Supplementary Information for:

Highly Energy-Efficient Hydrogenolysis of High-Density Polyethylene via Hydrogen Nonthermal Plasma Reaction Engineering

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Supplementary Information contents:

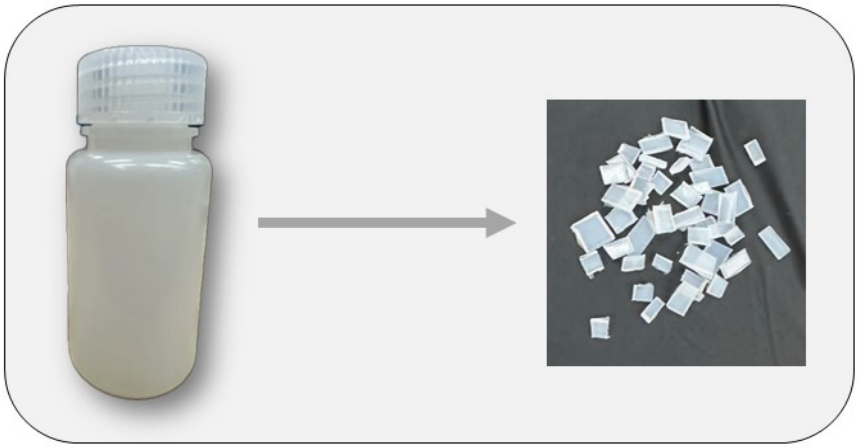

Figure S1. Waste pill bottles made of HDPE used for nonthermal plasma-assisted hydrogenolysis reaction.

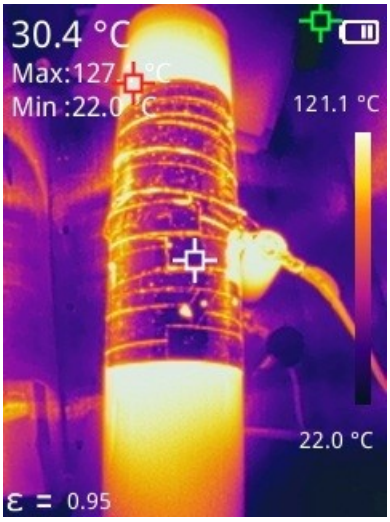

Figure S2. Maximum reaction temperature measured by an infrared thermal camera.

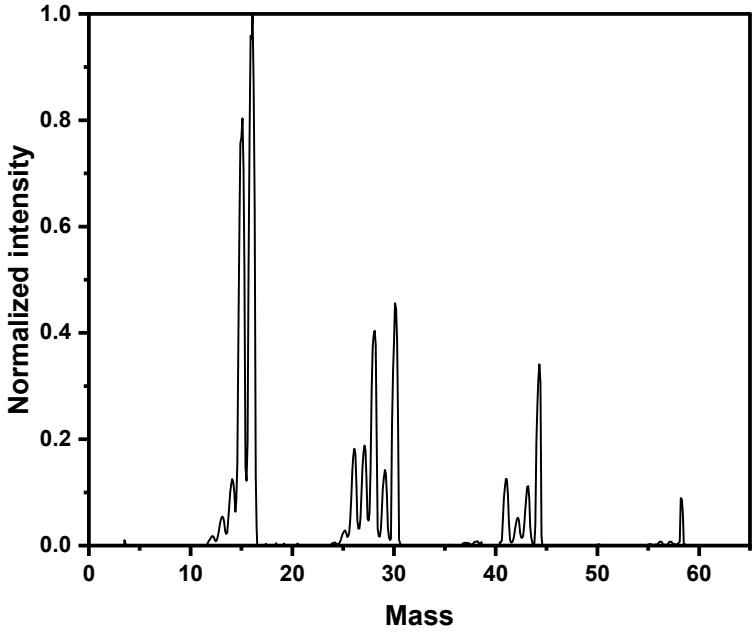

Figure S3. Mass spectrum of the gas product of nonthermal H_2 plasma-assisted hydrogenolysis of HDPE (rector OD=17mm, PZL=8cm, loading density=0.188g/cm3, reaction time=10min, and input power=60W).

