Magnetically Aided alkaline Seawater Electrolysis with Revolutionary products -MASER-

REENDECO PC, Athens March 2024

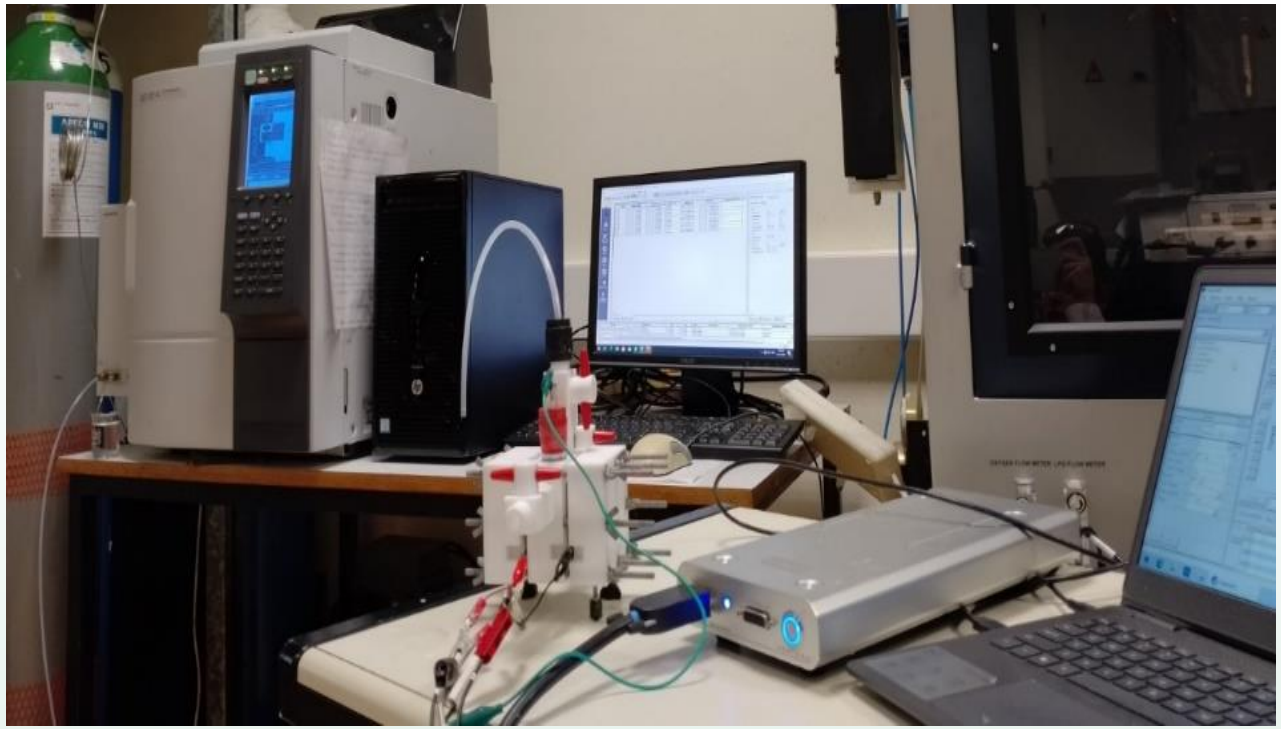
The main novel and inventive steps
1. The cell

- Use of electrodes having inside them **properly oriented permanent magnets to enhance the Lorentz force** effect to accelerate cations upwards (to enhance hydrogen productivity) and further push anions downwards to enhance the quality of the electrolysis by product
- After several experiments, the alloy INCONEL 625 was found to be suitable for electrolysis, suffering an absolute minimum corrosion and erosion, as well as **enhancing the catalytic behaviour** during direct seawater electrolysis
- The process does not use membranes, **allowing for ambient pressure operation** of our direct seawater electrolysis.

The main novel and inventive steps
2. The method

The method of hydrogen production is realized in two steps: at first, the first electrolytic cell produces hydrogen and NaOH, **allowing self-production for of NaOH in the desired concentration**. The second electrolytic cell uses the by-product of the first electrolytic cell, **producing hydrogen with less energy consumption**, namely 44-47 kWh/kgH_2 instead of 53-56 kWh/kgH_2. Then, the by-product of the second cell is enhanced by the produced Cl_2 **resulting in ClO_2 sweater solution**, which is a better disinfectant for ballast water treatment than NaClO, the rather classic ballast water treating solution.

