

Figures

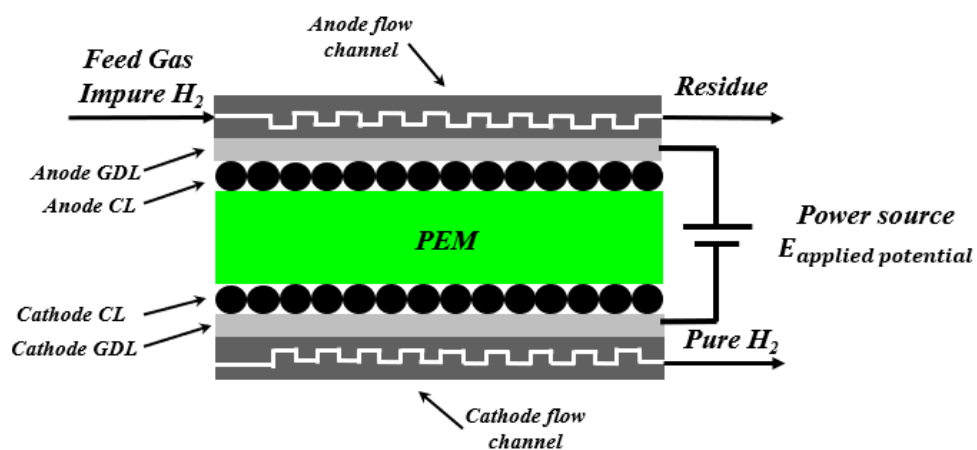


Figure 1. Electrochemical hydrogen pump (EHP) used for hydrogen purification (The white zigzag line indicates that the gas flow path is zigzag under real condition)

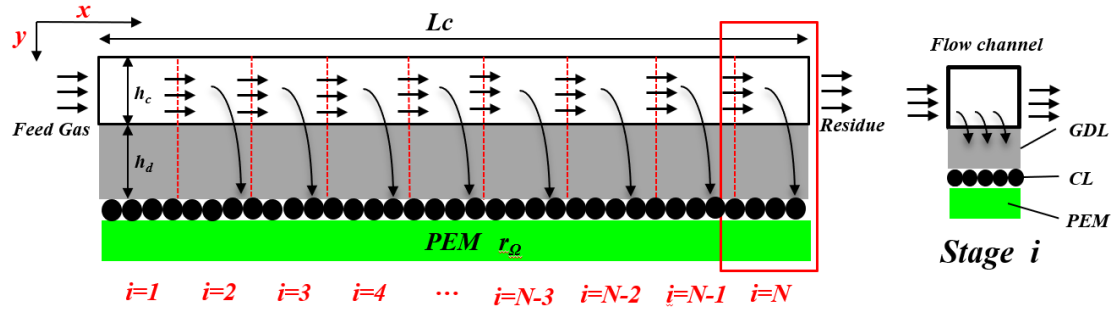


Figure 2. EHP model computational domain (half EHP with single straight flow channel)

