Supporting Information

Direct electrooxidation of ammonia-enriched wastewater using a bipolar membrane-integrated electrolytic cell

Jeong-Hee Kang [1], Gyung-Geun Oh [1], Bong-Jae Lee [1], Seongwon Im [1,2], Weonjae Kim [1], Sungwon Kang [1,*] and Ji-Hyung Han [3,*]

[1] Department of Environmental Research, Korea Institute of Civil Engineering and Building Technology, 283 Goyang-daero, Ilsanseo-gu, Goyang-si 10223, Republic of Korea; ohgg0404@kict.re.kr (G.-G.O.); bjdream@kict.re.kr (B.-J.L.); swim9828@scnu.ac.kr (S.I.); wjkim1@kict.re.kr (W.K.)

[2] Department of Environmental Engineering, Sunchon National University, 255 Junang-ro, Suncheon 57922, Republic of Korea

[3] Jeju Global Research Center, Korea Institute of Energy Research, 200 Haemajihaean-ro, Gujwa-eup, Jeju 63357, Republic of Korea

* Correspondence: kangsw93@kict.re.kr (S.K.); jihyung0760@kier.re.kr (J.-H.H.); Tel.: +82-31-910-0773 (S.K.); +82-64-800-2249 (J.-H.H.)

Text S1. A method to adjust NH_3-N concentration in SW.

In the previous study, ammonium (NH_4^+) was adsorbed at the monolayer on AmER (Kang et al., 2023). Desorption was achieved by ion exchange with mono-valent cation, such as K^+, Na^+. During the desorption, mono-valent cation occupied the NH_4^+ adsorption site. Therefore, the amount of disappeared mono-valent cation was almost identical with that of NH_4^+ released into desorbing solution. The desorbing agent was 1 M KNO_3 with deionized water. Accordingly, SW was prepared using NH_4NO_3, KNO_3, and deionized water as follows:

0.1 M NH_3-N: 0.1 M NH_4NO_3 + 0.9 M KNO_3

0.3 M NH_3-N: 0.3 M NH_4NO_3 + 0.7 M KNO_3

0.5 M NH_3-N: 0.5 M NH_4NO_3 + 0.5 M KNO_3

Text S2. A procedure for particle separation.

Real reject water (RW) was collected from dewatering filtrate of anaerobic digestion sludge process in local municipal wastewater treatment plant (Goyang-si Korea). RW was refrigerated as soon as bring to laboratory. After settling during 24h in refrigerator, the supernatant was drained. Polychlorinated aluminum (PAC, purity = 17%) was used after 10-fold dilution with

deionized water. The diluted PAC was added into the supernatant of 10L. The mixture was stirred using mechanical stirrer for 2 minutes with 200 rpm. Subsequently, it was stirred with 40 rpm until floc was formed. After floc formation, the upper water was taken and filtered with GF/C filter. The filtered water was used to prepare NH_3-N enriched wastewater described in **Text S3**.

Text S3. A column test method for NH_3-N enriched wastewater preparation.

A PVC pipe (Poly Vinyl Chloride) column was utilized as adsorption column. The column has a dimension of ??mm diameter and mm length. The column was filled with 4.8 g of AmER. The RW derived from **Text S2** was introduced into the column at a flow rate of 0.5 mL min^{-1}. The NH_3-N concentration in influent was approximately 480 mg-N L^{-1}. When the effluent of column approached to 480 mg-N L^{-1} adsorption was stopped. Desorption of NH_3-N was conducted by 1M KNO_3 injection at flow rate of 0.25 mL min^{-1}. Injection of KNO was ceased as soon as the total concentration of NH_3-N in cumulative effluent reached 1400 mg-N L^{-1}.

Table S1. The chemical properties of sludge dewatering filtrate before and after particle separation.