Initial experiments – GC



Experiments were conducted in the above custom-made seawater electrolysis cell. Hydrogen production was monitored by GC, under the same potential values (-1.95V, -2.1V) for all seawater solutions. NaOH enhancement was tested for 4%, 10%, 20%, 30% & 40% wt. The effect of magnetic field was also examined and evaluated.

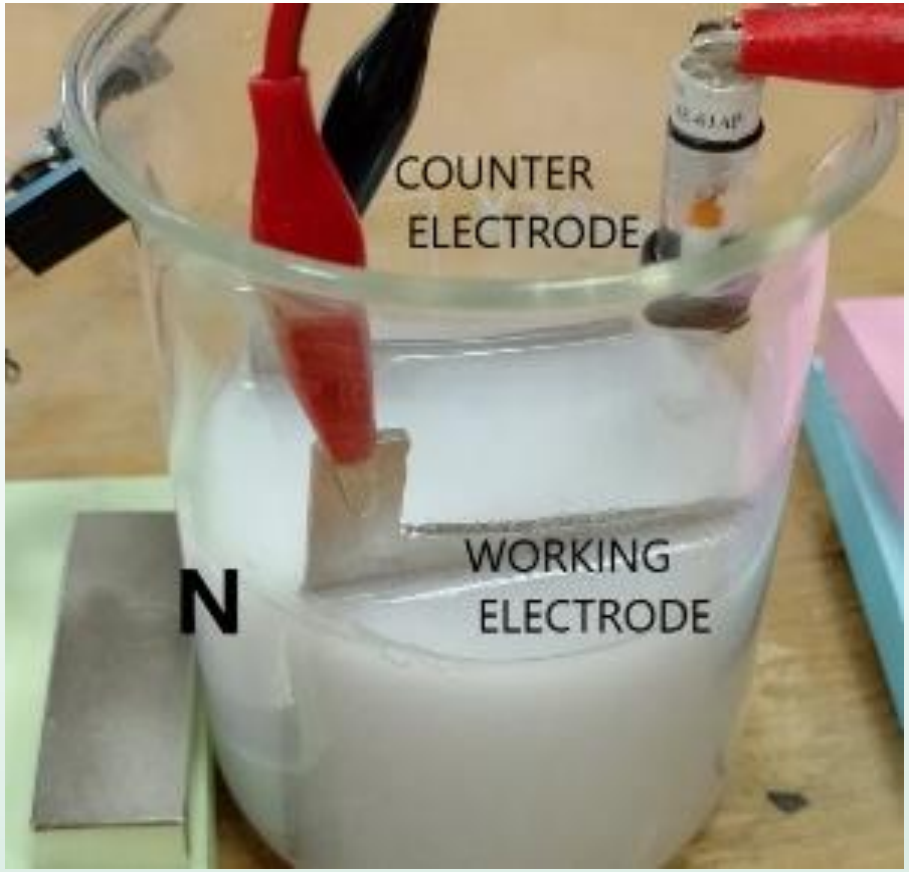
GC Results

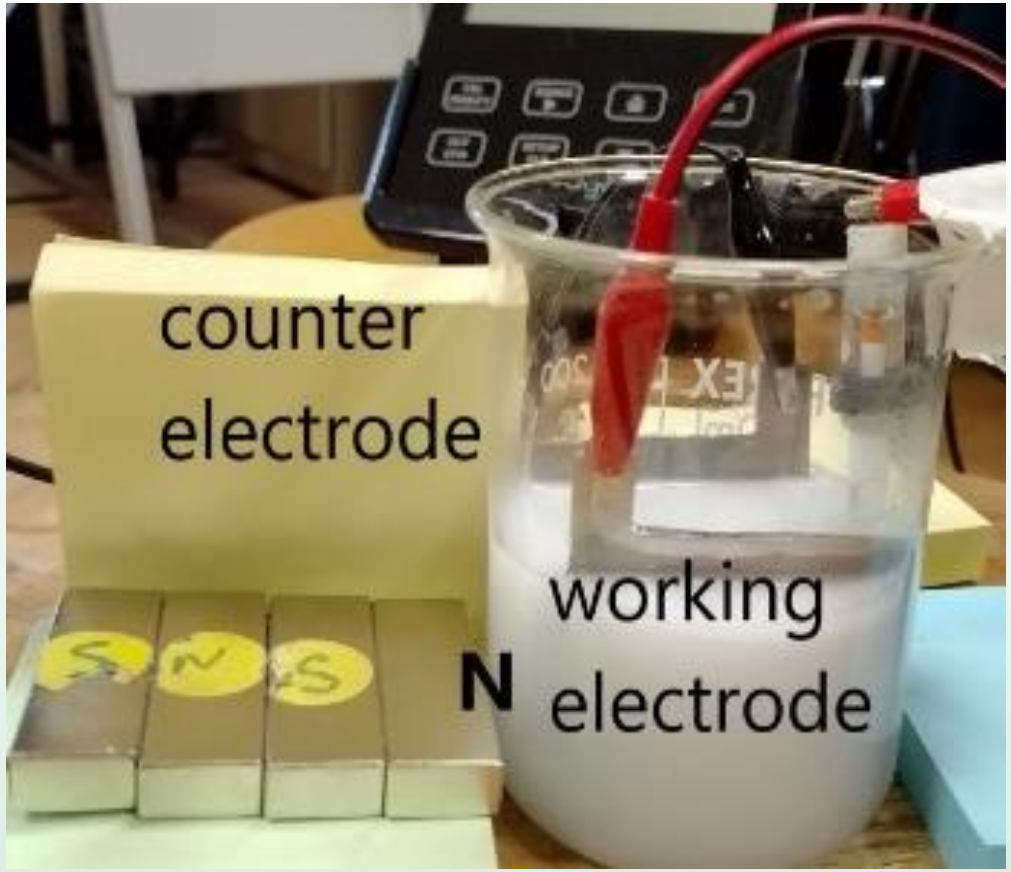
Comparison of all the solutions at the same potential									
Concentration of NaOH in seawater solution (w/v)	Average Current / I (A)	Potential / E (V)	Average ppm H_2	Average ppm O_2	Potential vs Hg/HgO	mg H_2	mg O_2	Wh	kWh/kg H_2 vs Hg/HgO
4% NaOH	-0,98	-1,95	421486	295241	-1,78	1,52	16,9	0,058147	**38,3**
10% NaOH	-1,23	-1,95	426112	**309100**	-1,78	1,53	17,7	0,073141	**47,8**
20% NaOH	-1,25	-1,95	430146	302424	-1,78	1,55	17,3	0,07417	**47,9**
30% NaOH	-1,23	-1,95	429800	258209	-1,78	1,55	14,8	0,07298	**47,2**
40% NaOH	-1,17	-1,95	**445477**	284242	-1,78	1,60	16,2	0,06942	**43,3**

- Almost stable hydrogen production per time frame: 1.50 mg – 1.60 mg
- Lower energy consumption at 4% wt. NaOH in seawater solution
- Highest hydrogen production at 40% wt. NaOH in seawater solution