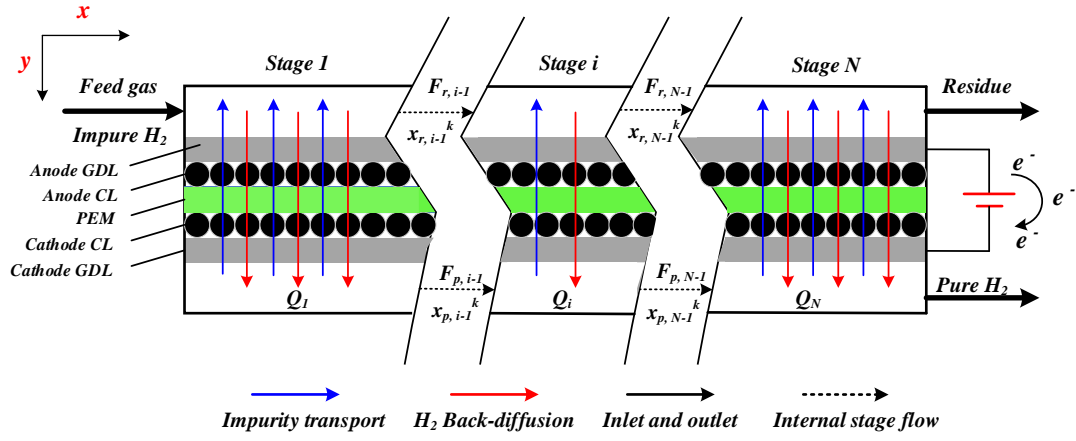


Figure 3. Schematic diagram of the component transmembrane transportation

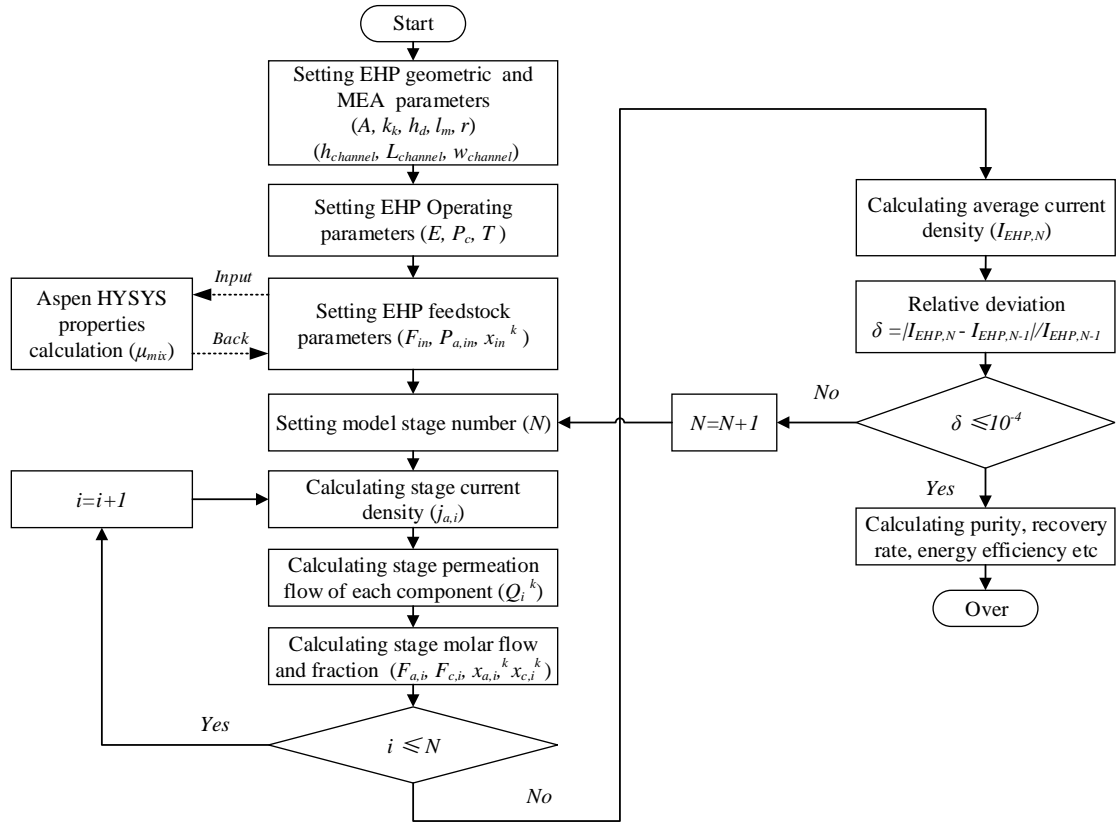


Figure 4. Solution procedure diagram of proposed model

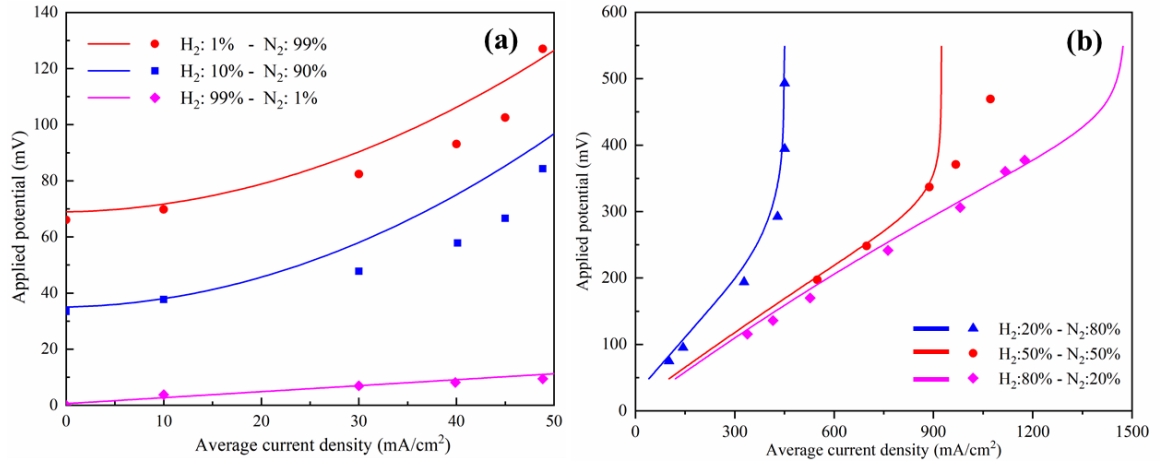


Figure 5. Comparison between simulation and experiment polarization curve under H₂ – N₂ feedstock system (symbols: experiment data from Onda et al.¹⁸ and Nordio et al.²² lines: simulation data)

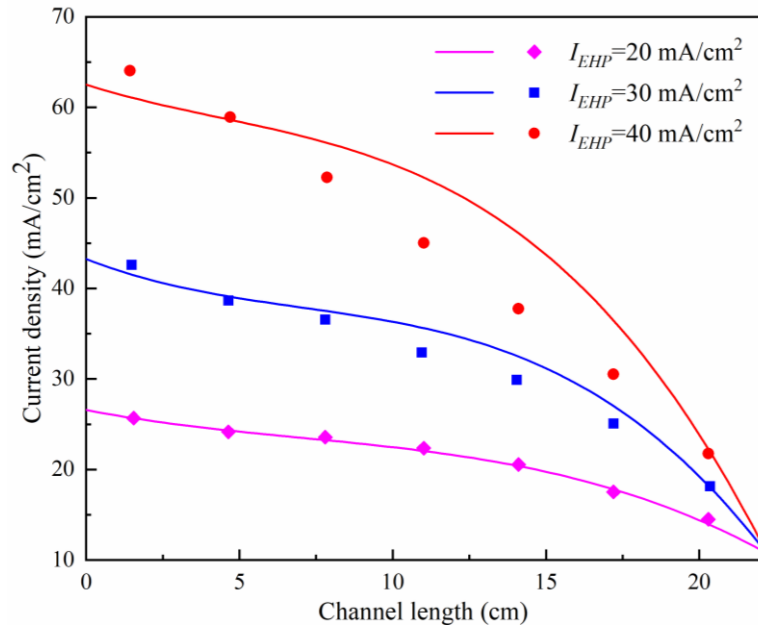


Figure 6. Comparison of current density distribution between simulation and experiment under H₂ – N₂ feedstock system (H₂ content: 1 mol%. symbols: experiment data from Onda et al.¹⁵ lines: simulation data)

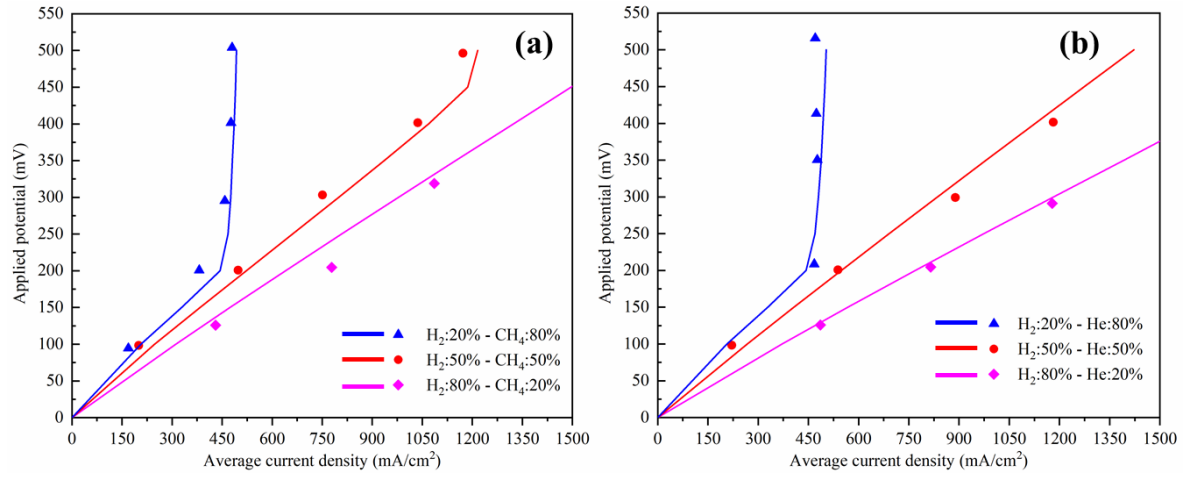


Figure 7. Comparison of polarization curve between simulation and experiment (symbols: experiment data from Nordio et al.²² lines: simulation data). (a) H₂ - CH₄. (b) H₂ - He

