Electronic Supplementary Material

Power-to-chemicals: sustainable liquefaction of food waste with plasma-electrolysis

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Table S1. The pH of solutions with time under acidic or alkaline conditions.

Time (min)	0	2	4	6	8	10	12
Acidic condition	5.28±0.01	5.42±0.02	5.64±0.03	5.76±0.02	5.84±0.02	5.83±0.03	-
Alkaline condition	12.78±0.01	12.52±0.03	11.27±0.02	10.08±0.04	9.42±0.04	8.36±0.04	8.03±0.05
None	7.12±0.01	7.08±0.04	6.91±0.04	6.82±0.02	6.54±0.03	6.49±0.03	6.48±0.03

Table S2. The influence of solvent ratio on liquefaction (PEG200/glycerol: 3/1 (volume ratio), pH control: 1.25% H_2SO_4, 1.25% NaOH (mass ratio)).

PEG200/ glycerol (Vo/Vo%)	Liquefaction rate (%)		
	Acidic condition	Alkaline condition	None
1/0	80.08±0.48	69.78±0.56	55.22±0.87
4/1	81.58±0.52	78.06±0.97	66.97±0.49
3/1	91.59±0.75	81.81±0.65	69.88±0.73
2/1	87.68±1.14	68.72±0.78	64.77±0.91
1/1	82.77±0.43	56.91±0.56	55.86±1.13
1/2	71.47±0.69	35.44±0.88	43.42±1.03
1/3	60.05±1.19	21.28±1.24	35.77±0.75
0/1	52.44±1.21	19.77±0.84	31.37±0.82

Table S3. The elemental analysis of the products.

Samples	Element									
	C (PE)	C (Oil bath)	H (PE)	H (Oil bath)	N (PE)	N (Oil bath)	O (PE)	O (Oil bath)	HHV (PE) MJ/kg	HHV (Oil bath) MJ/kg
Leftover	49.240		8.638		2.306		33.130		23.142	
Residue (H^+)	43.320	42.780	5.279	8.638	1.030	0.706	50.158	42.911	14.532	14.130
Residue (OH^-)	47.160	43.580	7.120	6.032	1.203	1.052	48.236	43.512	18.194	16.115
Residue (None)	45.591	44.200	6.058	6.981	1.382	1.227	48.066	37.181	17.457	15.448
Bio oil (H^+)	50.160	50.104	11.097	9.196	0.11	1.412	37.010	39.288	26.300	25.007
Bio oil (OH^-)	49.870	49.514	10.530	10.498	0.078	0.854	38.739	40.717	25.073	23.386
Bio oil (None)	49.973	49.612	10.945	9.691	0.113	1.154	37.912	40.483	25.855	23.607

Table S4. Relative content of oxides in residues.

Oxide	Residues (PE at the acidic condition)	Residues (oil bath at the acidic condition)	Residues (PE at the alkaline condition)	Residues (oil bath at the alkaline condition)	Residues (PE and none)	Residues (oil bath and none)
Na_2O	6.79%	4.83%	24.33%	23.05%	24.54%	19.67%
K_2O	1.32%	1.26%	7.99%	6.74%	6.72%	5.74%
CaO	13.08%	10.30%	27.94%	24.95%	28.31%	26.64%
Fe_2O_3	0.66%	0.00%	1.52%	0.36%	1.38%	0.00%
MgO	0.17%	0.00%	1.71%	1.06%	1.73%	0.41%
Al_2O_3	0.00%	0.00%	0.19%	0.71%	0.15%	0.00%
SiO_2	0.00%	0.00%	0.12%	0.00%	0.14%	0.00%
P_2O_5	11.42%	1.89%	14.44%	17.96%	14.24%	16.80%
SO_3	60.71%	81.72%	14.24%	24.82%	15.03%	30.74%
ZnO	0.00%	0.00%	0.19%	0.35%	0.12%	0.00%
WO_3	5.86%	0.00%	7.32%	0.00%	7.66%	0.00%

Table S5. Content of main elements in the liquid product without catalyst added.