Cyclic Voltammetry for field evaluation

Cyclic Voltammetry at 100 mV/s



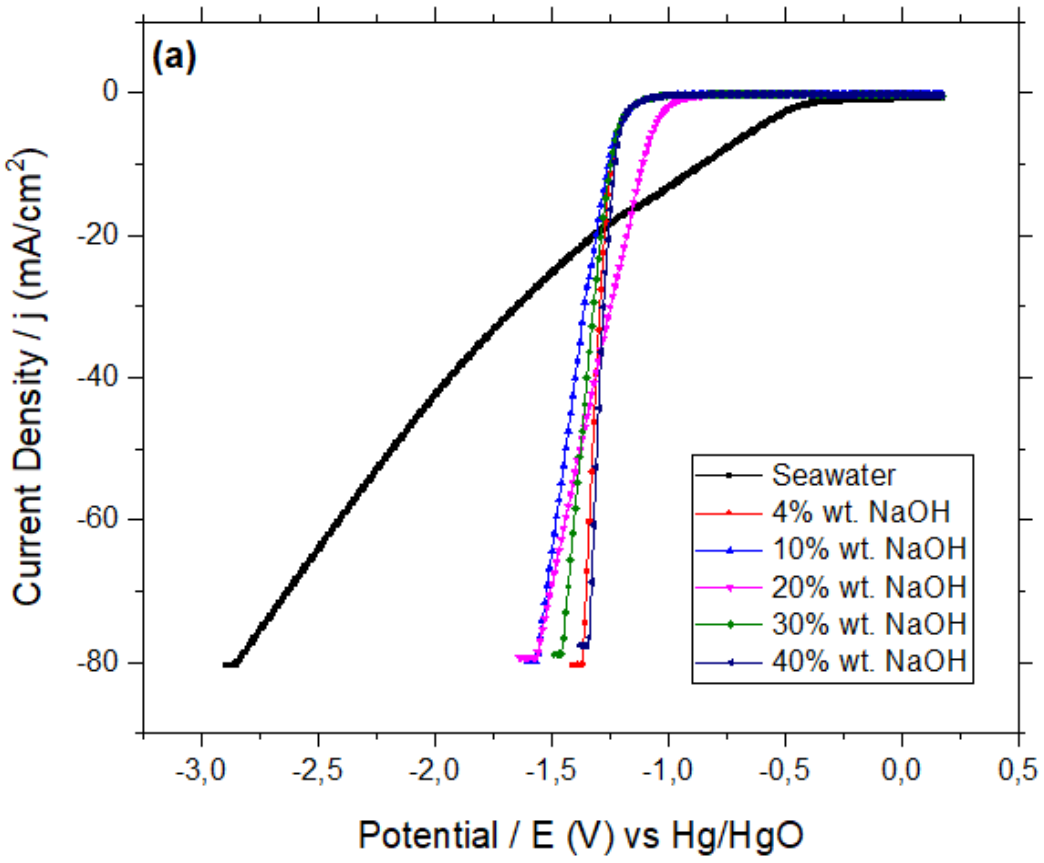


Experiments were conducted in beaker. Cyclic voltammetry scans measured for all the solutions in the absence and presence of magnetic field (MF).

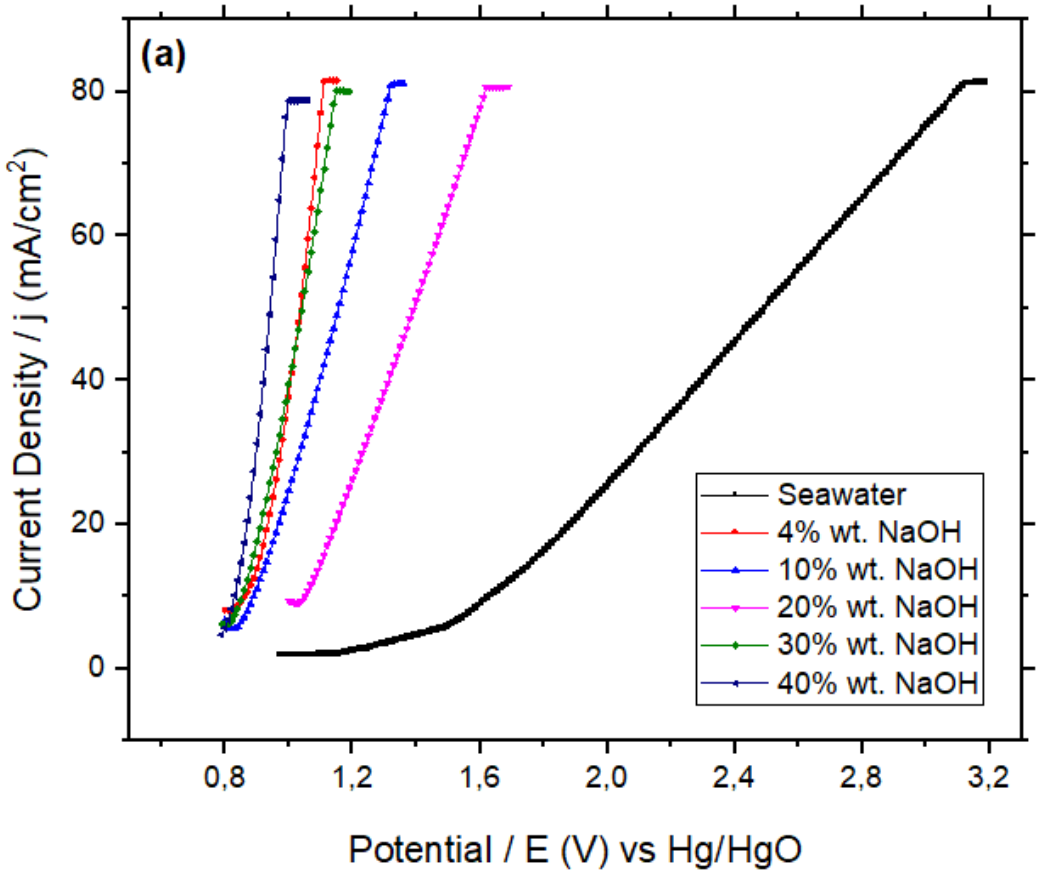
Typical Beaker Experiments to observe the field effect

