Flow-through Intensified ElectroDialysis (FIELD) System to Manage Inland Brine

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This project will develop a prototype FIELD system to simultaneously eliminate ppb-level heavy metals and ppt-level PFAS for resource-efficient inland RO brine management.

Background

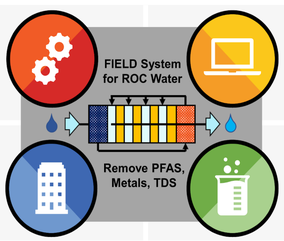
- Inland RO brine contains metals and PFAS.
- These regulated pollutants need selective removal for cost-effective management.

Constituents	Unit	EPRI ROC	Wastewater ROC	Brackish Water ROC
pH		7.7	6.0-8.0	7.0-8.0
TDS	ppm	52,300	1,000-6,000	8,000-12,000
PFOA	ppt	N.M.	60-180	10-2300
PFOS	ppt	N.M.	40-80	4-59
Nickel	ppb	163	18-72	20-40
Copper	ppb	N.M.	7-38	600-800
Lead	ppb	N.M.	2-133	6-60
Manganese	ppb	414	11-92	50-2100

Research Objective and Activities

Act. 1 Engineered Design
Shiqiang Zou (Auburn, lead)
Design & optimize flow-through electrodes and prototype FIELD systems for actual ROC treatment

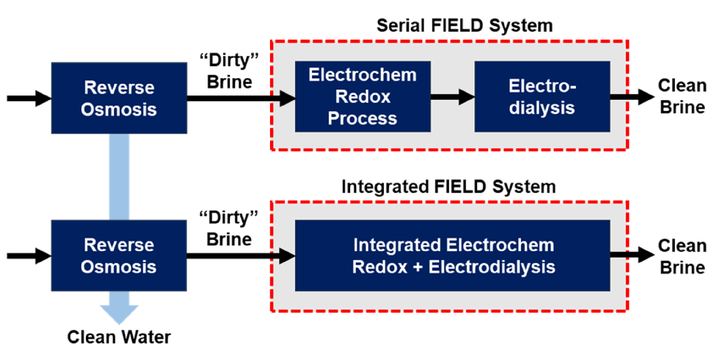
Act. 2 Material Informatics
Anubhav Jain (LBNL)
Screen reactive materials and model PFAS electrooxidation and heavy metal plating processes



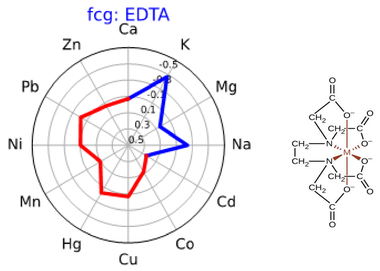
Act. 4 Technology Impact
Jason Monnell (EPRI)
Chris Impellitteri (Water Tower)
Assess technological impact of FIELD and identify its deployment potential in inland desalination

Act. 3 Interfacial Electrochem
Haotian Wang (Rice Univ)
Functionalize electrodes to selectively remove PFAS and metal, characterize competing ion behavior

FIELD System for Brine Purification

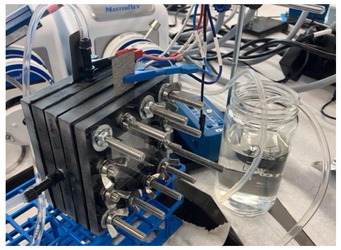


DFT Gibbs energy screening of EDTA chelate formation

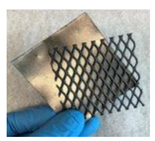


EDTA + M ⟶ [EDTA-M]