Samples	Concentration (ppm)						
	Na	Mg	K	Ca	Fe	W	Cl
Leftovers	19254.33	300.3	5501.5	8667.6	399.4	0	21891.2
Bio-oil (PE)	666.02	10.37	192.79	27.78	0.47	16.33	60.30
Aqueous solution (PE)	1.06	0.09	1.28	1.08	0.04	0	12.32
Bio-oil (Oil bath)	1426.28	29.81	571.59	611.88	42.92	0	1288.2
Aqueous solution (Oil bath)	70.55	19.39	68.62	34.21	7.71	0	35.77
Removal rate (PE)	81.85%	82.00%	81.82%	98.32%	99.25%	-	99.86%
Removal rate (Oil bath)	60.50%	45.00%	44.98%	62.53%	42.86%	-	99.25%

Table S6. The content of ammonia, nitrite, and nitrate ions before and after PE.

(mmol)	Before	Acidic condition (pH=5.8)	None (pH=7.12)	Alkaline condition (pH=9.92)
NH_4^+	2	-	0.24	0.31
NO_2^- (mmol)	-	0.04	0.08	0.11
NO_3^- (mmol)	-	0.07	0.13	0.16

Table S7. The mass balance of the metal without catalyst added.

Samples	**Concentration (mg)**				
	Na	Mg	K	Ca	Fe
Leftovers	66.3094	1.0030	18.3050	28.5498	1.1140
Bio-oil (PE)	11.482	0.1788	3.3237	0.4790	0.0081
Aqueous solution (PE)	0.0019	0.0002	0.0023	0.0019	0.0001
Ash (PE)	52.8254	0.8241	14.9790	28.0690	1.1059
Bio-oil (Oil bath)	24.5891	0.5140	9.8542	10.5488	0.7340
Aqueous solution (Oil bath)	0.1270	0.0349	0.1235	0.06158	0.01388
Ash (Oil bath)	41.5934	0.4542	8.3273	17.9394	0.3602

Table S8. Anion concentration in leftovers, liquefied products, and evaporated water solution.

	Leftover	Bio-oil	Aqueous solution	Residue
NO_3^-(μM)	4129.17	105.54	220.12	120.77
NO_2^-(μM)	180.90	17.47	69.72	57.56
NH_4^+(μM)	92.64	12.66	354.61	399.24
CO_3^{2-}(μM)	7037.50	41.17	31.83	1889.17