Contents	Dimension	Value	
		Before	After
pH	-	6.3	5.9
Fluoride	mg L^{-1}	1.02	1.16
Chloride	mg L^{-1}	331.66	304.98
Nitrite	mg L^{-1}	L.D	L.D
Nitrate	mg L^{-1}	3.85	4.29
Phosphate	mg L^{-1}	183.47	140.90
Sulfate	mg L^{-1}	16.77	19.72
Sodium	mg L^{-1}	174.71	174.04
Potassium	mg L^{-1}	90.88	107.80
Magnesium	mg L^{-1}	9.50	16.77
Calcium	mg L^{-1}	24.11	17.45
Ammonium	mg L^{-1}	486.06	482.67

*L.D: less than detection limit

Table S2. The Pseudo-first order kinetic constant of initial 120 minutes and end of experiment.

Time	Pseudo-first order kinetic constant (10^{-3} min^{-1})		
	pH_0 11.5	pH_0 13	$pH_0$13 + KOH add
For initial 120 min	3.07	3.33	3.06
Overall	1.82	3.46	5.23

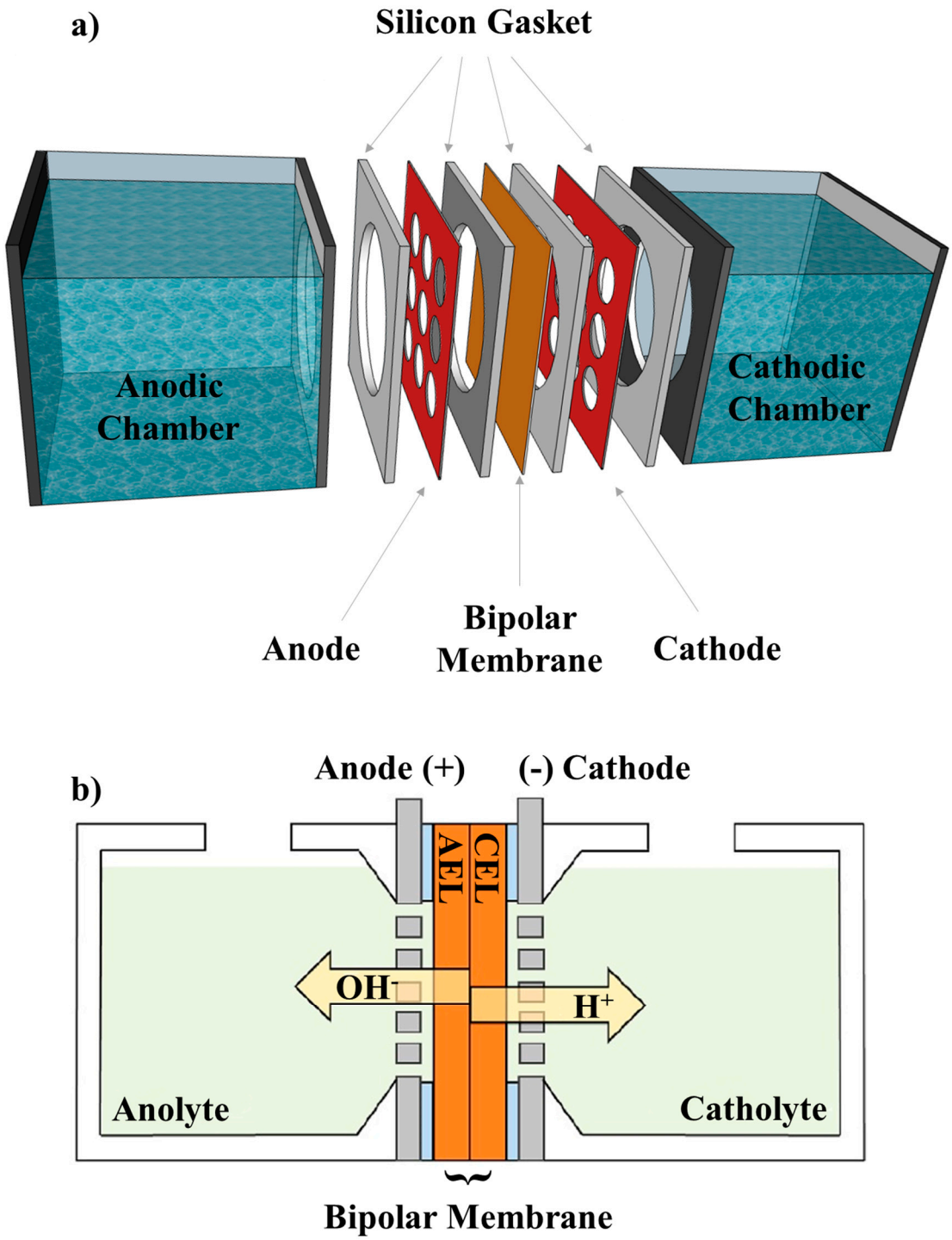


Fig. S1. a) A configuration of BPM-integrated electrolytic cell and b) schematic representation of a bipolar membrane under a reverse bias mode. The description (b) is reproduced from Han et al., (2022), Copyright by Elsevier.

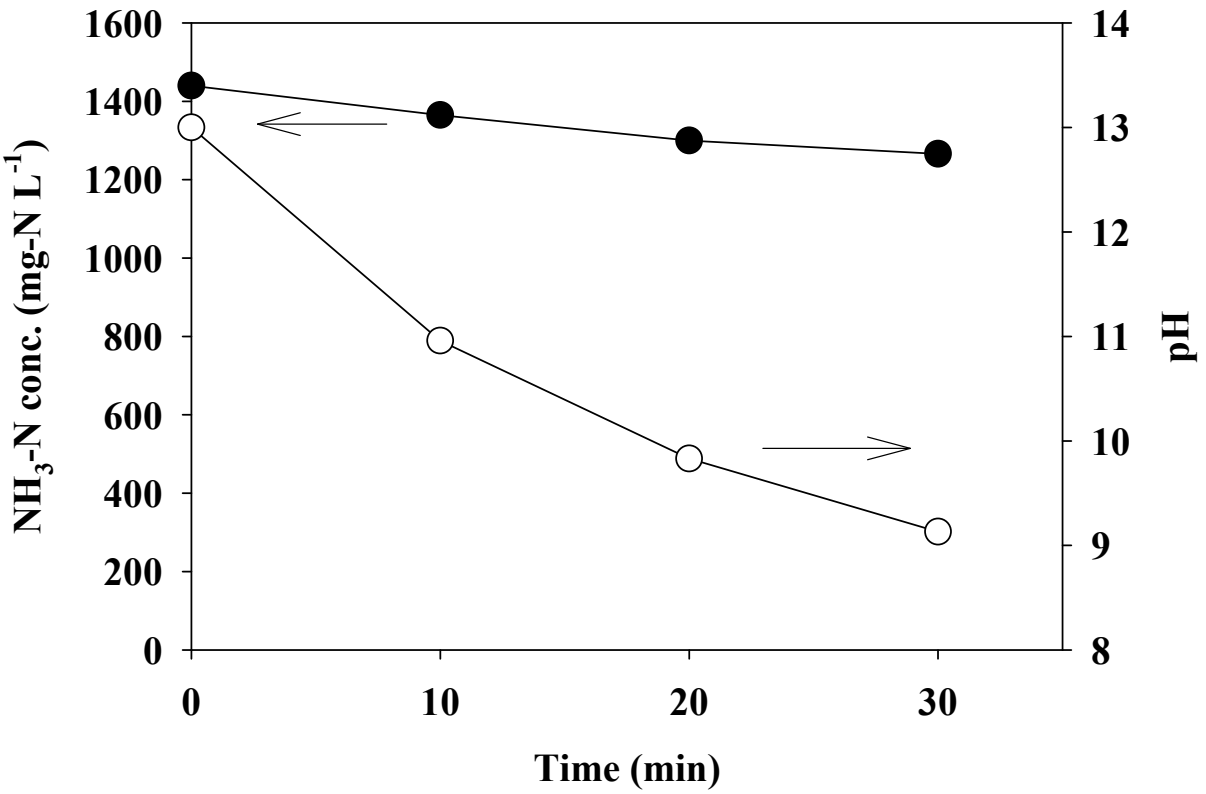


Fig. S2. The changes of NH_3-N concentration and pH using anion exchange membrane (fumasep® FAS-50, FUMATECH, Germany).

