Gas diffusion electrodes for PBI-based PEM fuel cells

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Acid doped polybenzimidazole (PBI) membranes have been suggested as electrolyte for proton exchange membrane fuel cells (PEMFC).[1,2,3] Methods for preparing gas diffusion electrodes and membrane-electrode assemblies (MEAs) with PBI membranes have been developed by several groups.[4,5] In this work electrodes were constructed with PBI as the catalyst binder by tapecasting **(Figure 1)**. The PBI-containing electrodes were doped with phosphoric acid to order to improve the proton conductivity and hot-pressed onto acid doped PBI membranes for fuel cell tests.

The performance of PBI membrane-based fuel cells was investigated with electrodes of varied porosities at temperatures up to 200°C. **Figure 3** shows a set of polarization curves obtained from electrodes with overall porosities of 43 and 62%, respectively, operating on both oxygen and air at the cathode. Significant improvement for electrodes of high overall porosity was observed with air in the high current density range, where mass transportation is limiting the fuel cell performance.

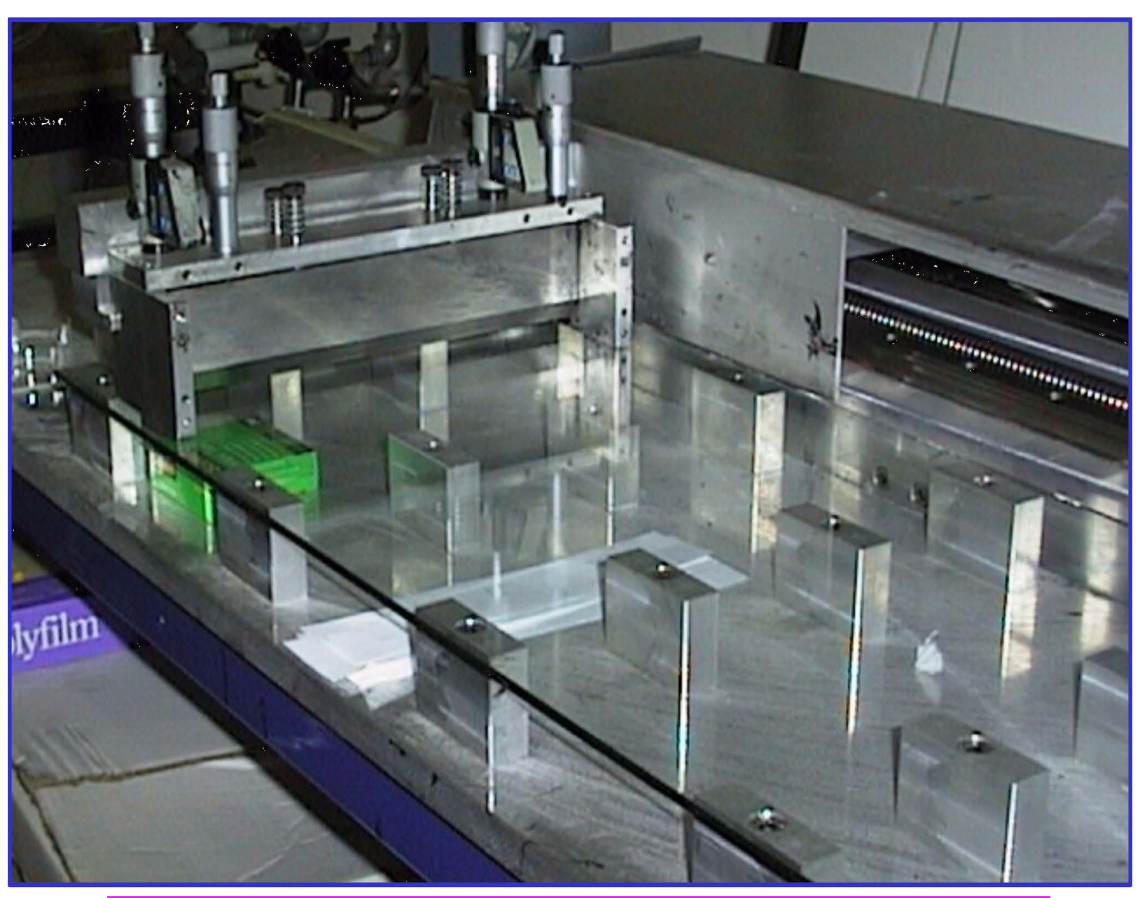

Figure 1. Tape-casting machine for preparing gas diffusion electrodes.