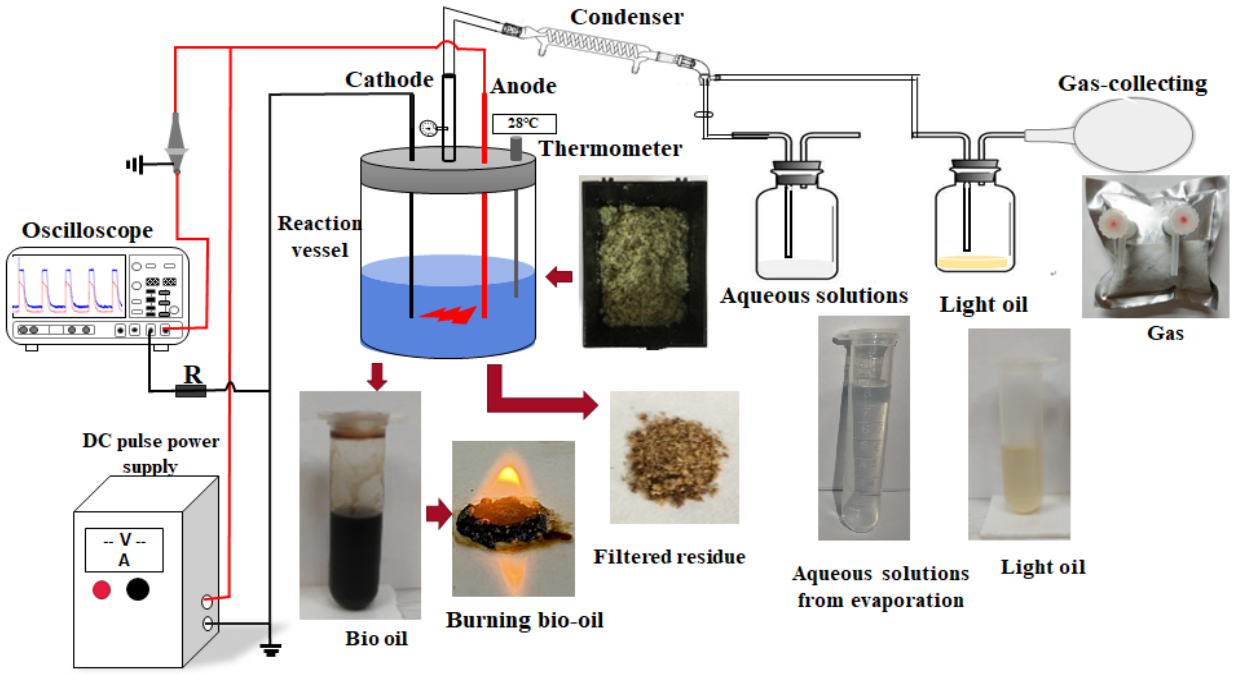

Fig. S1. Schematic diagram of plasma electrolysis liquefaction system.

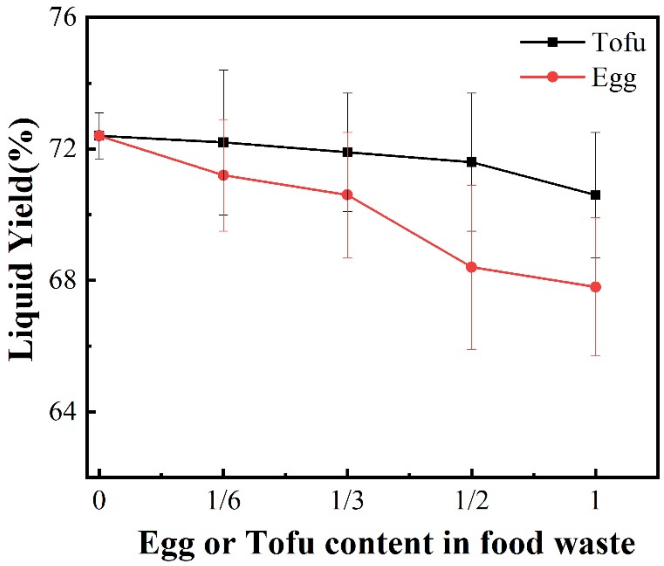

Fig. S2. The effect of increasing the egg/tofu content on liquefaction at a fixed food waste weight of 3.33 g. Without added catalyst; PEG200/glycerol ratio = 3/1; liquid-solid ratio = 7/1; time = 10 mins

