

Effects of Chloride Contamination on PEFCs

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Polymer electrolyte membrane fuel cells (PEFCs) are susceptible to contaminants present in the air and fuel stream. Chloride (Cl^-) is a contaminant which is commonly present in air near marine environments and also present as a de-icer on roads during winter [1]. In addition, Pt-based catalysts are often synthesized from chloride-containing precursors and trace amount of chloride may remain after synthesis [2]. Moreover, to reduce hydrogen production and transportation costs, the direct use of waste or byproduct hydrogen from chemical plants (e.g., in the chlor-alkali industry) can also introduce chloride in fuel stream [3].

Performance and durability of PEFCs under Cl^- contamination is investigated by introducing HCl and five metal (Al, Fe, Cr, Mg, and Ni) chloride salt solutions in the air stream under constant operating conditions. The role of relative humidity is also studied with the effect of AlCl_3 .

Figure 1 shows the effect of HCl and five different chloride salt solutions. During baseline test, cell performance is stable for all the tests and in last five hours, voltage degradation rate is $0.4118\mu\text{V}/\text{hour}$. Projected performance for DI water is plotted with this degradation rate. With the start of contaminants injection, voltage degradation rate increases. Significant performance decay is observed for HCl within 48 hours of contamination. Although chloride (Cl^-) concentration (28.5 mM) is constant for all the tests, performances are better for chloride salts compared to HCl. Cell performance degradation can be ranked as $\text{HCl} > \text{AlCl}_3 > \text{FeCl}_3 > \text{CrCl}_3 > \text{NiCl}_2, \text{MgCl}_2$.

Figure 2 shows the effect of AlCl_3 with 50% RH in cathode side. When cell is exposed to AlCl_3 , sudden voltage drop occurs and then cell voltage oscillates. At some point, the fuel cell can no longer sustain the desired load. Compared to cell 2 operated at higher cathode relative humidity (AlCl_3 , refer to Table 1), there are two possible explanations behind this severe effect. Firstly, with lower RH in contaminant injection side, water content decreases and contaminant concentration is increased in the liquid water phase, which can result increase in the mass transport rate of the contaminants to the active surfaces [4]. Secondly, at lower relative humidity, any liquid water present evaporates, resulting in precipitation of the salt in the pores of the gas diffusion media and the gas channels, and eventually block the flow channels.

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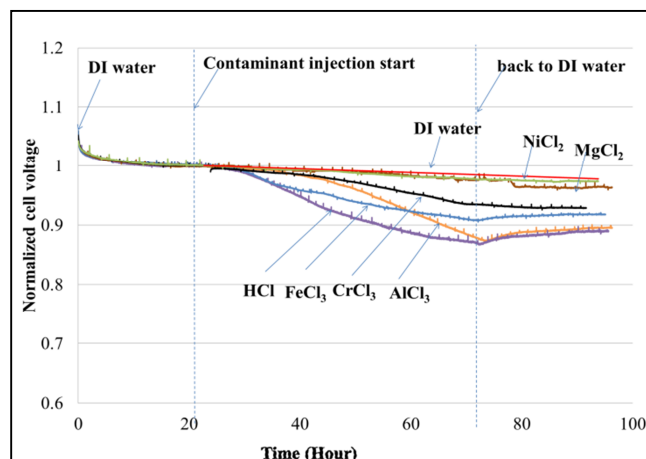


Figure 1. Cell voltage vs. time measured at $1 \text{ A}/\text{cm}^2$ when cells are exposed to HCl (cell 1), AlCl_3 (cell 2), FeCl_3 (cell 3), CrCl_3 (cell 4), MgCl_2 (cell 5), and NiCl_2 (cell 6). Other operating conditions are listed in Table 1.

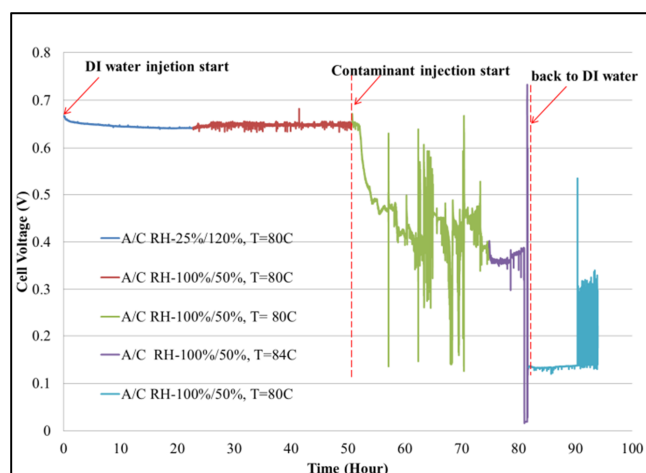


Figure 2. Cell voltage vs. time measured at $1 \text{ A}/\text{cm}^2$ when cell is exposed to AlCl_3 (cell 7). Other operating conditions are listed in Table 1.

Table 1 Operating conditions for the tests

Cell No.	Contaminants	Conc. (mM)	Operating conditions
1	HCl	28.5	RH A/C: 25%/120%
2	AlCl_3	9.5	Stoic flow A/C: 10/4
3	FeCl_3	9.5	Back pressure A/C: 1.5/15 psig
4	CrCl_3	9.5	Flow rate H_2/Air :
5	MgCl_2	14.25	1742.5/1559.5 mL/min
6	NiCl_2	14.25	
7	AlCl_3	9.5	RH A/C: 100%/50%
8	AlCl_3	9.5	Stoic flow A/C: 2/2 Back pressure A/C: 7/7 psig Flow rate H_2/Air : 349/730 mL/min

References

- [1] S.T. Ali, Q. Li, C. Pan, J.O. Jensen, L.P. Nielsen, P. Møller, *Int. J. Hydrogen Energy*, 36 (2011) 1628-1636.
- [2] H. Li, H. Wang, W. Qian, S. Zhang, S. Wessel, T.T.H. Cheng, J. Shen, S. Wu, *J. Power Sources*, 196 (2011) 6249-6255.
- [3] T. J. Schmidt, U. A. Paulus, H. A. Gasteiger, R.J. Behm, *J. Electroanal Chem.* 508 (2001) 41-47.
- [4] H. Li, S. Zhang, W. Qian, Y. Yu, X.Z. Yuan, H. Wang, M. Jiang, S. Wessel, T.T.H. Cheng, *J. Power Sources*, 218 (2012) 375-382.