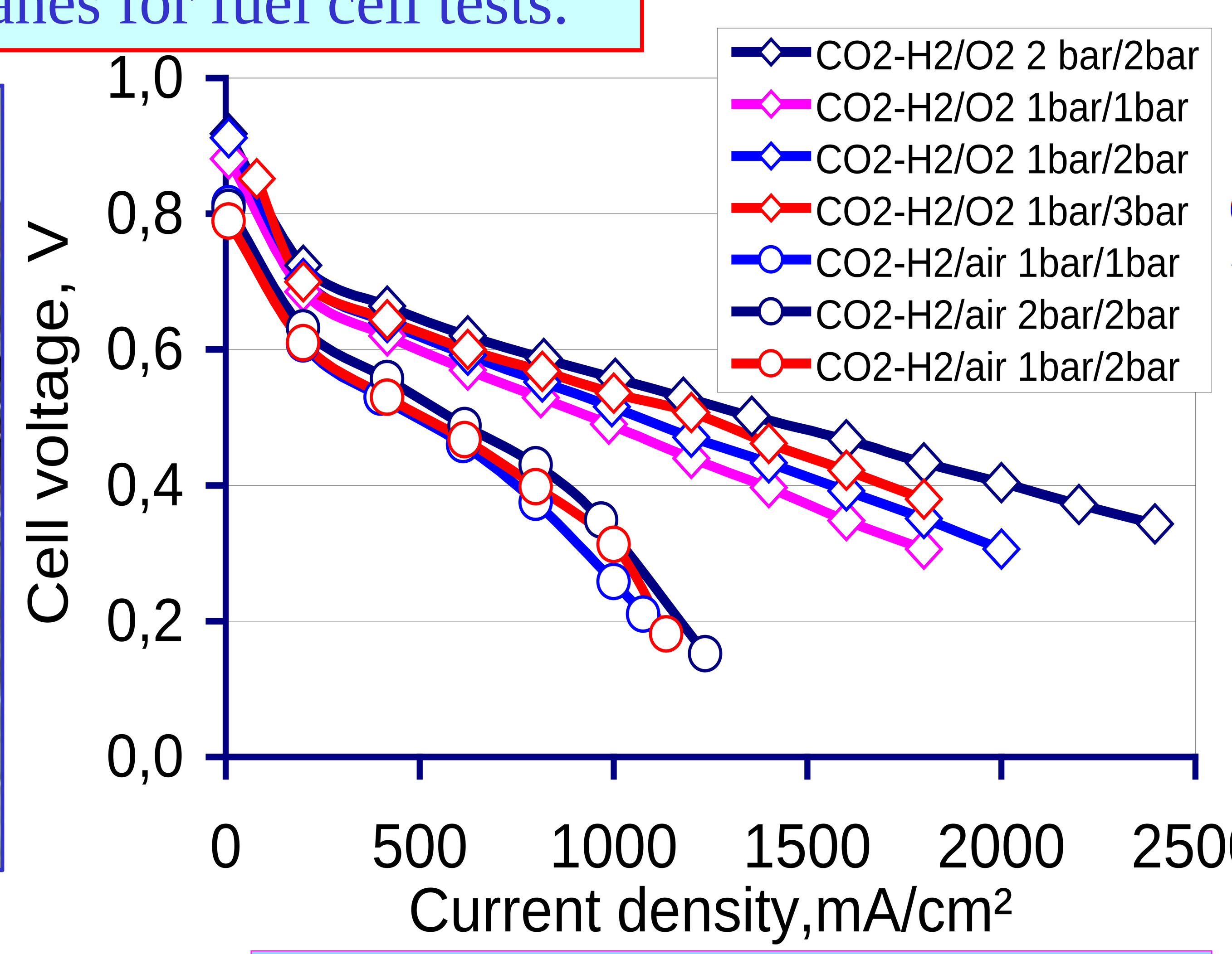

Figure 4. Polarization curves of a PBI cell under different pressures at 200°C. Electrode: 0.6 mgPt/cm²; 25 cm²; Overall porosity: 62%; Fuel flow: 10 L/h; O_2 flow: 4 L/h; Air flow: 8 L/h.

