Transition Metal Sulfide Electrocatalysts for PEM Fuel Cells

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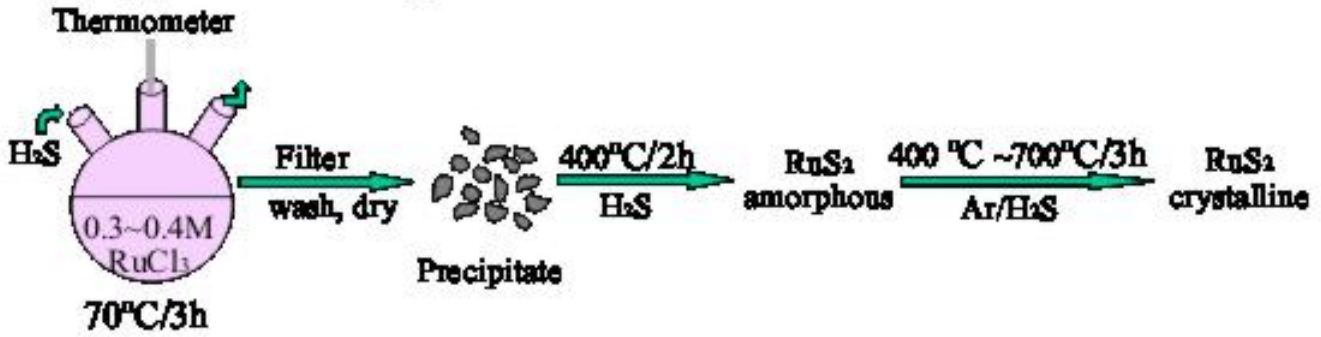
Objectives

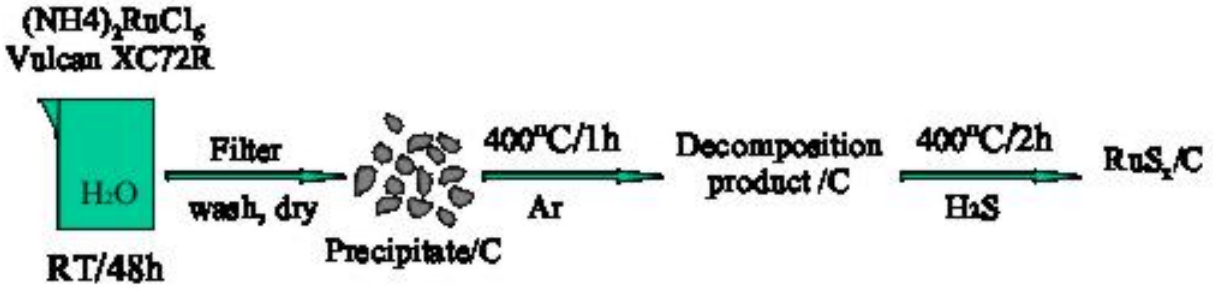
- Investigate non-platinum electro-catalysts with CO tolerance
- Focus on transition metal sulfides as electro-catalysts
- Known catalysts for hydrogen dissociation
- Single phases or promoted systems e.g. Ni/MoS_2
- Started with RuS_2 – probably the best hydrogen dissociation catalyst
- Previous work on oxygen reduction using RuS_x electrocatalysts

Synthesis of RuS_x Electrocatalysts

Unsupported RuS_x:



RuS_x supported on carbon (impregnation method):