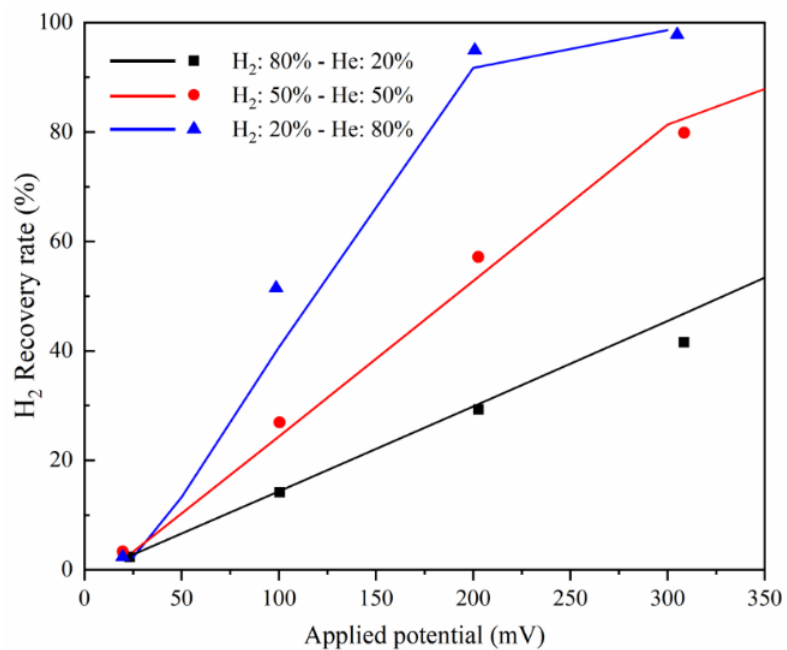


Figure 8. Comparison of hydrogen recovery rate between simulation and experiment under H₂ – He feedstock system (symbols: experiment data from Nordio et al.²² lines: simulation data).

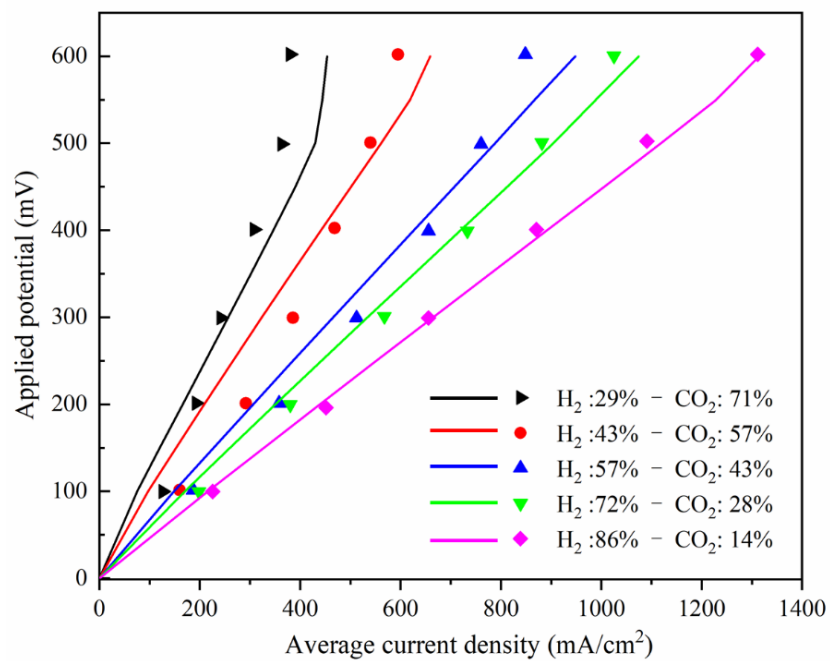


Figure 9. Comparison of polarization curve between simulation and experiment under H₂-CO₂ feedstock system (symbols: experiment data from Abdulla et al.¹⁹ lines: simulation data).

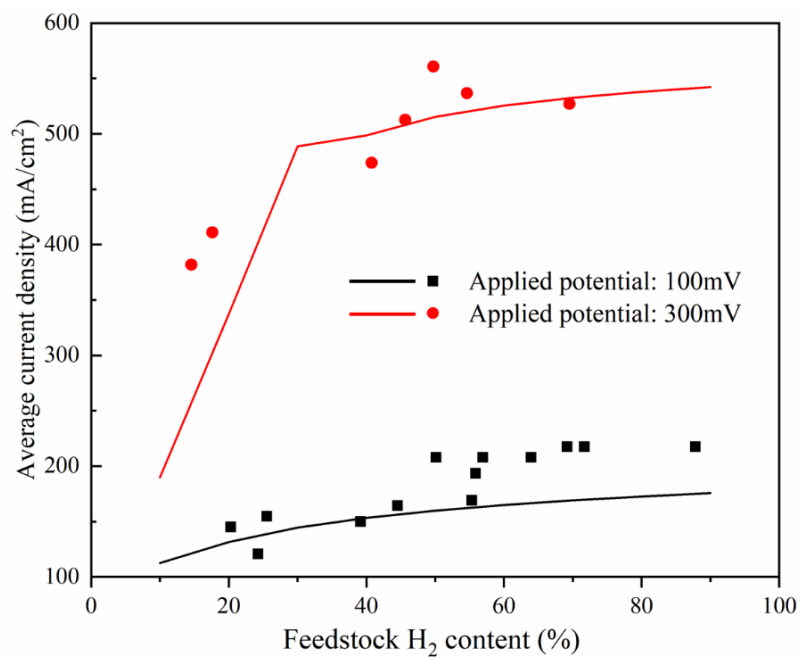


Figure 10. Comparison of current density between simulation and experiment under H₂ - CO₂ feedstock system (symbols: experiment data from Abdulla et al.¹⁹ lines: simulation data).

