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PLASMA-ASSISTED METHANE PYROLYSIS IN A DC THERMAL PLASMA TORCH: EXPERIMENTAL INVESTIGATION AND THERMODYNAMIC–KINETIC MODELING

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Introduction

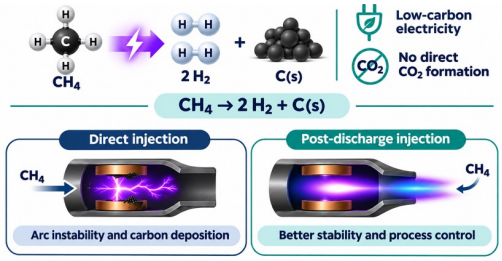


Fig. 1. Comparasion of direct and post-discharge methane injection strategies

Objectives

- Investigate thermal plasma-assisted methane pyrolysis for turquoise hydrogen production.
- Evaluate CH_4 conversion and H_2 production using post-discharge injection.
- Compare experimental results with thermodynamic and kinetic models.

Methodology

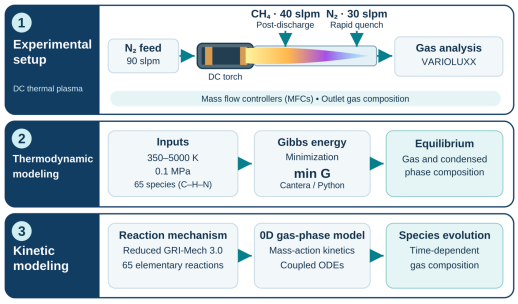


Fig. 2. Methodological workflow for plasma-assisted methane pyrolysis.

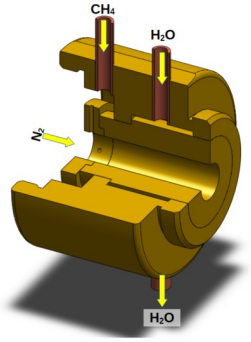


Fig. 3. 3D schematic of the methane reforming device used in the plasma reactor.

Results and discusses

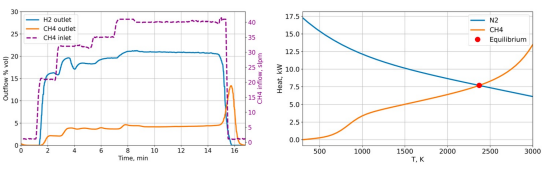


Fig. 4. Time-resolved CH4 feed rate and outletconcentrations of H2 and CH4. Fig. 5. Heat content variation of the N2 plasma jet and the CH4 stream.

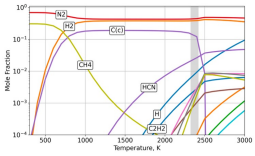


Fig. 6. Calculated gas composition under thermody-namic equilibrium conditions.

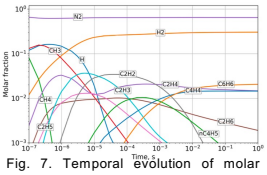


Fig. 7. Temporal evolution of molar fractions of chemical species during methane pyrolysis at 2370 K.

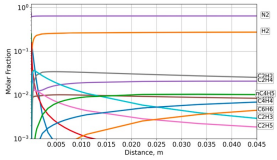


Fig. 8. Axial profiles of gas-phase molar fractions at a fixed temperature of 2370 K.

Species	10^{-5}	10^{-3}	10^{-2}	10^{-1}	1
C_2H_2	0.0287	0.0179	0.0026	–	–
C_2H_3	0.0336	0.0014	–	–	–
C_2H_4	0.0121	0.0202	0.0171	0.0156	0.0147
C_2H_5	0.0125	0.0011	–	–	–
C_2H_6	0.0095	0.0072	0.0043	0.0028	0.0019
C_4H_4	–	0.0096	0.0141	0.0145	0.0145
C_6H_6	–	0.0078	0.0164	0.0195	0.0205
CH_3	0.0105	–	–	–	–
H	0.0187	–	–	–	–
H_2	0.2325	0.2812	0.2955	0.3011	0.3037
N_2	0.6394	0.6450	0.6465	0.6456	0.6446
nC_4H_5	0.0017	0.0085	0.0029	–	–
$\Sigma\ C_xH_y$	0.1086	0.0737	0.0574	0.0524	0.0516

Fig. 9. Axial profiles of gas-phase molar fractions at a fixed temperature of 2370 K.

Conclusion

Thermal plasma-assisted methane pyrolysis with post-discharge injection demonstrated high CH_4 conversion (92%) and H_2 production (~1 vol.%). Thermodynamic and kinetic modeling highlighted the importance of residence time and non-equilibrium effects, confirming the potential of this technology for turquoise hydrogen production. Optimize reactor design, operating conditions, and energy efficiency to enhance hydrogen production and enable industrial-scale turquoise hydrogen producti

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Acknowlegments

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