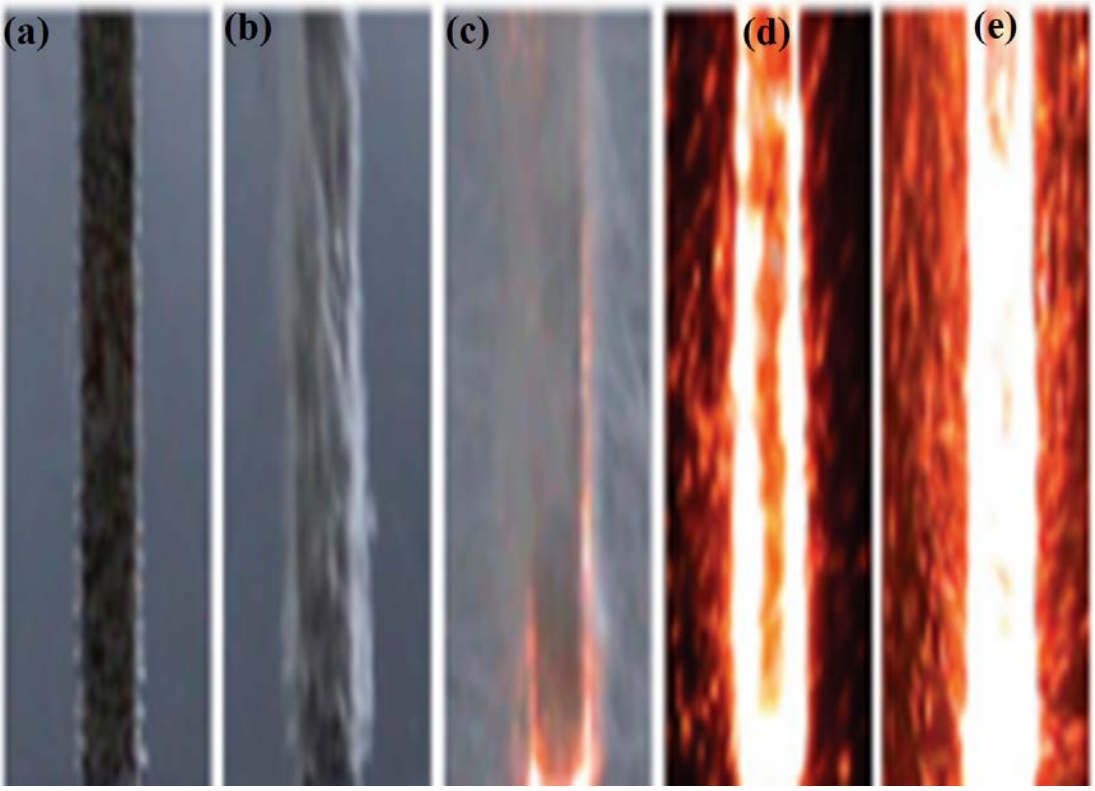

Fig. S3. Cathode photos at different stages of plasma electrolysis, (a) Gas is generated on the cathode surface, (b) Gas covers the cathode surface, (c) Local gas discharge photos on the cathode surface, (d) Large-area gas discharge photos on the cathode surface , (e) Photo of spark discharge covering the cathode surface.