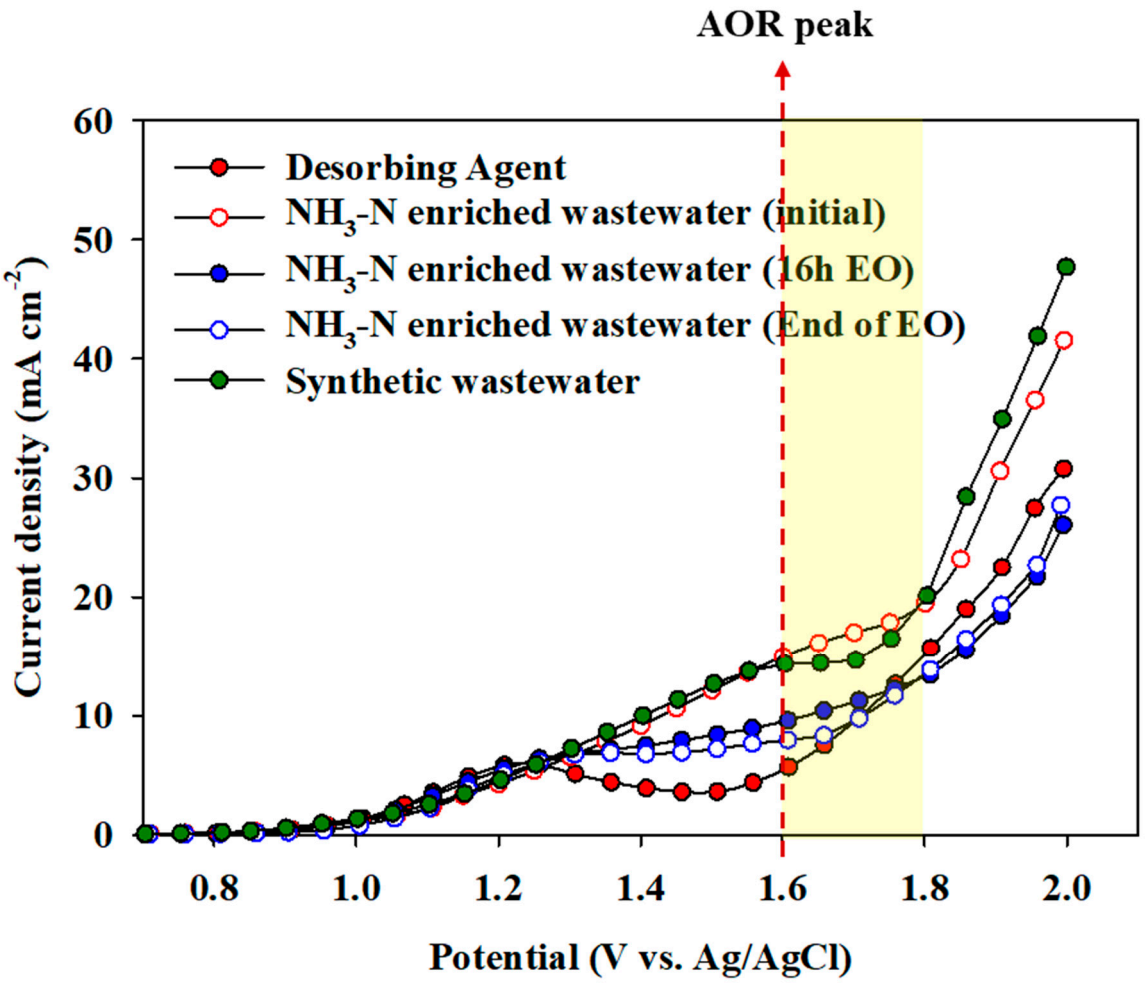


Fig. S3. LSV curves with respect to the electrolysis time under the above pH 12 condition. Scan rate is 50 mV s^{-1}.

