Life-cycle assessment analysis of bio-jet fuel production from waste cooking oil via hydroconversion

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1. Hydrogen consumption

Table S1. The results of hydrotreatment waste cooking over NiMo/8AHFS-Y [1]

Sample	Y_{OLP} %	S_{C4-8} %	S_{C9-15} %	S_{C16-18} %	C_{17}/C_{18}	CO/CO_2
NiMo/8AHFS-Y	82.3	30.0	42.3	27.7	1.9	0

Table S2. Chemical properties of waste cooking oil and soybean oil [1,2]

Property	Waste cooking oil	Molecular weight	Soybean oil
Palimitic acid (C16:0, wt%)	25.0	256.4	10.7
Linoleic acid (C18:2, wt %)	28.9	280.4	56.3
Oleic acid (C18:1, wt %)	39.7	284.3	24.2
Stearic acid (C18:0, wt %)	6.3	282.5	5.0
Acid value (mgKOH/g)	65.5		0.1

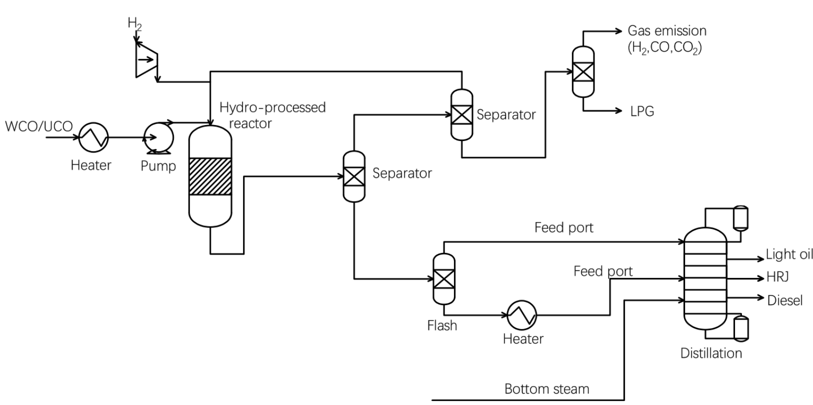

Figure S1. Preparation of jet fuel by one-step hydrogenation of waste cooking oil

Table S3. HDO reaction equations [2, 3]

	Reactions
R.1	$C18:1 + H_2 \rightarrow C_{17}H_{36} + CO_2$
R.2	$C18:1 + 4\,H_2 \rightarrow C_{18}H_{38} + 2\,H_2O$
R.3	$C18:2 + 2\,H_2 \rightarrow C_{17}H_{36} + CO_2$
R.4	$C18:2 + 5\,H_2 \rightarrow C_{18}H_{38} + 2\,H_2O$
R.5	$C16:0 \rightarrow C_{15}H_{32} + CO_2$
R.6	$C16:0 + 3\,H_2 \rightarrow C_{16}H_{34} + 2\,H_2O$
R.7	$C18:0 \rightarrow C_{17}H_{36} + CO_2$
R.8	$C18:0 + 3\,H_2 \rightarrow C_{18}H_{38} + 2\,H_2O$
R.9	$CO + H_2O \leftrightarrow CO_2 + H_2$ (ignore)

Table S4. The hydrogen consumes of triglycerides [3]

Triglyceride Scission	Mole (kmol/day)	Mass (ton/day)
Fatty acids formed	$2.18*10^3$	600
Hydrogen consumed	$1.46*10^3$	2.9

The data of hydrogen requirements for hydrocracking is from Table S8 in the Supplementary Material of reference 3.