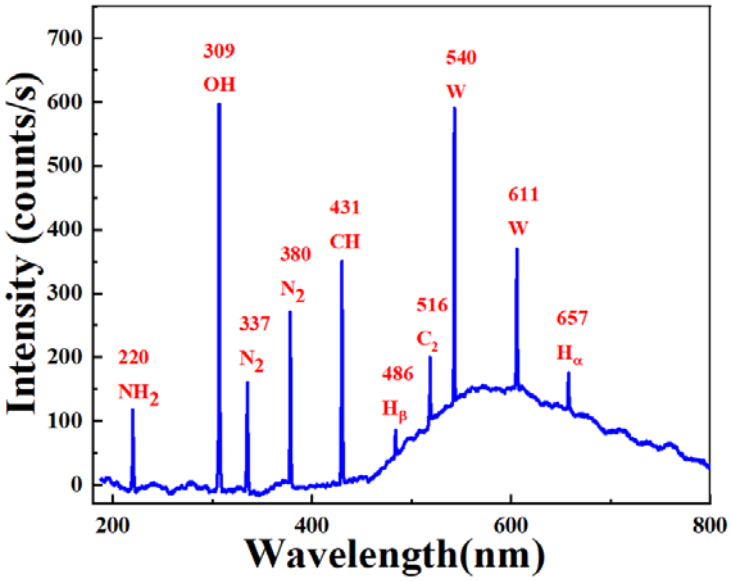

Fig. S4. Emission spectra of spark discharge

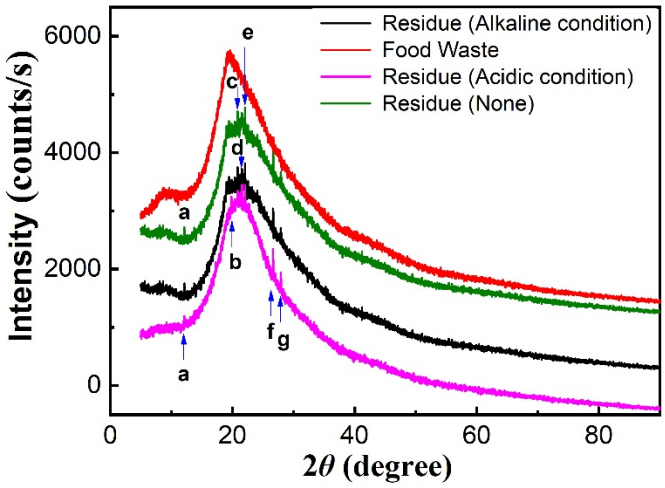

Fig. S5. Food waste compositions of dry sludge, residue under acidic, alkaline catalyst and residue under no catalyst added , a, Mullite ($3Al_2O_3$-$2SiO_2$); b, Micarex ($KAl_2Si_3AlO_{10}(OH)_2$); c, Quartz (SiO_2); d, Albite ($NaAlSi_3O_8$); e, Hematite (Fe_2O_3); f, Leucite ($KAlSi_2O_6$); g, Magnetite (Fe_3O_4).

