Evaluation of anion exchange membrane water electrolysis for green hydrogen supply

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GEWEX The Global Energy and Water Exchanges Program

Background

- In our previous study, the production of green hydrogen has been reviewed to show economic weakness due to the low utilization of renewable energy generation plants in Korea and the high unit cost for production.
- Owing to the current status of the renewable energy market and policy of South Korea, the possibility of technological development within a short term is low, indicating the need to depend on extracted and imported hydrogen.

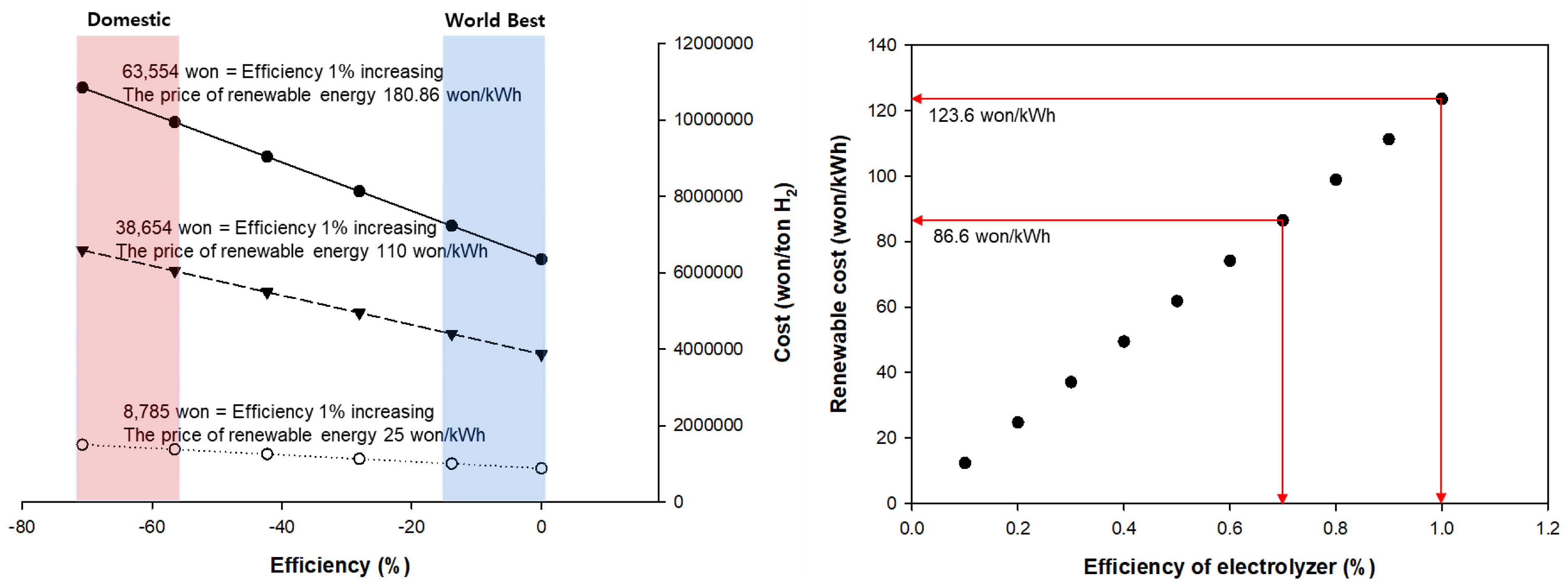

Figure 1. The effect of electrolysis efficiency and renewable energy cost to produce green hydrogen in Korea (based on 5500 won/kg H_2)

- Therefore, the development of technologies in various fields for the domestic production of green hydrogen is required at the same time as overseas cooperation in hydrogen production and import.
- This study was to compare/evaluate the stability and applicability of anion exchange membrane (AEM) water electrolysis to the existing commercialized anion exchange membranes under strong base conditions.

Materials and Methods

- Seven types of AEMs were selected through previous studies, and stability evaluation under strong base conditions was conducted in 1M KOH (60°C for 20d).
- AEMs : Astom (Japan) – ASE & AHA, Selemion (Japan) - AHO, Fujifilm (Japan) - AEM T10, Humatech (German) - FAA 75 & FAA 130, Ionac (USA) - MA 3475

Table 1. Characterization of commercial anion exchange membranes (AEMs)

No.	Corp.	AEM	Thickness (μm)	IEC (meq/g)	Conductivity (mS/cm)	ER (Ω/cm²)	Stability (%)	Strength (MPa)
1	Fumatech	FAA-3-30	25-35	1.7-2.1 (Cl)	4-7 (Cl) 40 (OH)	0.3-0.5	0-2 (Br)	25-40a
2		FAA-3-50	47-53	1.85	as above	<2.5(Cl)	as above	as above
3		FAA-3-PK-75	75	1.39 (Cl)	>2.5 (Cl)	<2.0 (Cl)	0 (Br)	20-45a
4	Tokuyama	A201	28	1.8	42 (OH)	-	2 (MD) 6 (TD)	96 (dry, Cl)
5	Ionomr	AF1-HNN8-50-X	50	2.1-2.5	>80	0.13	-	60 (dry, I)
6		AF1-HNN8-25-X	25	2.1-2.5	>80	0.063	-	60 (dry, I)
7		AF1-HNN5-50-X	60	1.4-1.7	15-25	0.42-0.67	-	60 (dry, I)
8		AF1-HNN5-25-X	25	1.4-1.7	15-25	0.21-0.33	-	60 (dry, I)
9	Dioxide Materials	Sustainion 37-50	50	-	80 (1M KOH, 30 °C)	0.045 (1 M KOH)	cracks when dry	cracks when dry
10	Orion Polymer	Pure materia m-TPN1	24	2.19 (OH)	19 (Cl) 54 (OH) >60	-	6 (Cl) 10 (OH)	30