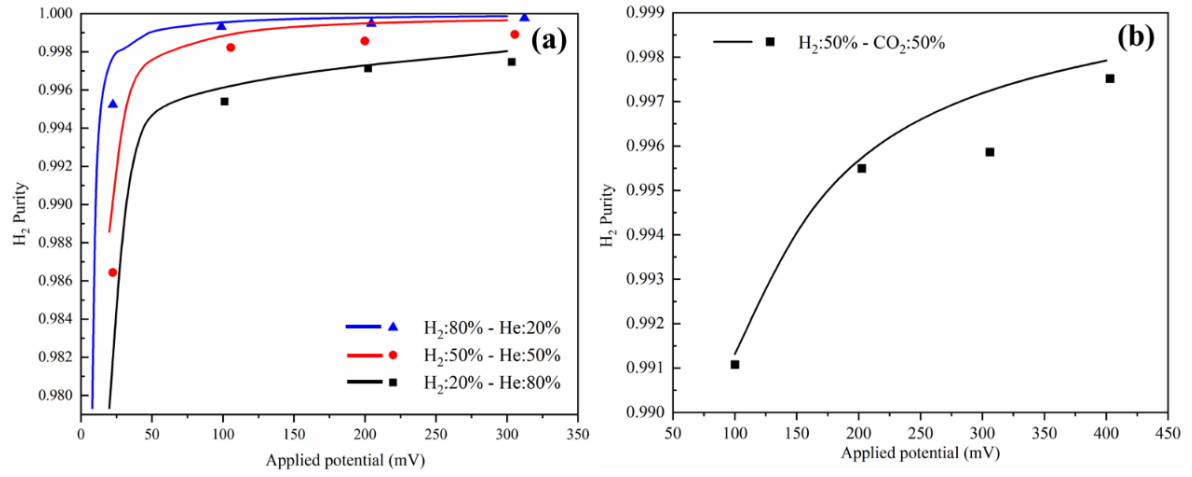


Figure 11. Comparison of product hydrogen purity between simulation and experiment (symbols: experiment data; lines: simulation data). (a) H₂ - He purity experiment data from Nordio et al.²² (b) H₂ - CO₂ purity experiment data from Nordio et al.³⁰

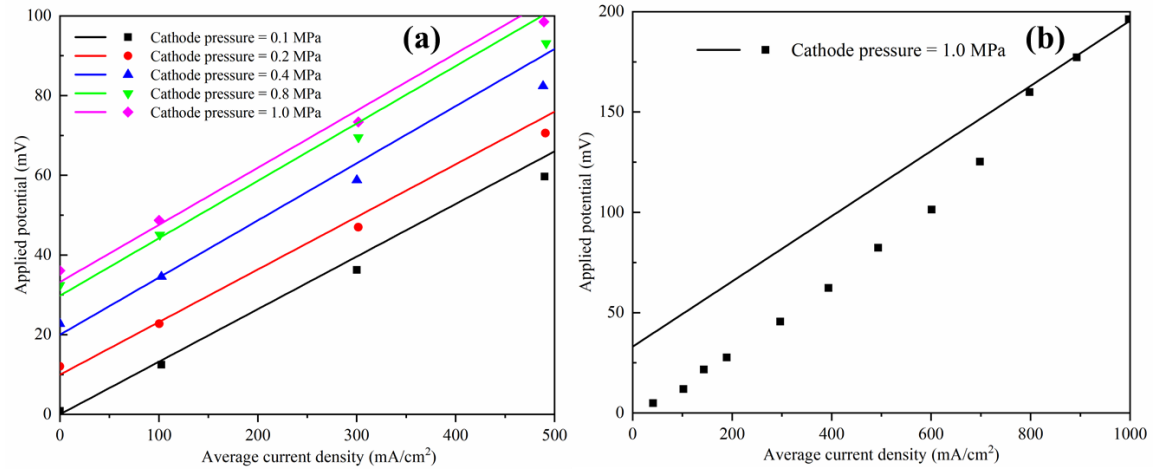


Figure 12. Comparison of pressured polarization curve between simulation and experiment (symbols: experiment data; lines: simulation data). (a) Experiment data from Onda et al.¹⁵ (b) Experiment data from Strobel et al.⁴⁹

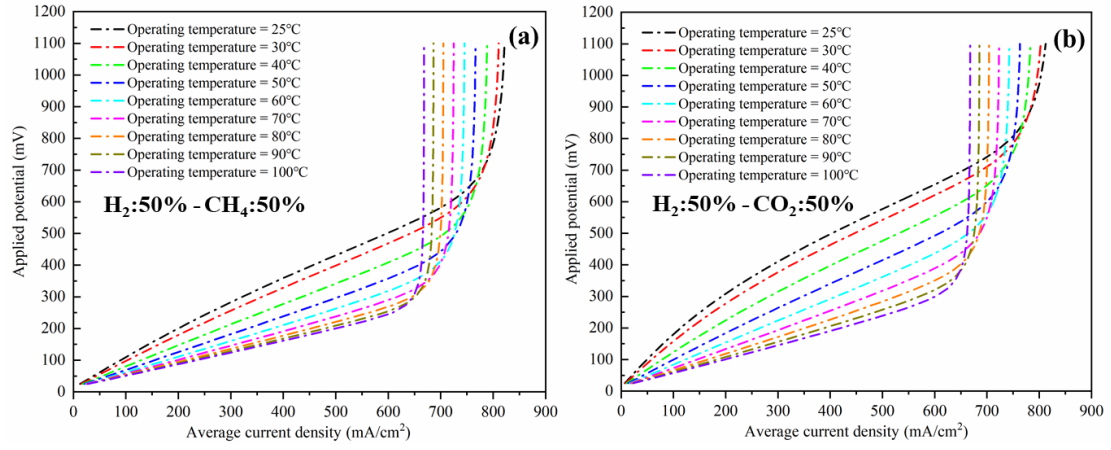


Figure 13. Polarization curve under different feedstock hydrogen content (operating temperature: 25 - 100 °C). (a) H₂: 50 mol% - CH₄: 50 mol%. (b) H₂: 50 mol% - CO₂: 50 mol%.

