Mass spectroscopy of SOFC fuel exhausts

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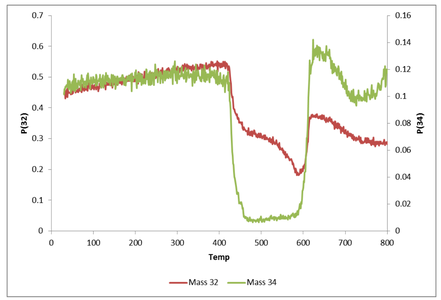
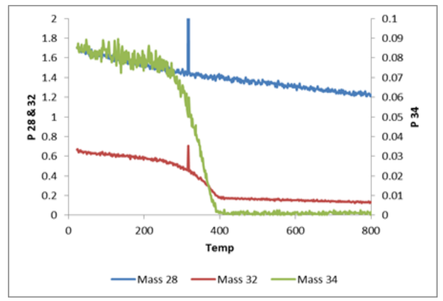
- **Objectives:**
- Determine the identity of species reaching the anode when phosphine (PH_3) is present in dry and wet fuel.
- Monitor the anode exhaust gas composition during operation of a SOFC in the presence and absence of PH_3.
- **Experimental:**
- Use a Cirrus MKS mass spectrometer to measure the pressures of gases with masses between 1 and 100 amu.
- Two configurations:
- Gas passes through an alumina tube while the temperature is ramped up, held and then cooled down.
- Gas passes over the anode of a Ni/YSZ anode supported cell at 800ºC
- Four gas mixtures:
- "Dry" hydrogen ($P(H_2O) < 1$ torr), "wet" hydrogen ($P(H_2O) = 10$ torr), "dry" hydrogen + 20 ppm PH_3, "wet" hydrogen + 20 ppm PH_3.

- **First configuration**: PH_3 does reach the anode in "dry" hydrogen at 800ºC, but reacts with O_2 or H_2O at lower temperatures.
- PH_3 reacts in "wet" hydrogen and in the presence of nickel at high temperatures.
- No new masses appear above mass 44 (CO_2) under <u>any</u> conditions. No evidence for the formation of HPO, HPO_2 or HPO_3.

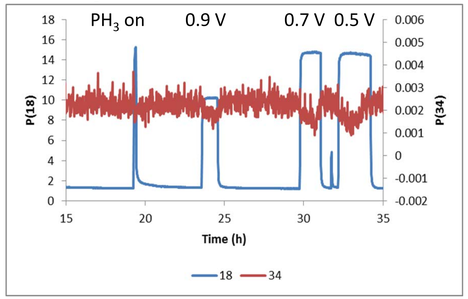


Mass 32 (O_2) & mass 34 (PH_3) during heating in dry H_2.

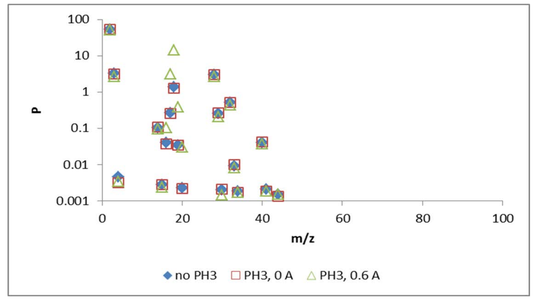


Mass 28 (N_2), mass 32 (O_2) & mass 34 (PH_3) during heating in wet H_2.

- **Second configuration**: Water from H_2 oxidation is readily detected.
- Mass spectra results were consistent with results from the first configuration.
- No PH_3 was detected in the exhaust at any time.
- No new masses above mass 44 were detected at any time. HPO, HPO_2, & HPO_3 are not products of PH_3 reactions.

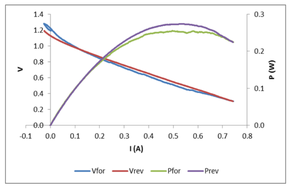


Mass 18 (H_2O) & mass 34 (PH_3) in dry H_2 after adding PH_3 and then applying cell voltages.

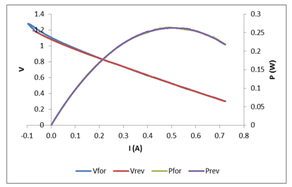


Mass spectra in dry H_2 with no PH_3, 20 ppm PH_3 at 0 A and 0.6 A current. All signals are due to H_2, H_2O, N_2, O_2, and Ar.

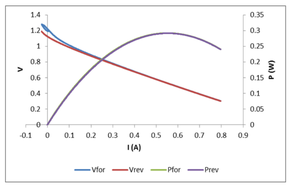
- The SOFC did not show significant power loss after 18 days operation in wet and dry H_2 with and without 20 ppm PH_3.



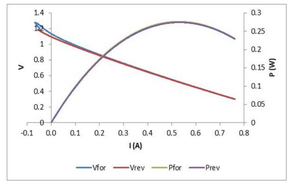
Dry H_2, 0.27 W



Wet H_2, 0.26 W



Dry H_2 + PH_3, 0.29 W



Wet H_2 + PH_3, 0.28 W

- **Future work**:
- Test syngas mixtures: H_2, H_2O, CO, CO_2, with and without PH_3.
- What happens to the PH_3?
- Look for evidence of deposits containing phosphorus inside the alumina tubes.

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