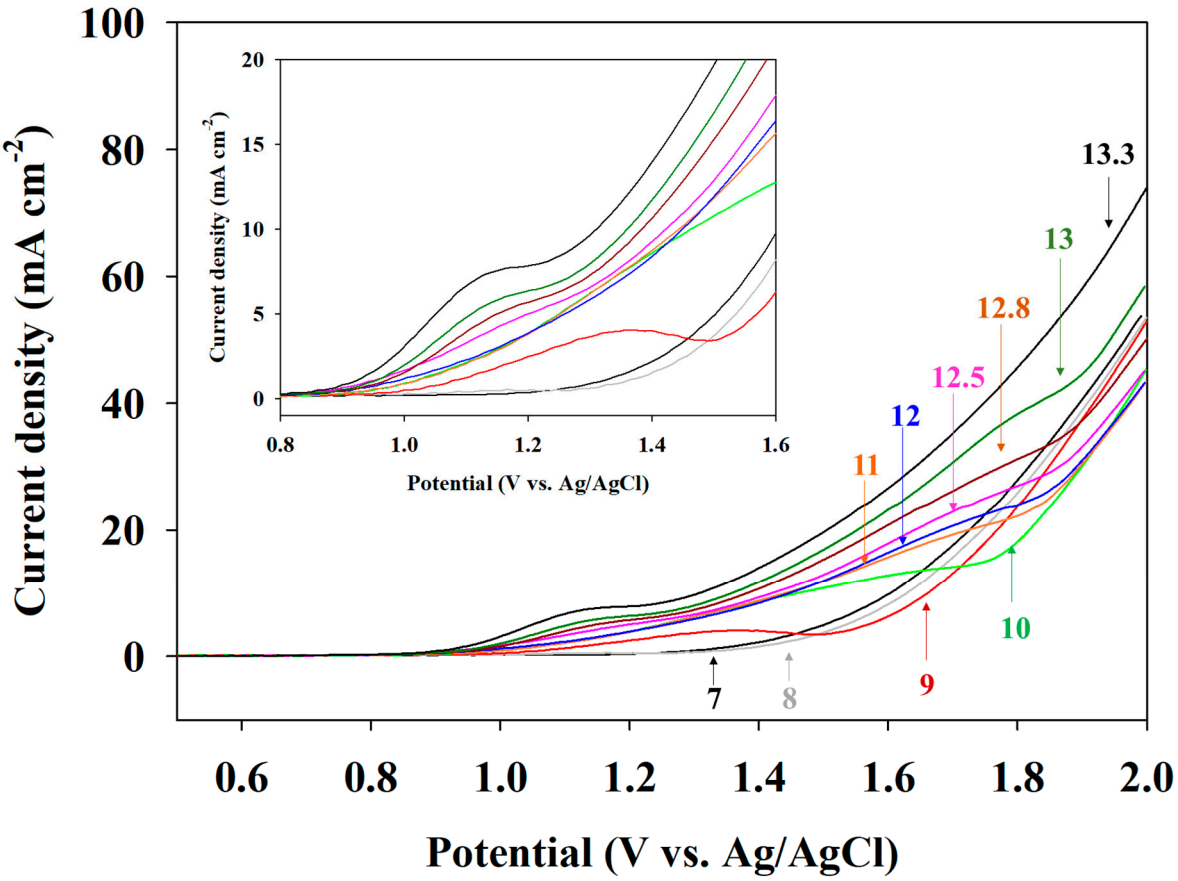


Fig. S4. LSV curves of Pt coated Ti electrode in NH_3-N-enriched wastewater. Scan rate is 50 mV s^{-1}. The offset shows the onset potential in detail.

References

Han, J. H., Jwa, E., Lee, H., Kim, E. J., Nam, J. Y., Hwang, K. S., ... & Chung, T. D. (2022). Direct seawater electrolysis via synergistic acidification by inorganic precipitation and proton flux from bipolar membrane. *Chemical Engineering Journal*, *429*, 132383. https://doi.org/10.1016/j.cej.2021.132383

Kang, S., Lee, B., Ahn, K. H., Im, S., Kim, B., Kim, T. H., ... & Chae, S. (2023). Facile synthesis of copper-substituted Prussian blue analog immobilized ion exchange resins for high-performance ammonium recovery from wastewater: Adsorption kinetics, isotherms, and regeneration. *Chemical Engineering Journal*, 457, 141128. https://doi.org/10.1016/j.cej.2022.141128