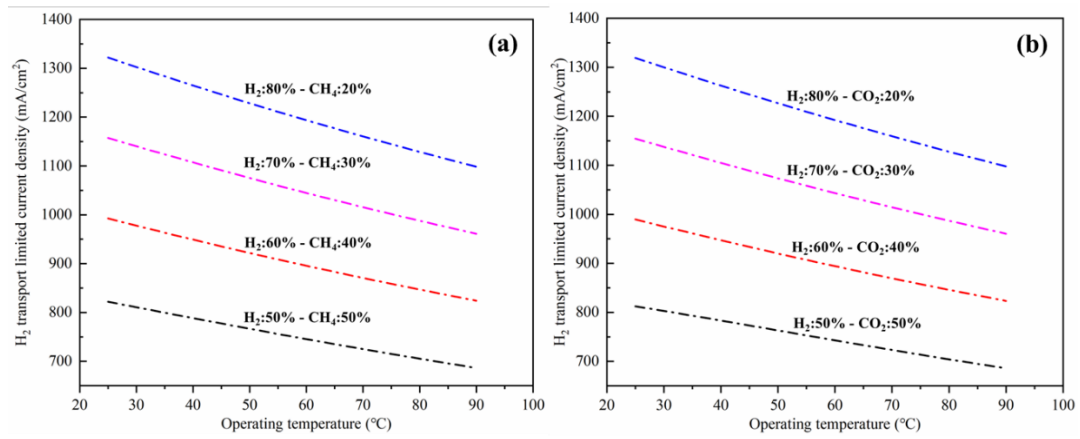


Figure 14. The relationship between hydrogen transport limited current density and operating temperature under different hydrogen feedstock content (H₂ content: 50 - 80 mol%). (a) H₂/CH₄. (b) H₂/CO₂.

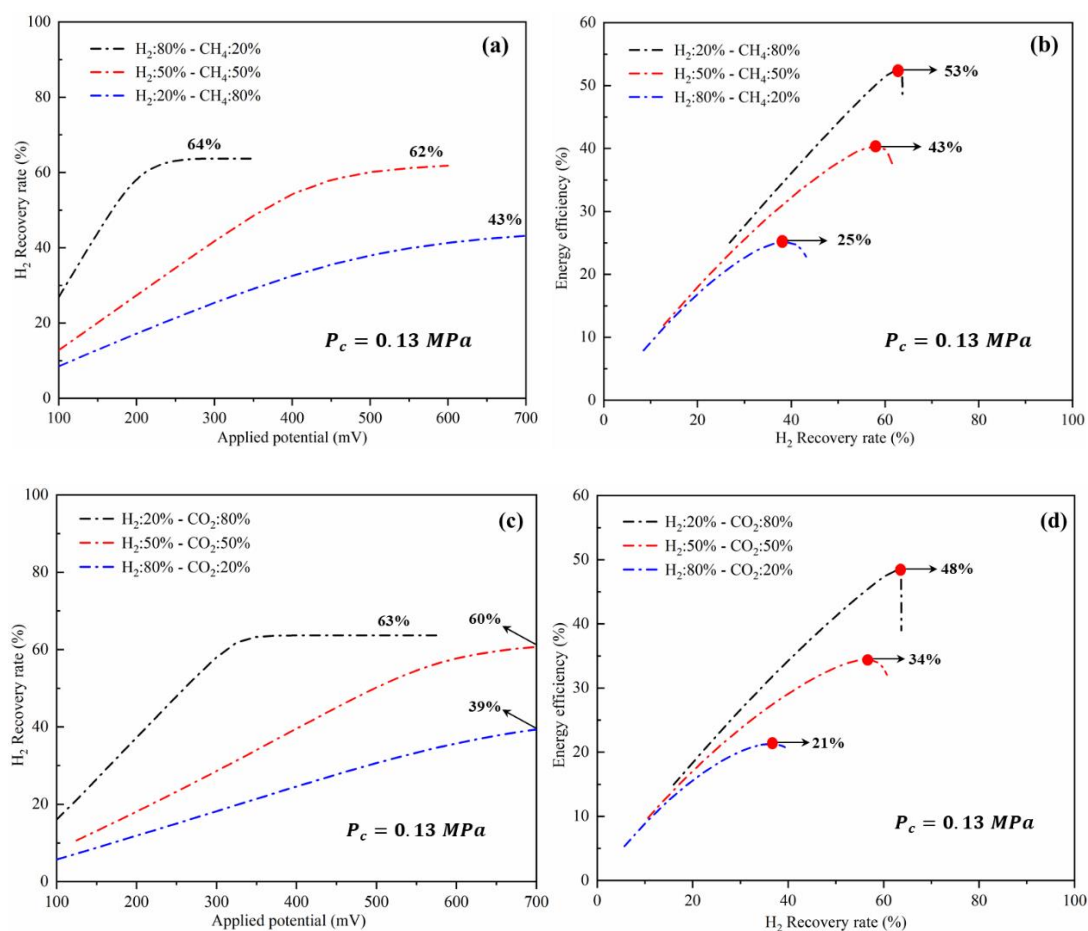


Figure 15. The relationship between hydrogen recovery rate, applied potential and energy efficiency under different feedstock hydrogen content (cathode pressure: 0.13 MPa H_2 content: 20 – 80 mol%). (a) hydrogen recovery rate applied potential (H_2/CH_4). (b) energy efficiency – hydrogen recovery rate (H_2/CH_4). (c) hydrogen recovery rate – applied potential (H_2/CO_2). (d) energy efficiency – hydrogen recovery rate (H_2/CO_2).