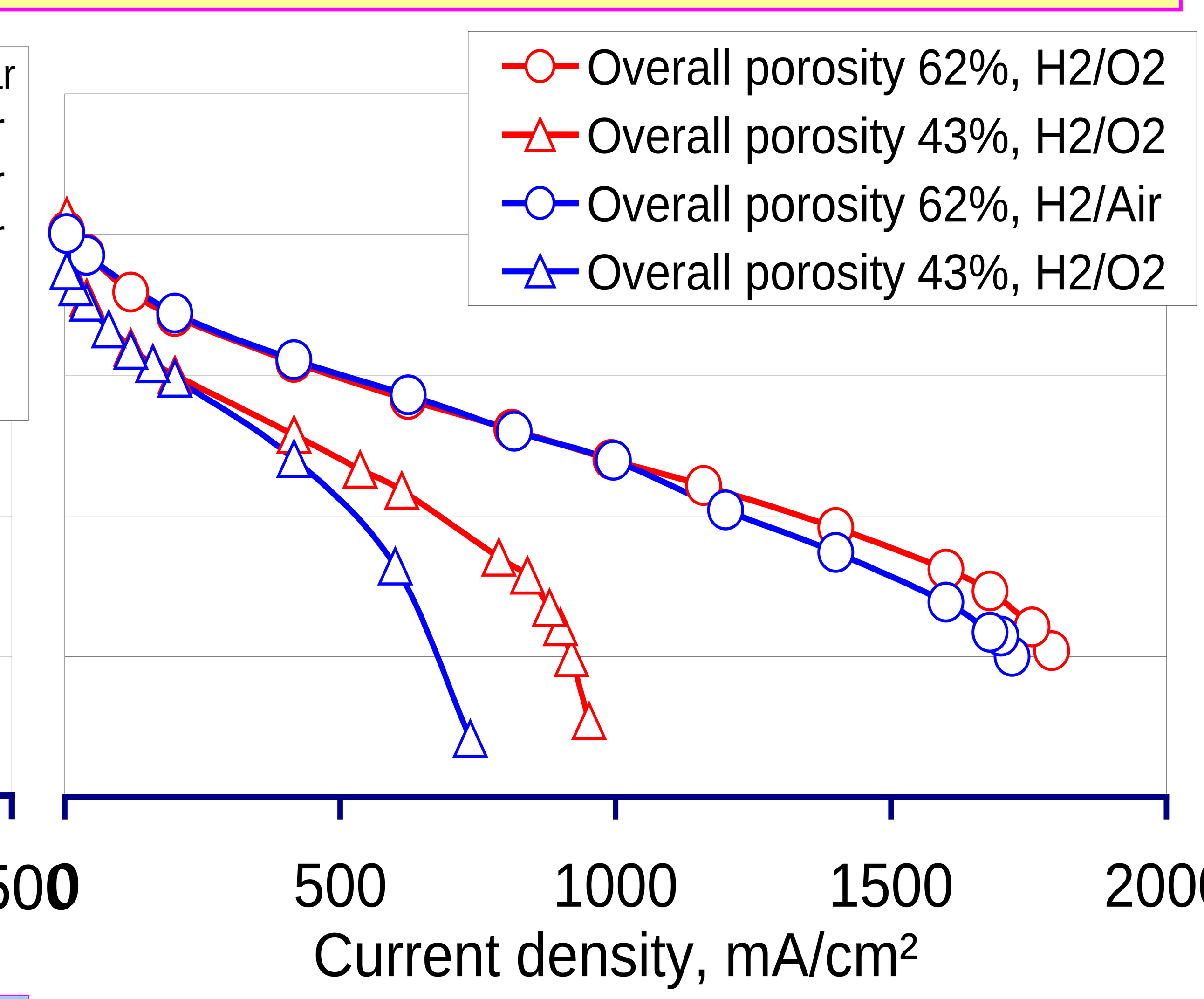

Figure 3. Polarization curves of a PBI fuel cell under ambient pressure at 200°C. Electrode: 0.6 mgPt/cm², 25 cm². H_2 and O_2 flow: 24 L/h[1]; Air flow: 48 L/h[1].

Several chemicals were used as additives into the catalyst slurry for improving the porosity of electrodes. The results are shown in **Figure 2**. Ammonium oxalate seems to be an effective one, giving an improved overall porosity from 43% to above 64%. ZnO is also effective, however, it should be removed afterwards by washing electrodes with dilute sulfuric acid.