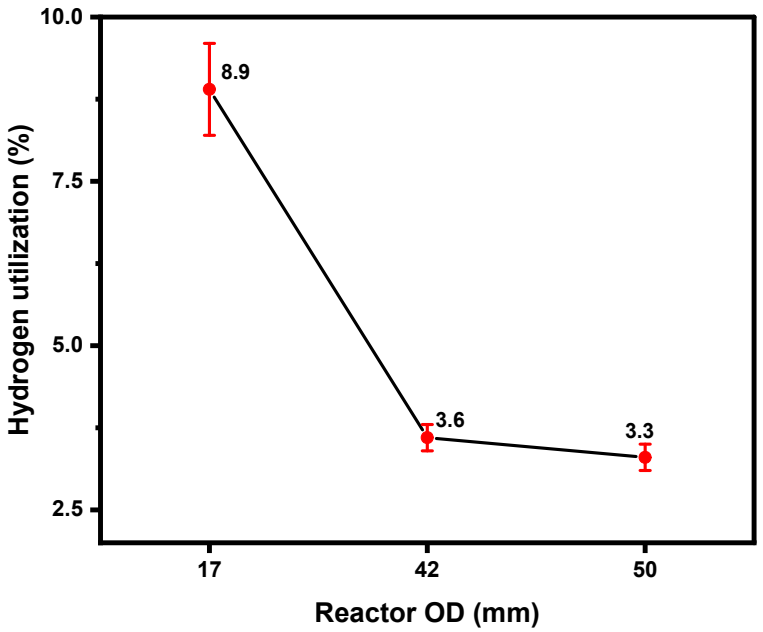

Figure S4. The effect of DBD reactor OD on the hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE (PZL=8cm, loading=2g, reaction time=10min, and input power=60W).

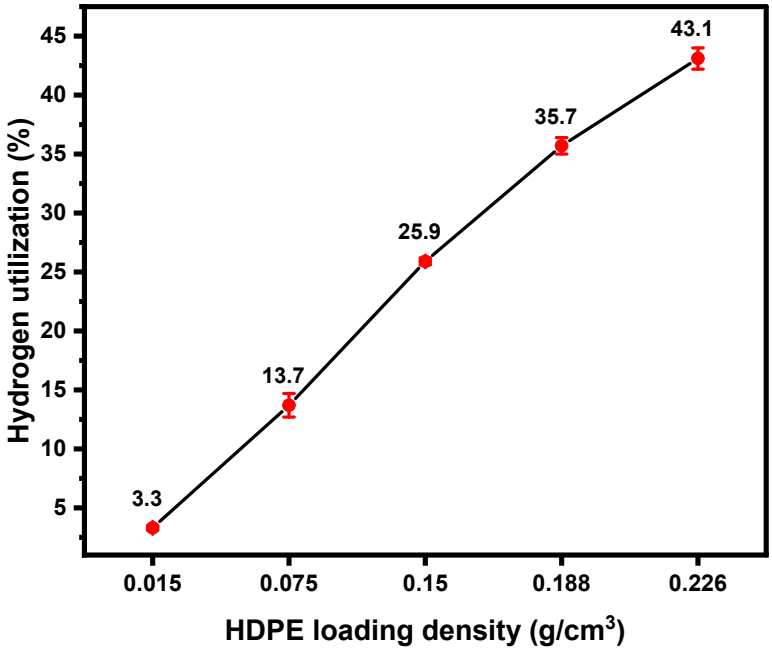

Figure S5. The effect of HDPE loading density at PZL=8cm and DBD reactor OD=50mm on the hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE (reaction time=10min and input power=60W).

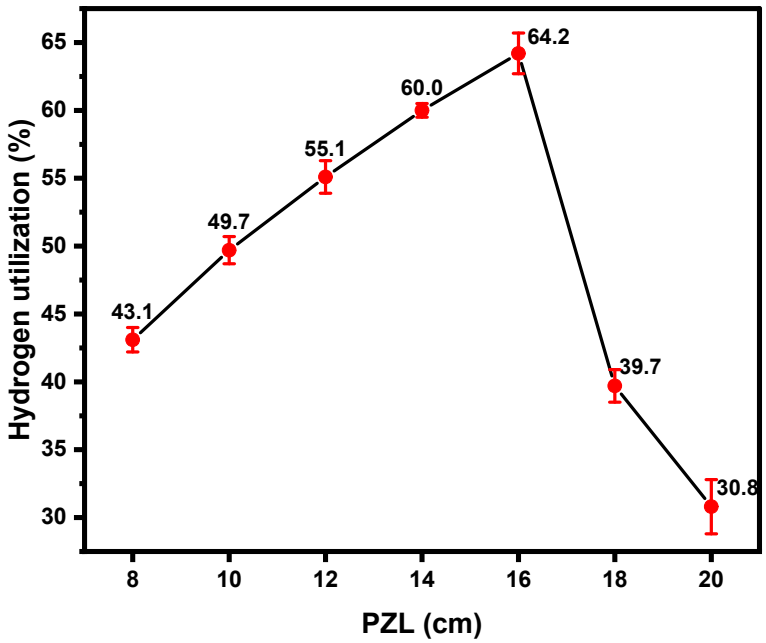

Figure S6. The effect of PZL on the hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE (DBD reactor OD=50mm, reaction time=10min, and input power=60W).