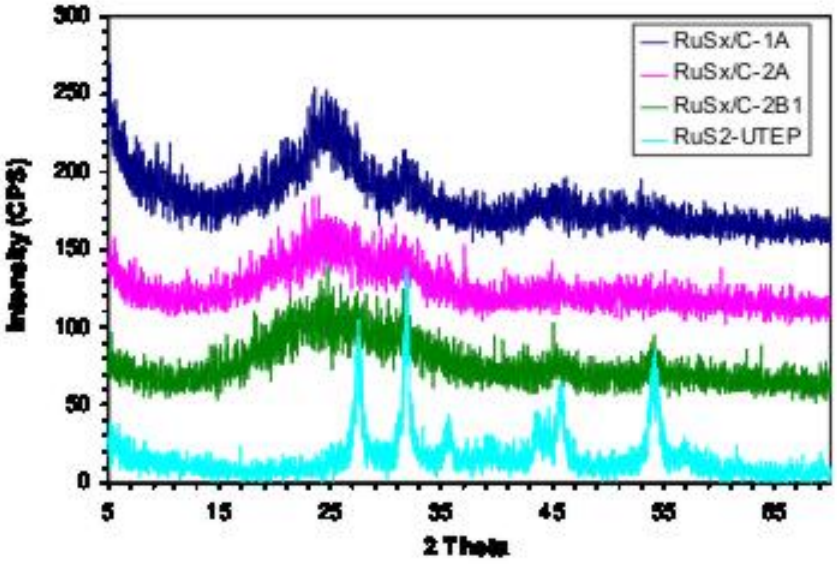


Characterization of RuS_x

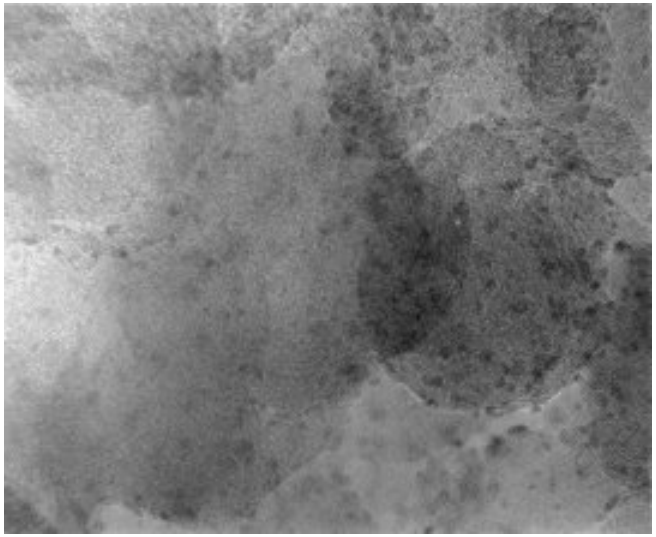
Samples	Synthesis	SEM/EDX S:Ru	TGA RuS_x%	SSA m^2/g
RuS_2 (UTEP)	400°C /2h/H_2 /H_2S	2.07(TGA)		59.7
RuS_2/C-1A	RT/48h 400°C/He/1h 400°C/H_2S/2h	2.5	18.2	190.2
RuS_2/C-2A	RT/48h 400°C/He/1h 400°C/H_2S/2h	2.59	33.9	176.6
RuS_2/C-2B1	Boiling/2h,RT/46h, RT/He/0.5h, 400°C/H_2S/2h	2.41	33.6	149.3

* SSA of Vulcan XC72R=234.90m^2/g

Characterization of RuS_x

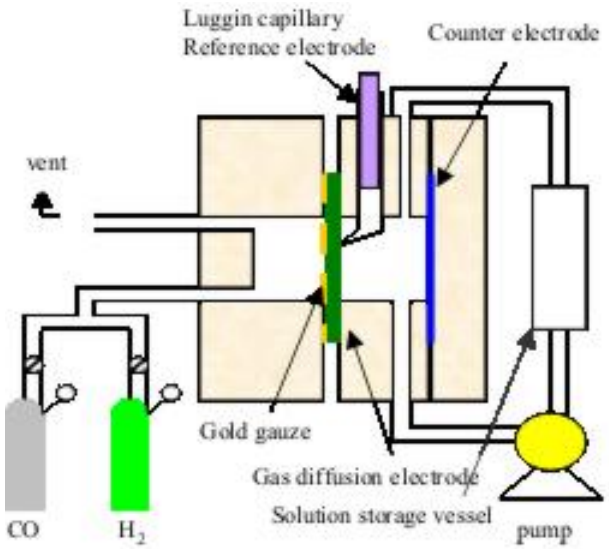


X-ray diffraction patterns of RuS_x and RuS_x/C



RuS_x dispersion on carbon (TEM image) sample: RuS_x/C-1A

Electrochemical Measurements



Three Electrode Cell

Electrode Preparation

The three-layer electrodes were prepared by spraying

Carbon paper (Toray, TGPH-090, E-TEK) with a diffusion layer was dried at 80°C for 1 h.

