification using CM nano-catalyst

Conditions \ Conversion efficiency	TG conversion (wt%)	FAME content (wt%)
Various catalyst loadings (wt%)		
0	85 ± 0.52	80 ± 0.50
1	94 ± 0.45	86 ± 0.47
3	98 ± 0.48	94 ± 0.44
5	96 ± 0.42	92 ± 0.40
Various methanol additions (wt%)		
0	98 ± 0.48	94 ± 0.44
1	97 ± 0.44	94 ± 0.38
3	98 ± 0.36	95 ± 0.40
5	96 ± 0.45	94 ± 0.43
7	98 ± 0.48	94 ± 0.35
Catalyst reuse (cycle)		
0	98 ± 0.36	95 ± 0.40
1st	98 ± 0.39	93 ± 0.30
2nd	96 ± 0.48	90 ± 0.32
3rd	92 ± 0.31	88 ± 0.34
4th	88 ± 0.33	82 ± 0.42

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