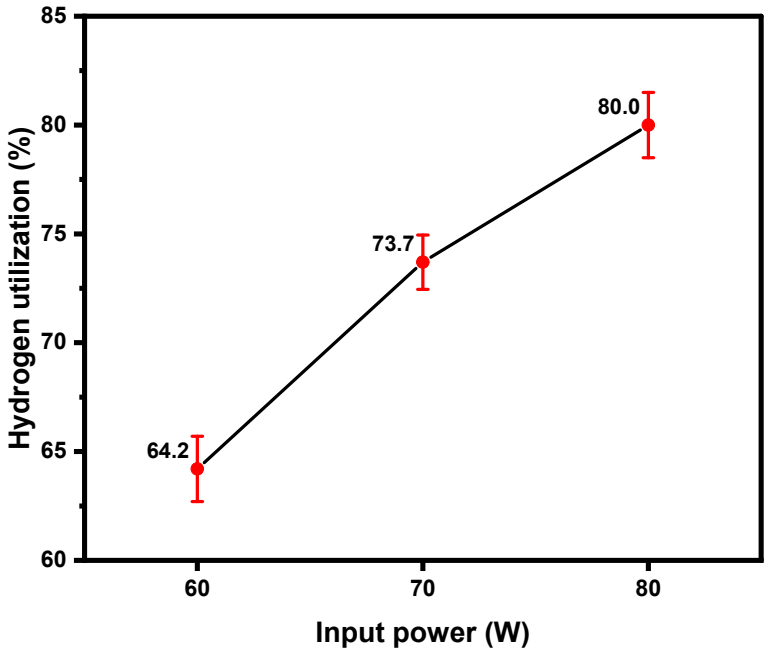

Figure S7. The effect of input power on the hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE (DBD reactor OD=50mm, reaction time=10min, and loading=54g).

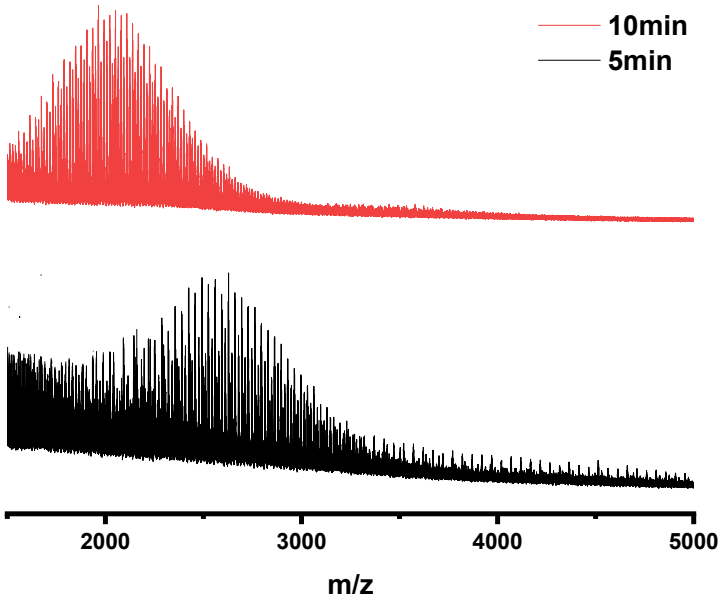

Figure S8. Effect of reaction time on MALDI spectra of wax products of nonthermal plasma-assisted hydrogenolysis of HDPE (DBD reactor OD=50mm, input power=60W and loading=54g).