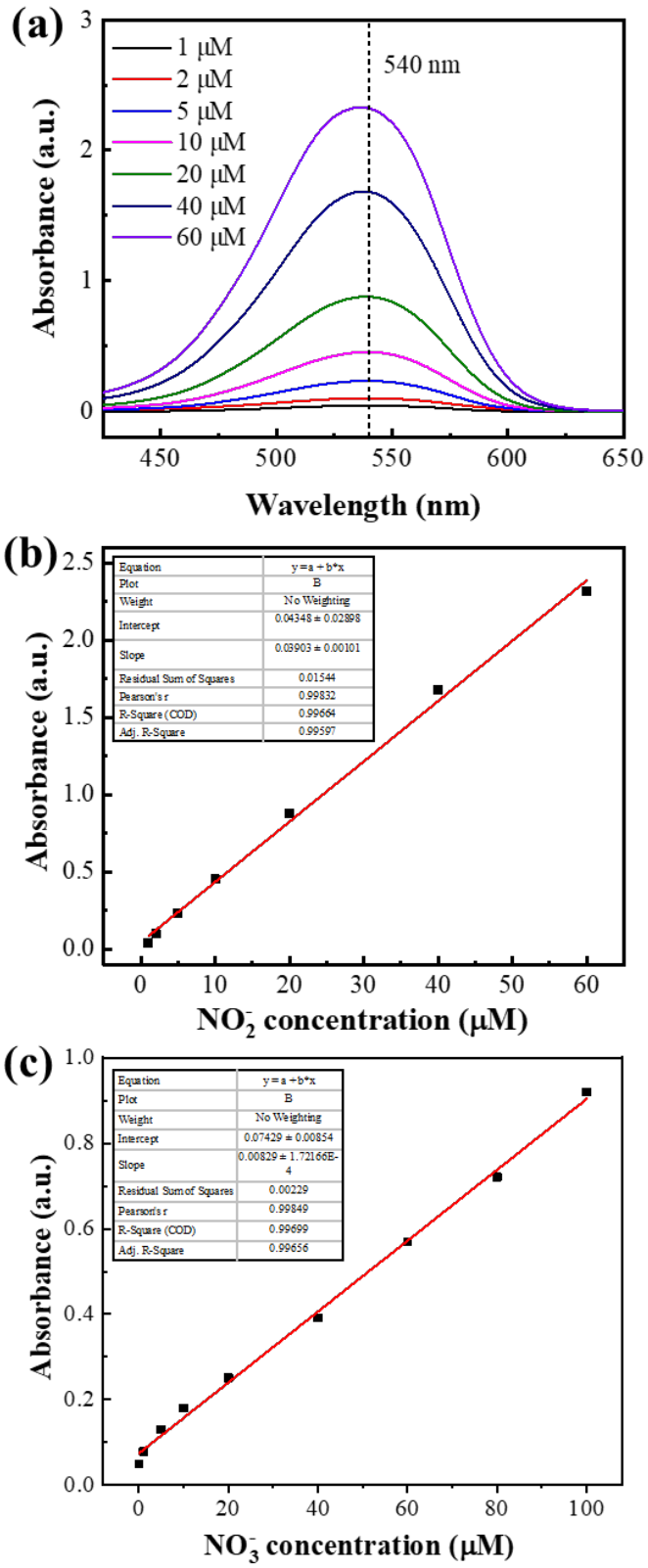

Fig. S6. Absorbance curves of nitrite standard solutions and the linear relationship between the optical density (OD) and the nitrite concentration. (a) Standard nitrite solution absorbance curve. (b) Linear relationship between OD and nitrite concentration. (c) Linear relationship between OD and nitrate concentration.

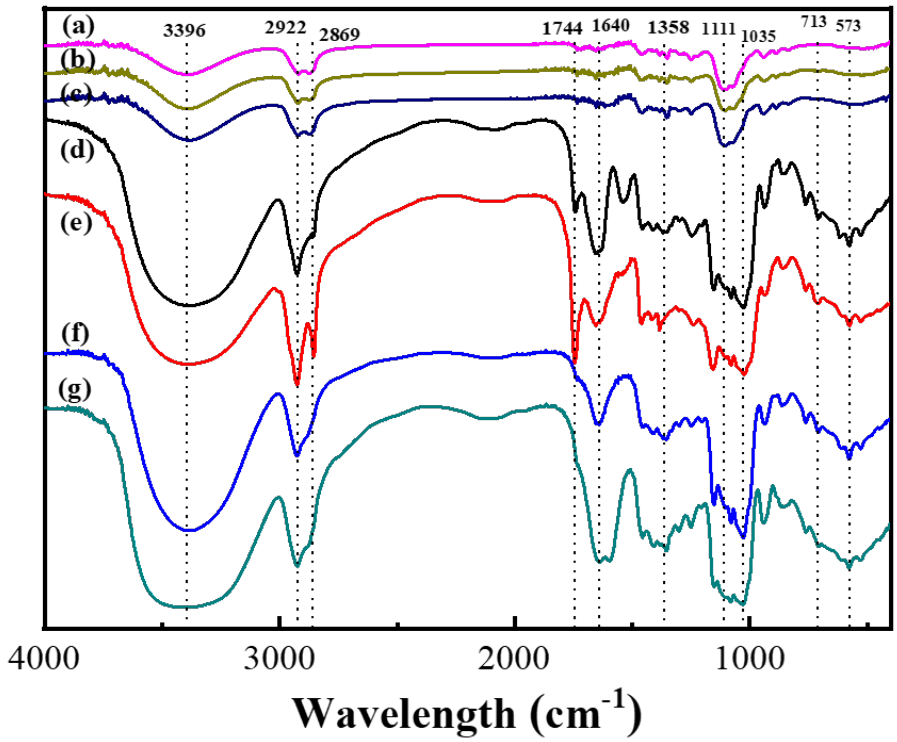

Fig. S7. Infrared spectra of leftovers and products under different catalytic conditions (a, b, and c show the liquefied products under acid, no catalyst added, and alkaline conditions, respectively; d, e, and f show the solid residues under acid, no catalyst added and alkali, respectively; g shows the waste material).