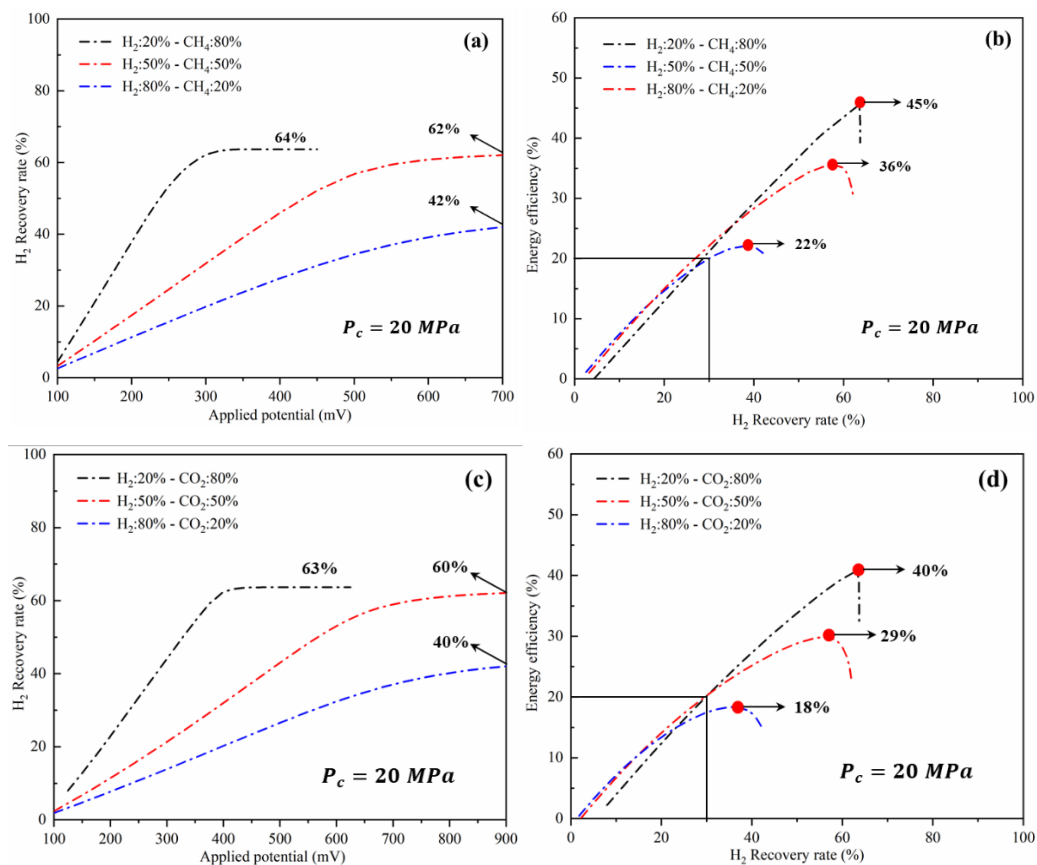


Figure 16. The relationship between hydrogen recovery rate, applied potential and energy efficiency under different feedstock hydrogen content (cathode pressure: 20 MPa H_2 content: 20 – 80 mol%). (a) hydrogen recovery rate – applied potential (H_2/CH_4). (b) energy efficiency – hydrogen recovery rate (H_2/CH_4). (c) hydrogen recovery rate – applied potential (H_2/CO_2). (d) energy efficiency – hydrogen recovery rate (H_2/CO_2).

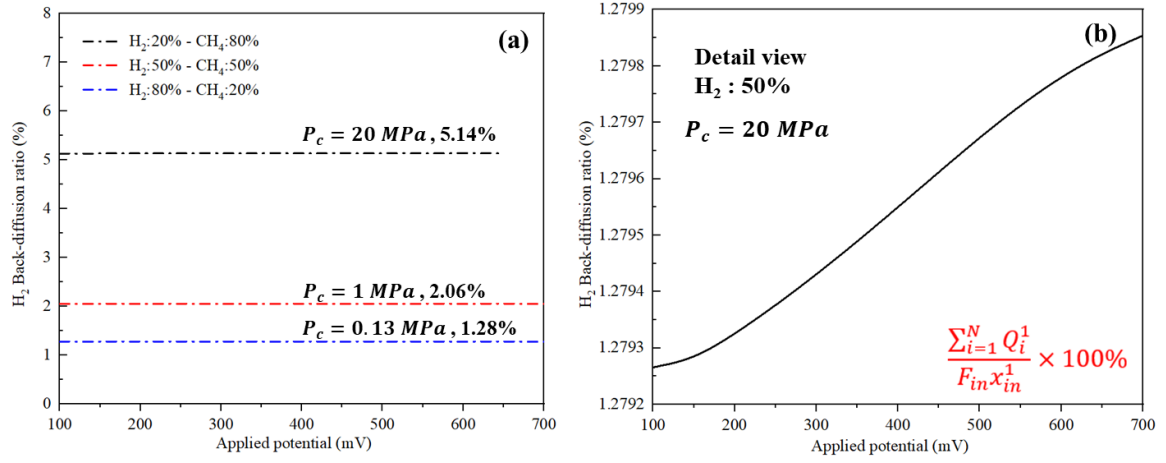


Figure 17. Relationship between hydrogen back diffusion rate and applied potential. (a) H_2/CH_4 , H_2 content: 20 - 80 mol%; cathode pressure: 20 MPa. (b) Detail view of the relationship between hydrogen back diffusion rate and applied potential.