Reactor setup and configuration

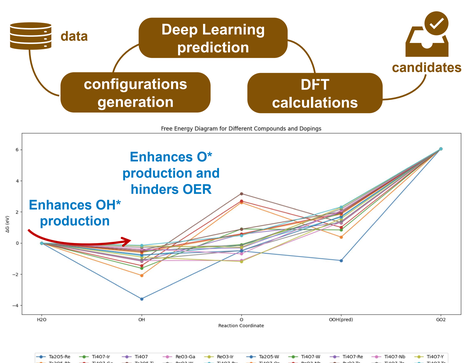


Working electrode: Reticulated Vitreous Carbon (60 ppi)

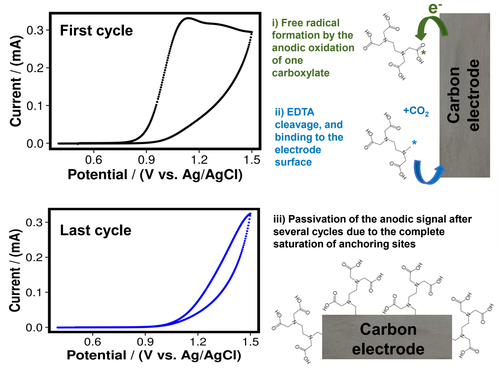


Counter Electrode: DSA or graphite

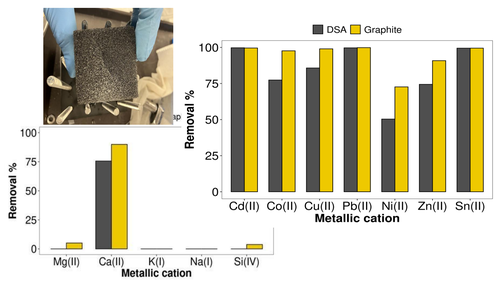
DFT catalyst modification screening for free radical production



EDTA electrografting mechanisms



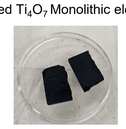
Performance in flow-through conditions



	DSA	Graphite
Removal performance (%)	93.6	97.9
Energy consumption in 24 h (kW*h*m^{-3})	0.19	0.22
Initial and final pH	8.8 / 8.5	8.5 / 8.2
Initial and final conductivity (mS cm^{-1})	13.09 / 12.95	13.26 / 13.18

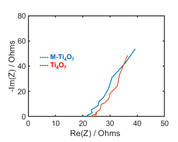
PFAS degradation with modified electrodes (Preliminary)

Sintered Ti_4O_7 Monolithic electrode

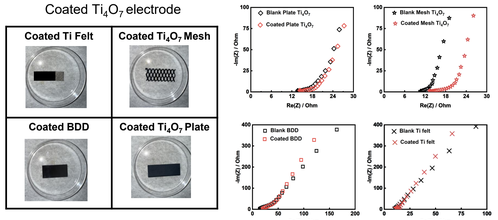


Doping with

Transition metals



Coated Ti_4O_7 electrode



NAWI CONNECTIONS

Period of Performance:
12/2023 – 03/2025

Topic Area:
Materials and Manufacturing

NAWI Leverage
The project team brings together five PIs from five research institutions with their unique expertise to contribute to this 2-year research plan. Harnessing the tools developed via NAWI, the experimental and computational results will also be shared via WaterDAMS and WaterTAP for future usage and reference.

KEY FINDINGS AND CONCLUSIONS

Key Findings:

- EDTA electrografting on glassy carbon was attained in aqueous solution and corroborated by electrochemical and spectroscopic evidence.
- The reactor with the electrografted cathode can selectively remove heavy metals. Its lower surface area needed a minimal energy input and had a limited impact on the pH and conductivity of the treated ROC.
- DFT screening showed that different common and commercial substrates are feasible for their doping to decrease the free energy of their OH* generation.

Conclusion

We successfully treated reverse osmosis brines emulating those from the Kay Bailey Hutchison Desalination Plant (El Paso, Texas) spiked simultaneously with six heavy metals in ppb-levels, obtaining >90% removal when operated in a single-pass, flow-through mode and with an energy consumption of only 0.22 kWh m^{-3}.

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