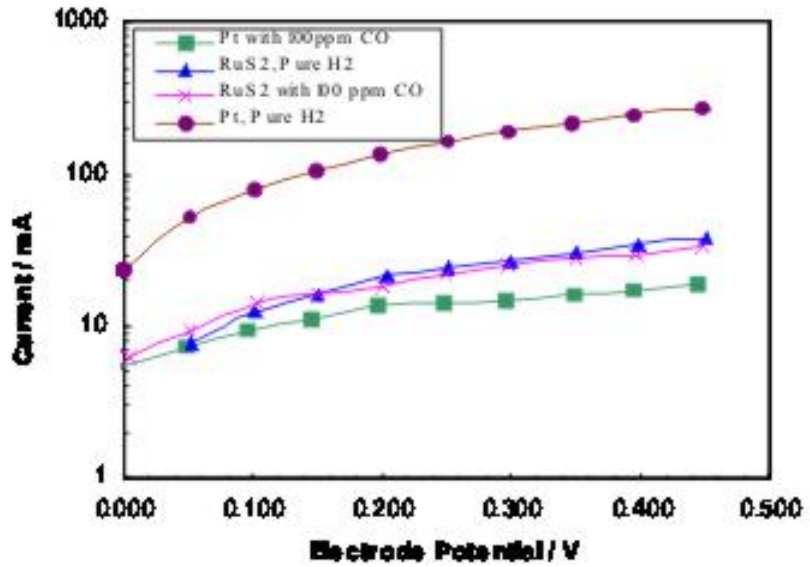
Catalyst ink formed from ruthenium sulfide, carbon powder (Vulcan XC-72R, Cabot), Nafion solution (5 wt.%, Aldrich) and glycerol/ethanol

The suspension was stirred - ultrasonic bath for 30 min.

The ink was airbrushed onto the weighed composite substrate and dried for 30 min at 80 °C

The catalyst loading was determined from the final electrode weight.