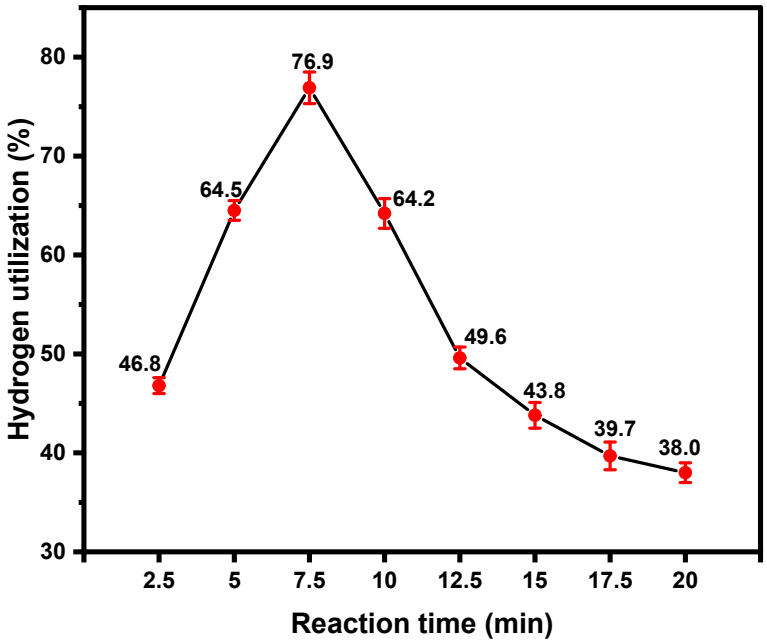

Figure S9. The effect of reaction time on the hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE (DBD reactor OD=50mm, input power=60W, and loading=54g).

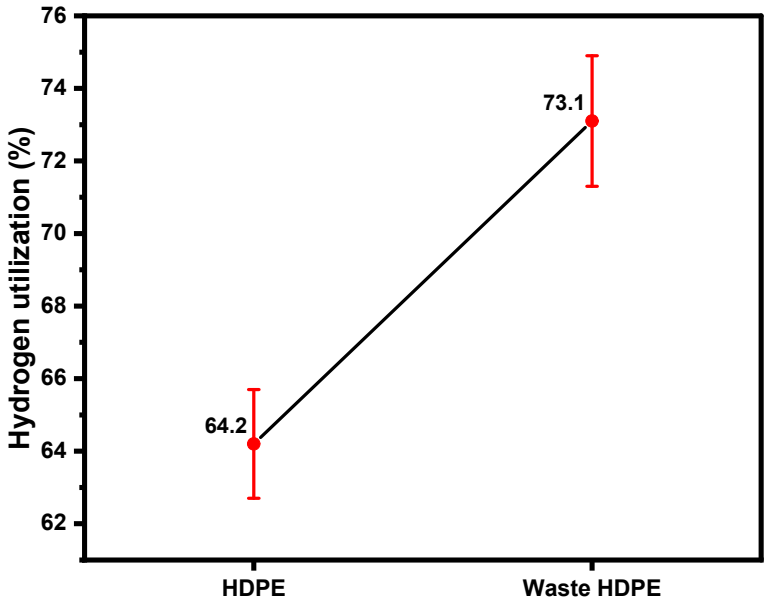

Figure S10. Comparison of hydrogen utilization of nonthermal plasma-assisted hydrogenolysis of HDPE and HDPE pill bottles waste (DBD reactor OD=50mm, input power=60W, and loading=54g).

Table S1. The heat of combustion of all gas products of HDPE hydrogenolysis [1].

Gas product	Heat of combustion (kJ/g)
CH_4	-55.6
C_2H_2	-11.8
C_2H_4	-50.3
C_2H_6	-51.9
C_3H_6	-49
C_3H_8	-50.3
C_4H_{10}	-49.5

Table S2. Thermodynamic properties for all reactants and products of HDPE hydrogenolysis [1,2].

Properties	H (kJ/mol)	S (J/mol/K)	H-TS (kJ/mol)
CH_4	-74.9	188.7	-131.1
C_2H_2	226.7	200.9	166.8
C_2H_4	54.5	219.3	-10.9
C_2H_6	-84.0	229.6	-152.4
C_3H_6	20.4	266.9	-59.1
C_3H_8	-104.7	269.9	-185.1
PE	7.0	28.3	-1.5
H_2	0.0	114.7	-34.2

$$Input\ energy\ due\ to\ hydrogen\ consumption(kJ) = moles\ of\ hydrogen\ reacted\ (mol) \times 22.4(\frac{mol}{l}) \times 12.78(\frac{kJ}{l})$$

(Eq. S1)

$$Electrical\ input\ energy(kJ) = input\ power(W) \times reaction\ time\ (s)$$ (Eq. S2)

$$Output\ energy\ of\ each\ gas\ product(kJ) = mass\ (g) \times heat\ of\ combustion(\frac{kJ}{g})$$ (Eq. S3)

$$Electric\ energy\ cost\ per\ 1\ gram\ of\ HDPE = \frac{Power\ (kW) \times Time(h)}{HDPE\ loading} \times 14.41\frac{cents}{kWh}$$ (Eq. S4)

References

1 NIST Standard Reference Database Number 69. DOI: https://doi.org/10.18434/T4D303.

2 U. Gaur and B. Wunderlich, *J Phys Chem Ref*, 1981, **10** 119-152. https://doi.org/10.1063/1.555677.