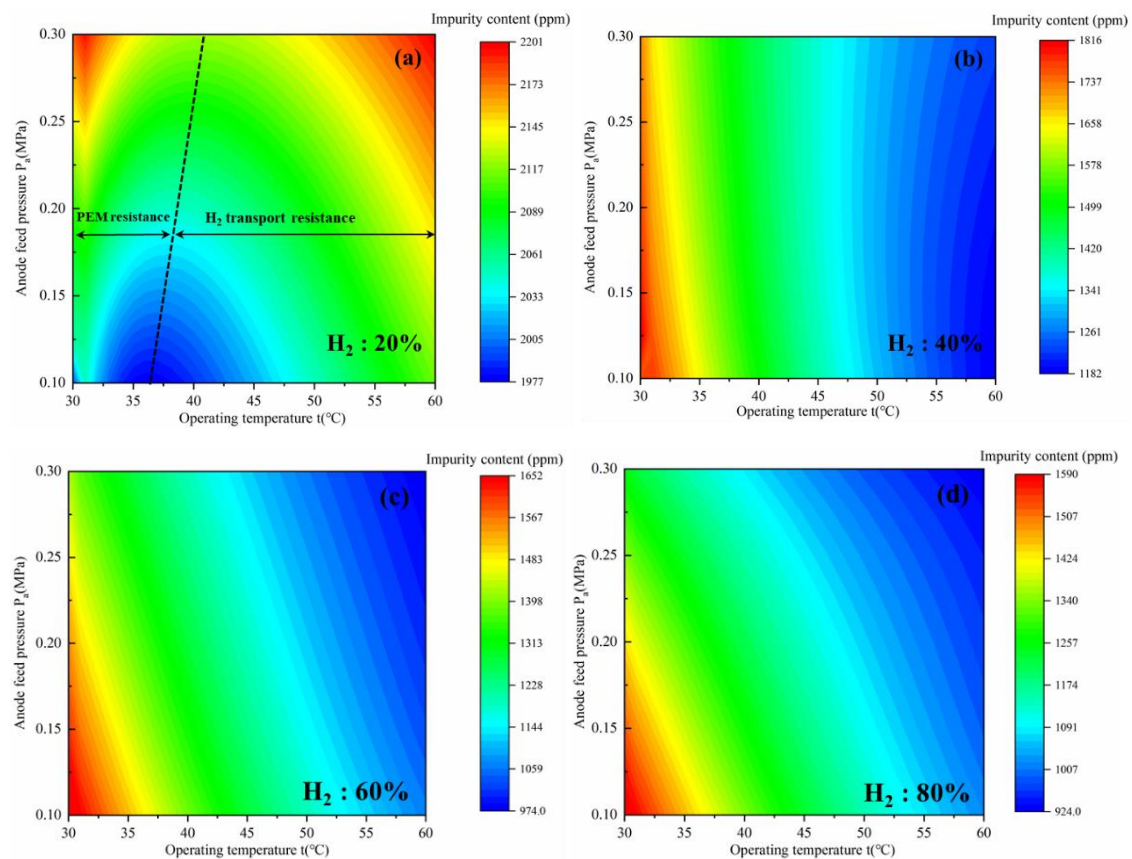


Figure 18. Effects of operating temperature and anode pressure on hydrogen purity (Feedstock H_2 content: 20 – 80 mol%; H_2/CH_4 ; applied potential: 300 mV). (a) H_2 content: 20 mol%. (b) H_2 content: 40 mol%. (c) H_2 content: 60 mol%. (d) H_2 content: 80 mol%.

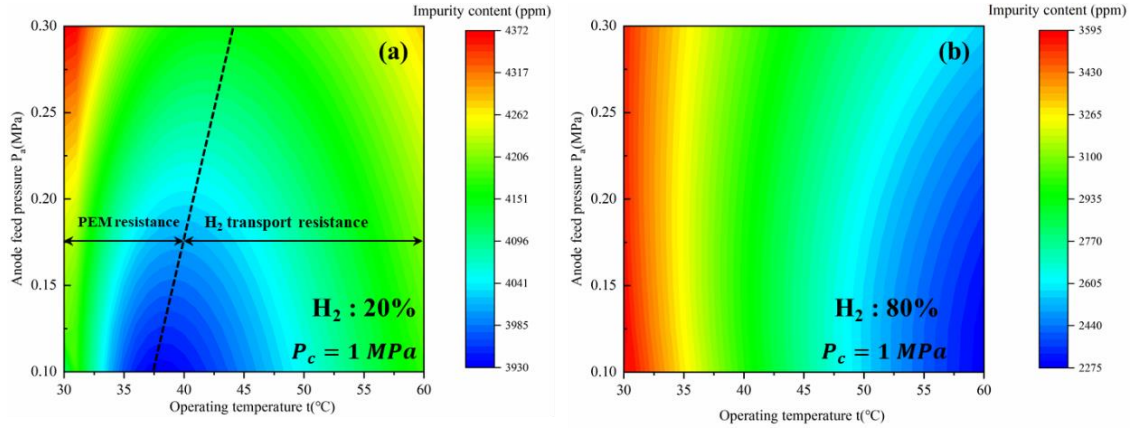


Figure 19. Effects of operating temperature and anode pressure on hydrogen purity (H_2/CH_4 ; applied potential: 300 mV; cathode pressure: 1 MPa). (a) H_2 content: 20 mol%. (b) H_2 content: 80 mol%.

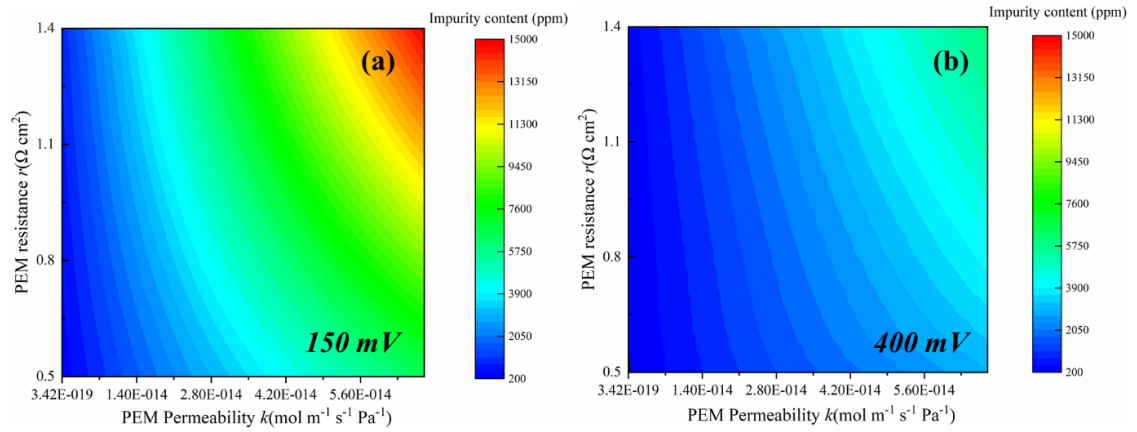


Figure 20. Effects of PEM permeability and resistance on hydrogen purity (H_2 content: 50 mol%). (a) 150 mV. (b) 400 mV.