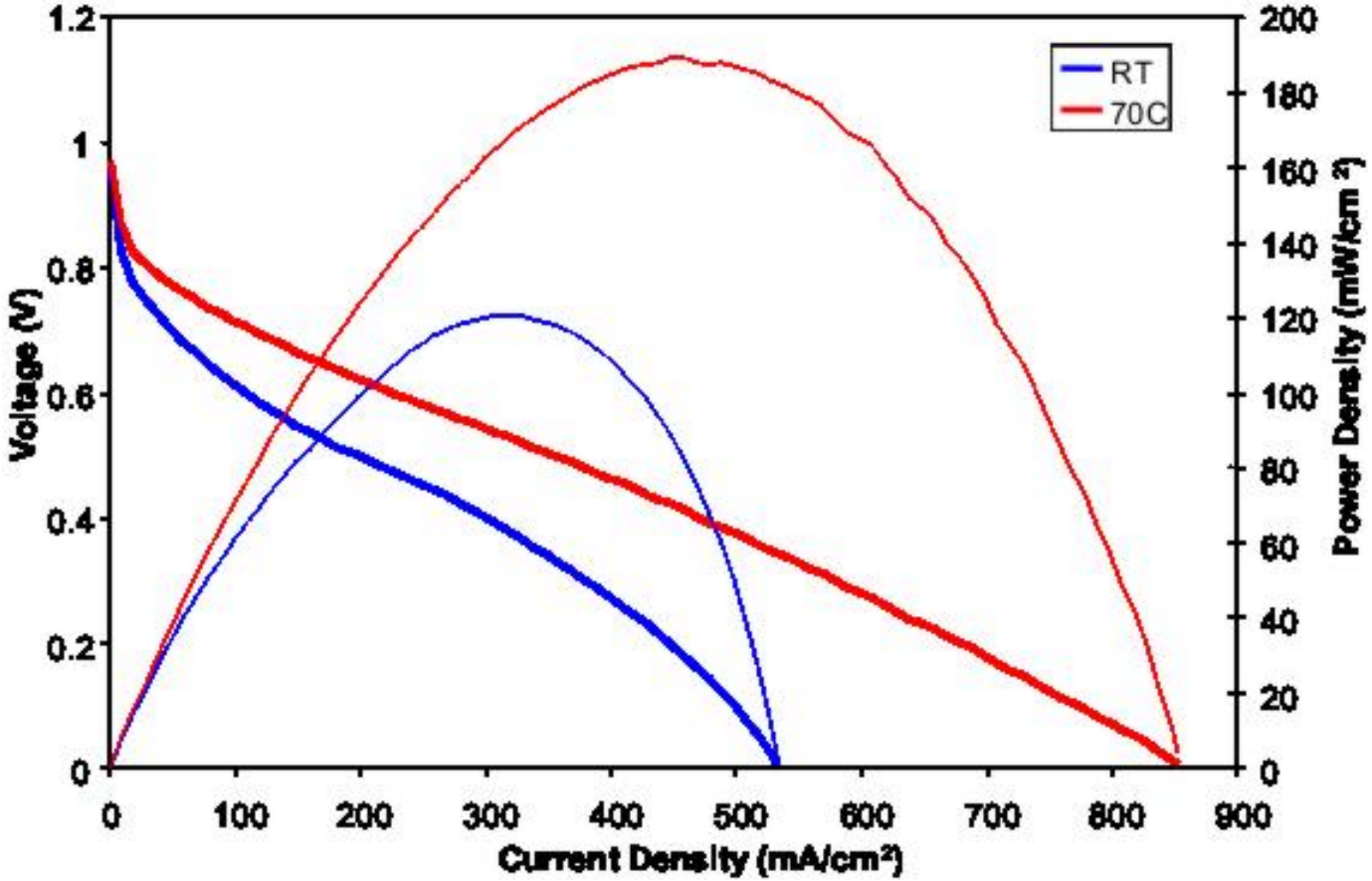
Effect of CO on RuS_2 Catalysts



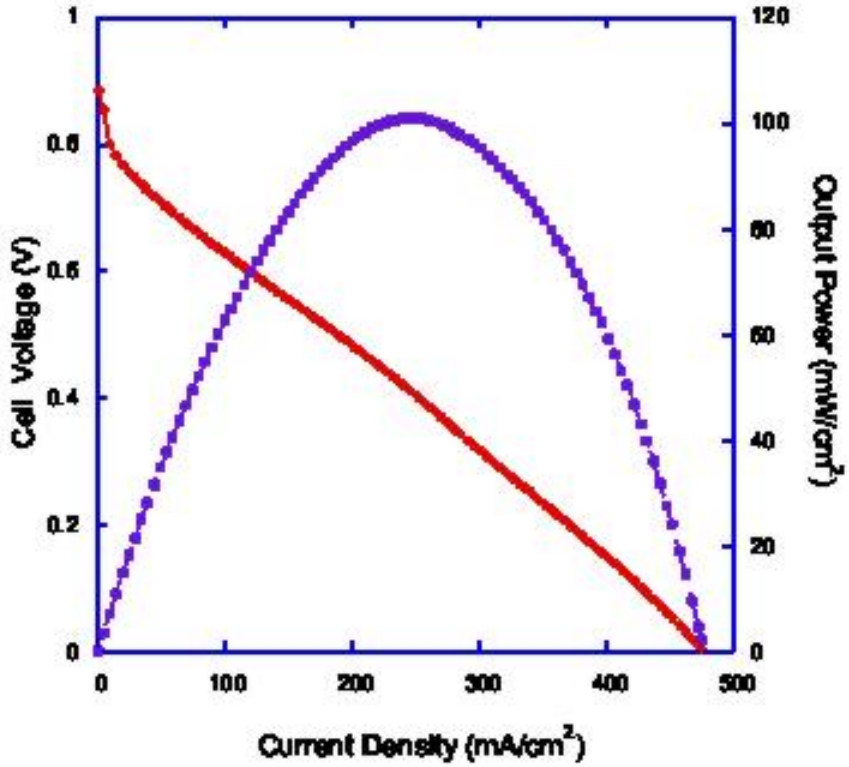
Polarization curves for H_2 oxidation on RuS_2 and Pt electrodes in 0.1M H_2SO_4 with 100 ppm CO-H_2. RuS_2 loading: 0.72 mg/cm^2

Single cell performance at different temperatures

(0.34 mg/cm^2 Pt loading for anode and cathode)



Single Cell –RuS_2 Anode



Conclusions

- RuS_2 is an active electrocatalyst for hydrogen oxidation
  - ~100 mW/cm^2 at ambient temperature
- Low activity catalysts show CO tolerance
- Origin of the activation behavior and CO tolerance of the activated catalyst not yet known