2. Data summary

Table S5. Hydrogen consumption / (ton /d)

Glycerol conversion	Double bond saturation	HDO reaction	Cracking reaction	Total	Consume	Residue
2.9	4.2	4.5	5.1	30.1	16.7	13.4

Table S6. Composition of the gas phase

Component	H_2	CO_2	C_3H_8
Volume (%)	96.4	2.1	1.5

Table S7. Quality Composition of the products

Product	Component	Yield
Water	H_2O	0.04
Liquid	C_8H_{16}	0.22
	$C_{12}H_{26}$	0.34
	$C_{17}H_{36}$	0.22
Gas	CO_2	0.10
	C_3H_8	0.07

3. Basic data

Table S8. The price of refined oils, RMB/ Ton

Refined oil	Price
LPG	5123
Naphtha	4794
Gasoline	8639
Jet fuel	4595
Diesel	7050

The price (including tax, October 2021) of petroleum-based oil products of was from Dagang refinery of Sinopec (Tianjin).

Table S9. The fuel consumption of fossil energy extraction process, % [4]

The proportion of fuel used in production processes	Crude oil	Fuel oil	Diesel	Gasoline	Natural Gas	Coal	Electricity
Crude oil	0	0.1	4.9	0.5	0.4	78.1	15.9
Coal	50.1	6.3	13.8	1.6	0	5.5	22.7
Natural Gas	0	3.5	7.7	0.9	72	3	12.9

Table S10. The proportion for various modes of fuel transportation in China [5]

Mode of transport	Coal	Crude oil	Natural Gas	Jet fuel
Highway	27.0	0.0	2.0	10.0
Waterway	18.0	16.0	0.0	10.0
Railway	55.0	55.0	0.0	10.0
Pipage	0.0	29.0	71.0	70.0

Table S11. Fuel consumption by different modes of transport [6]

Transport category	Type of energy consumed	Consumption coefficient	Unit
Highway	Diesel	0.05	L/(t·km)
Highway	Gasoline	0.08	L/(t·km)
Railway	Electricity	0.02	KW·h/(t·km)
Railway	Diesel	0.03	L/(t·km)

Table S12. Energy consumption and GHG emissions from different hydrogen sources

Hydrogen source	Energy consumption /(MJ/MJ)	GHG emissions (g/MJ)
Natural Gas	1.6	95.7
Coal	2.3	197.6
Nuclear energy	1.3	21.0
Solar energy	1.7	19.0
biomass	2.3	13.1

The data of Table S12 was from GREET.

Table S13. Life cycle energy consumption and GHG emissions from different diesel sources

Diesel source	Energy consumption /(MJ/MJ)	GHG emissions (g/MJ)
Crude oil	0.3	33.3
Soybean	0.7	30.8
Animal fat	0.9	19.8
Plant residue	2.0	24.9

The data of Table S13 was from GREET.

References

[1] Zhang ZW, Zhang XW, Chen H, Wang QF. Hydroconversion of Waste Cooking Oil into Green Biofuel over Hierarchical USY-Supported NiMo Catalyst: A Comparative Study of Desilication and Dealumination, Catalysts 2017; 7:281. https://doi.org/10.3390/catal7100281.

[2] Zhang ZW, Zhang XW, Wang QF. Influence of Impurities and Oxidation on Hydroconversion of Waste Cooking Oil into Bio-jet Fuel. Chem. Eng. Technol. 2020; 43:273–81. https://doi.org/10.1002/ceat.201900357.

[3] Barbera E, Naurzaliyev R, Asiedu A, Bertucco A, Resurreccion EP, Kumar S. Techno-economic analysis and life-cycle assessment of jet fuels production from waste cooking oil via in situ catalytic transfer hydrogenation. Renew Energ 2020; 160:428-449. https://doi.org/10.1016/j.renene.2020.06.077.

[4] China Energy Statistics Yearbook 2020, China Statistics Press, National Bureau of statistics, 2020. Available online: http://www.tjcn.org/tjnj/NNN/39747.html (accessed on 25 Jun 2021).

[5] China Transportation Yearbook 2020, People's Communications Press, Ministry of transport, 2020. Available online: http://nianjian.xiaze.com/down/2022/zgjtnj-htm-2020.html (accessed on 1 February 2022).

[6] He JC, Wu HW, Xu YQ. Energy Consumption of Locomotives in China Railways during 1975-2007. Journal of Transportation Systems Engineering and Information Technology. 2010; 22-27. DOI: 10.16097/j.cnki.1009-6744.2010.05.024.