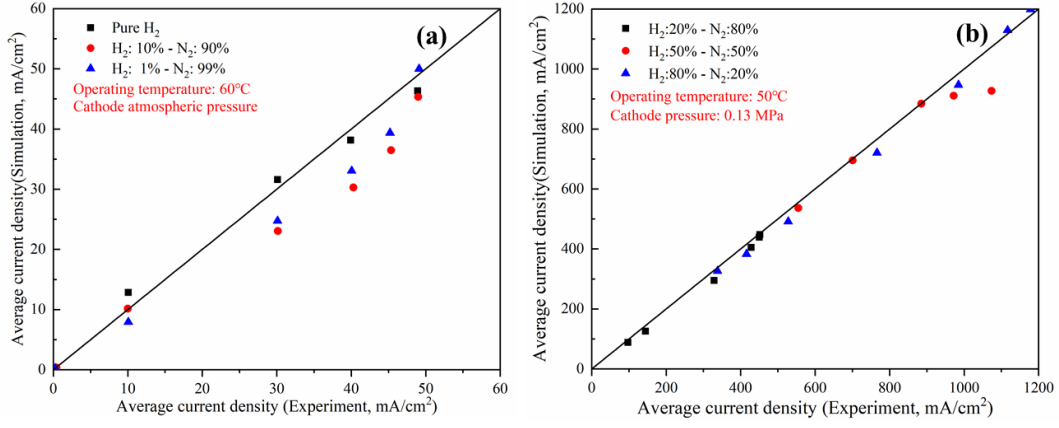


Figure B1. Comparison of Simulation and experiment current density under $H_2 - N_2$ feedstock system. (a) experiment data from Onda et al.¹⁸. (b) experiment data from Nordio et al.²².

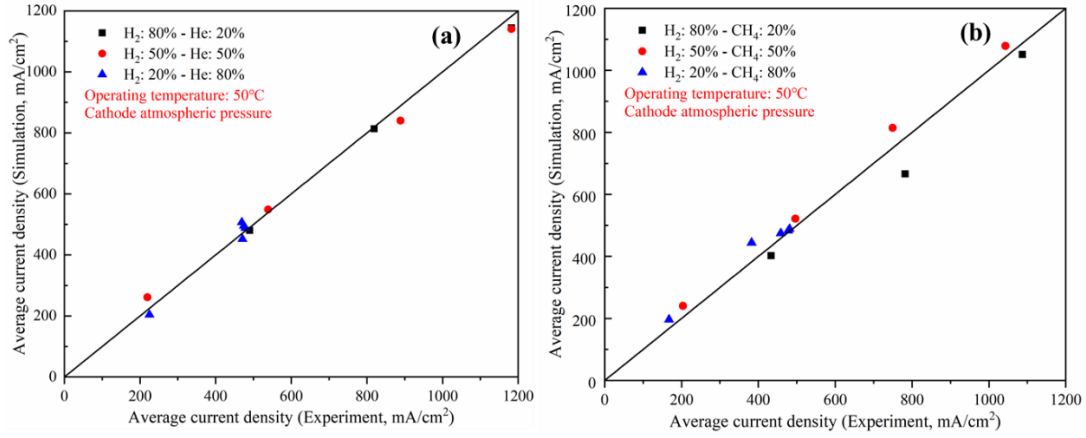


Figure B2. Comparison of simulation and experiment current density (experiment data from Nordio et al.²²). (a) $H_2 - He$. (b) $H_2 - CH_4$.

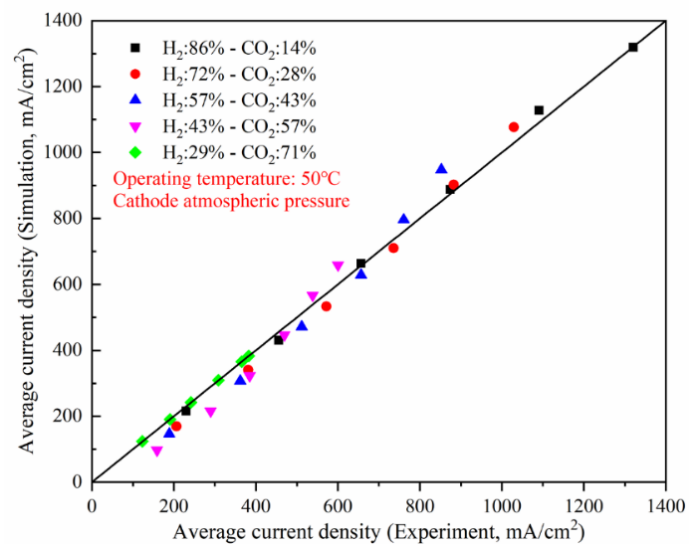


Figure B3. Comparison of simulation and experiment current density under H_2 - CO_2 feedstock system. (experiment data from Abdulla et al.¹⁹).

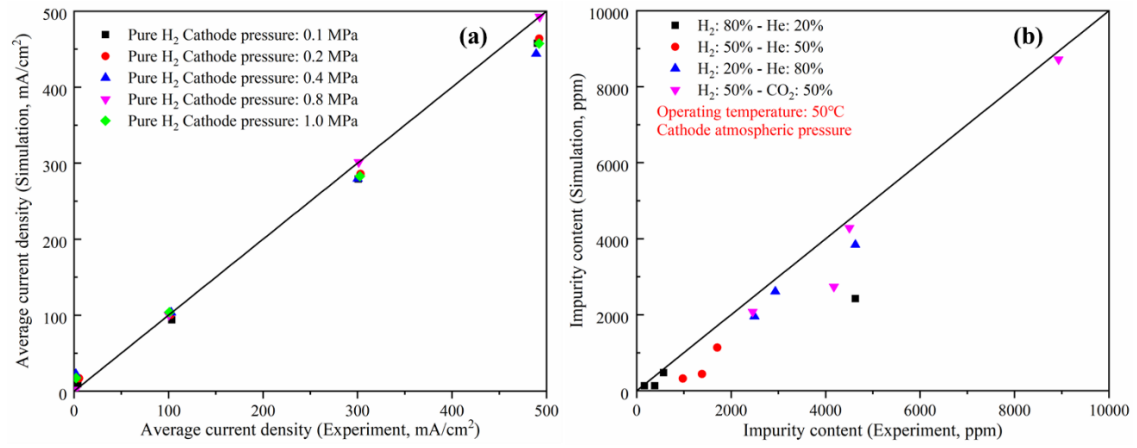


Figure B4. (a) Comparison of simulation and experiment current density under cathode high pressure (experiment data from Onda et al.¹⁸). (b) Simulation and experiment hydrogen impurity content (experiment data from Nordio et al.^{22,30}).