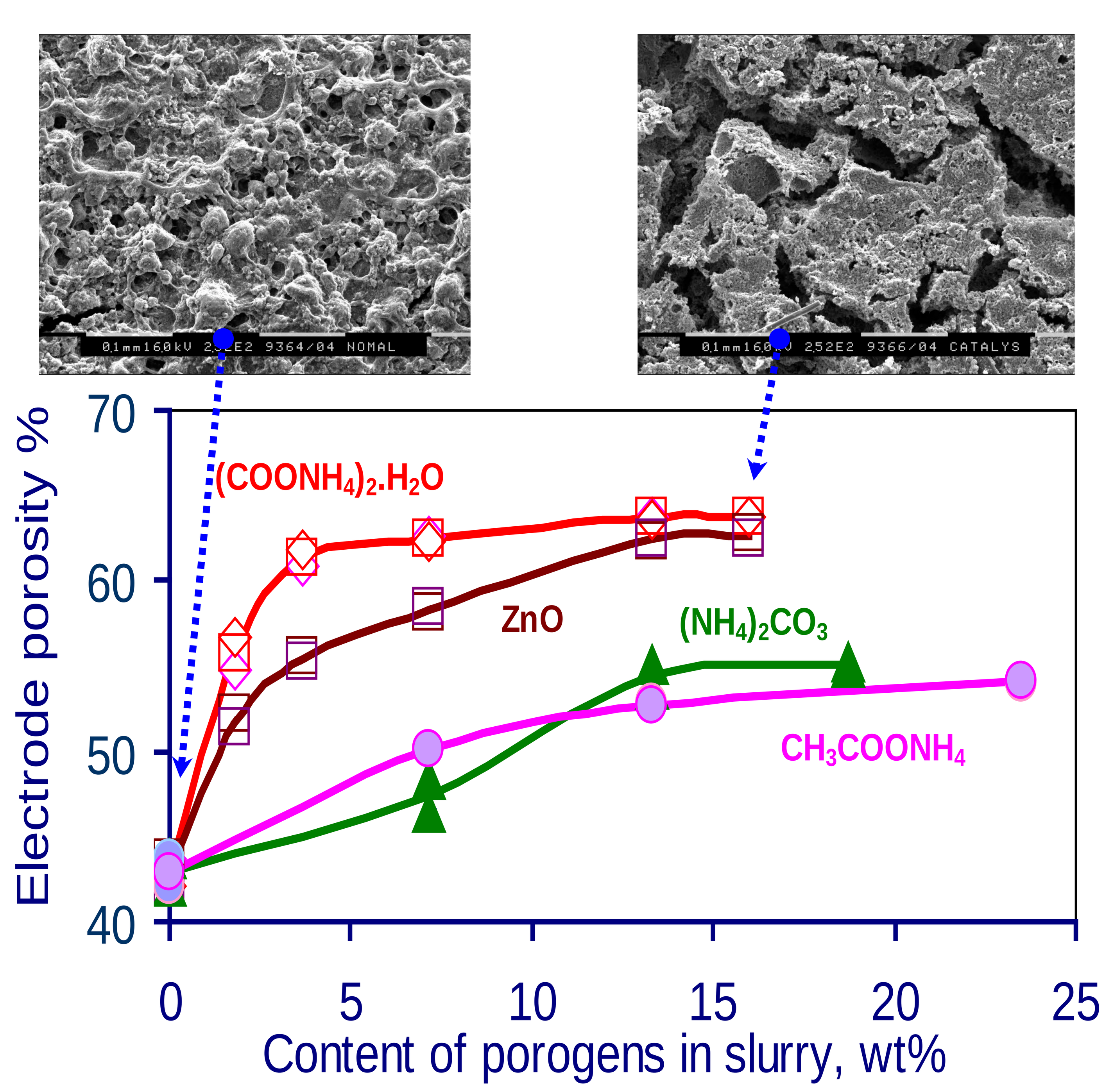

Figure 2. Overall porosity of electrodes prepared with different porogens.

With H_2 and H_2 containing 25% CO_2 as fuel, **Figure 4** shows a set of polarization curves under pressures from ambient to 4 bars on both anode and cathode sides. With electrodes of 62% porosity, no limiting current was observed at 2.5 A/cm² when O_2 is used. The hydrogen utilization was found to be above 93% from a mixture of 75%H_2-25%CO_2.

Table 1 summarizes the results with respect to operating pressures and electrode porosities, in term of current density at a cell voltage of 0.5V, indicating the enhanced pressure effect at higher electrode porosities.

Table 1. FC performance with different electrodes under different pressures.

Fuel / Oxidant	Pressure (atm)	Current density (mA/cm^2) at cell voltage of 0.5 V	
		Electrode porosity: 38%	Electrode porosity: 59%
H_2 / O_2	1 / 1	750	950
	1 / 2	950	1050
	1 / 3	1100	-
	2 / 2	1200	1230
H_2 / Air	1 / 1	250	370
	1 / 2	350	490
	1 / 3	480	-
	2 / 2	480	500
	3 / 3	620	-
75H_2 -25CO_2 / O_2	1 / 1	700	850
	1 / 2	-	1120
	1 / 3	-	1200
	2 / 2	1030	1350
	3 / 3	1280	-
	4 / 4	1450	-
75H_2 -25CO_2 / Air	1 / 1	280	490
	1 / 2	480	520
	1 / 3	500	-
	2 / 2	420	650
	3 / 3	550	-
	4 / 4	650	-

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References

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