Results and Conclusion

- AEMs analyzed thickness, conductivity, electrical resistance (ER), ion exchange capacity (IEC), water absorption (WU), swelling ratio (SR), and surface image under alkaline conditions.
- The AEMs with the least change rate for up to 20 days (480 hours) was the ASE membrane from Astom, followed by AHA from Astom and AHO from Selemion.
- In particular, Fujifilm AEM 10 and Fumatech FAA 75/130 showed significant changes in values of IEC , WU, and SR, resulting in poor stability under strong base conditions.

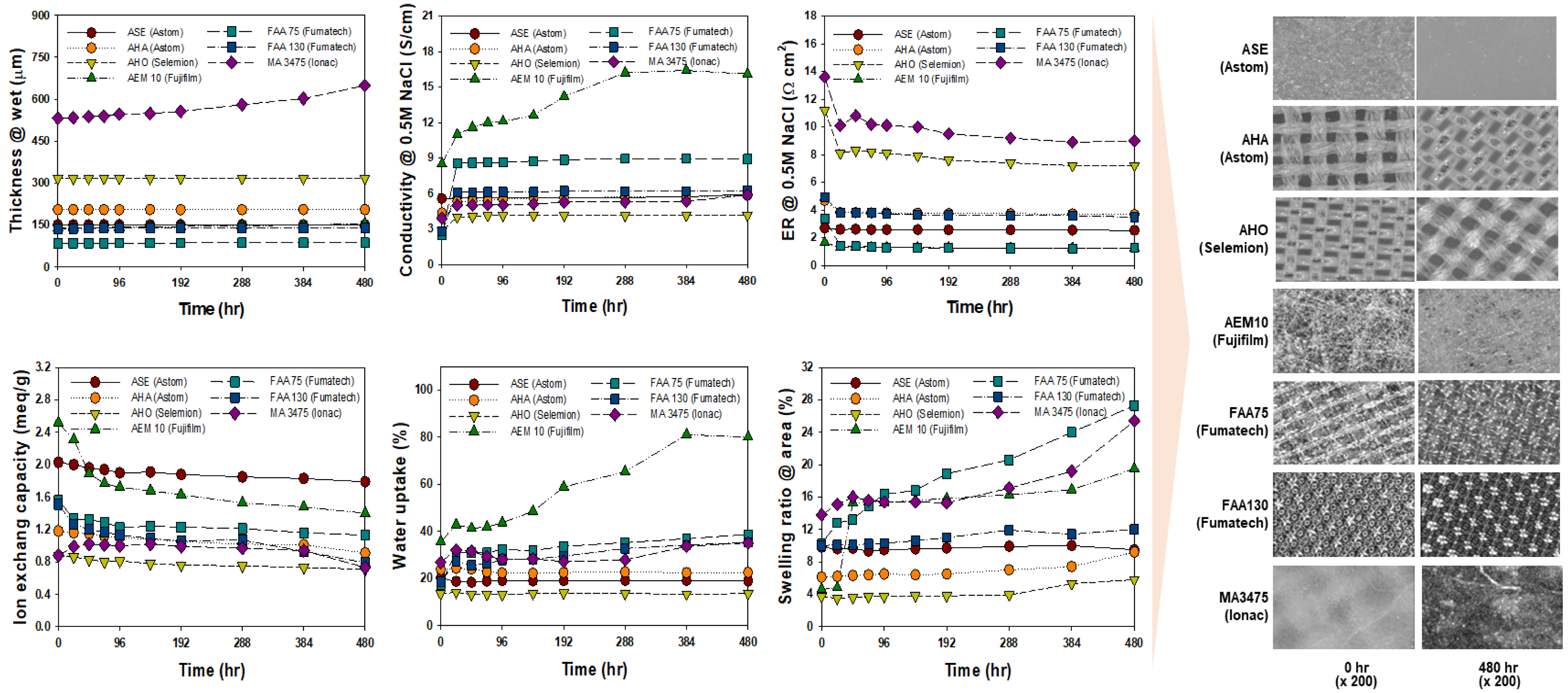

Figure 2. Characterization of commercially available AEM under alkaline conditions

- This phenomenon was also evident in surface images using optical microscopy, showing the largest membrane damage in MA 3475, based on a heterogeneous AEM.
- Consequently, among the commercially available AEMs, Astom's ASE/AHA membranes and Selemion's AHO membrane showed high applicability (within 15% of IEC) under strong basic conditions in AEM water electrolysis.
- In order to apply porous nanomaterials (graphene oxide, etc.) to an AEM in the future, it is necessary to refer to these ion exchange membranes that have ensured stability and efficiency in AEM water electrolysis.

References and Acknowledgments

- Kyoung Hoon Chu et al., International Journal of Hydrogen Energy 47 1409-1424, ACS Applied materials & Interfaces 8 22270-22279, ACS Applied materials & Interfaces 9 40369-40377, Chemical Engineering Journal 326 240-248; 327 629-647.
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