Absence of magnetic field

Comparison for H_2 production



Comparison for O2 and Cl2 production

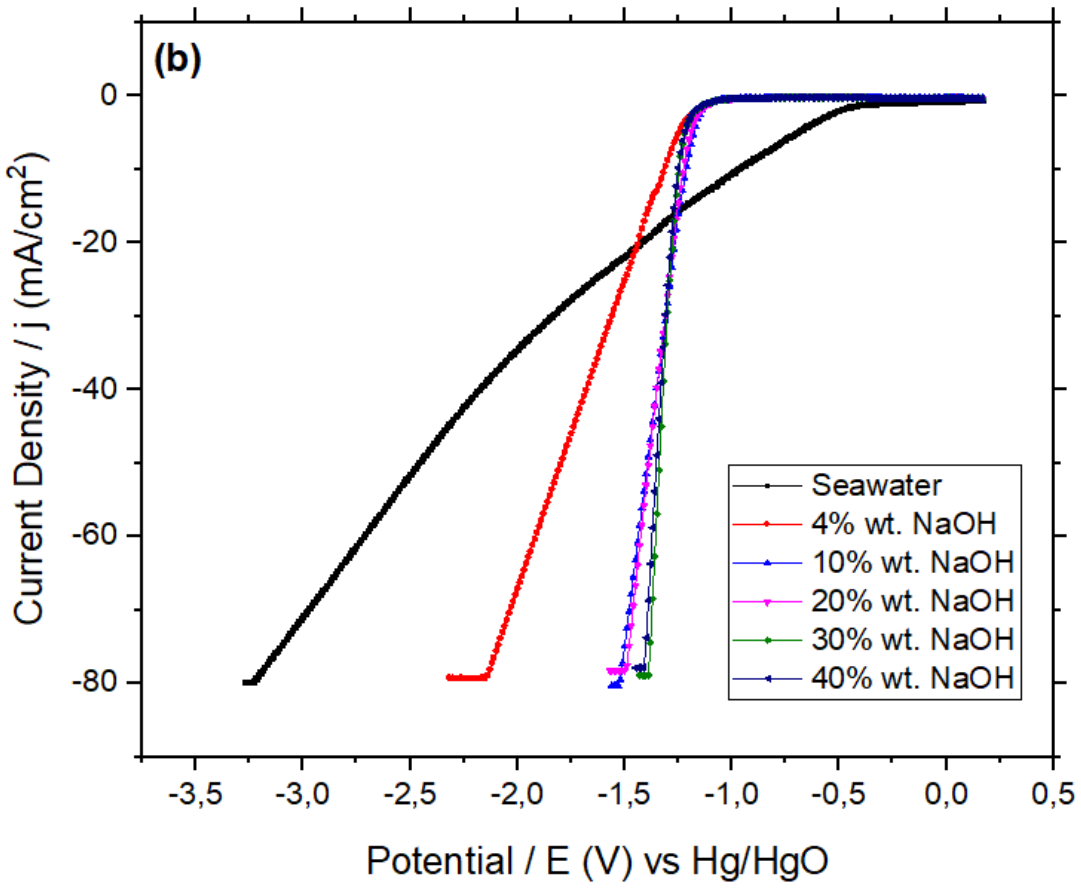


Better performance for HER, OER and CER at 40% and 4% wt. NaOH in seawater

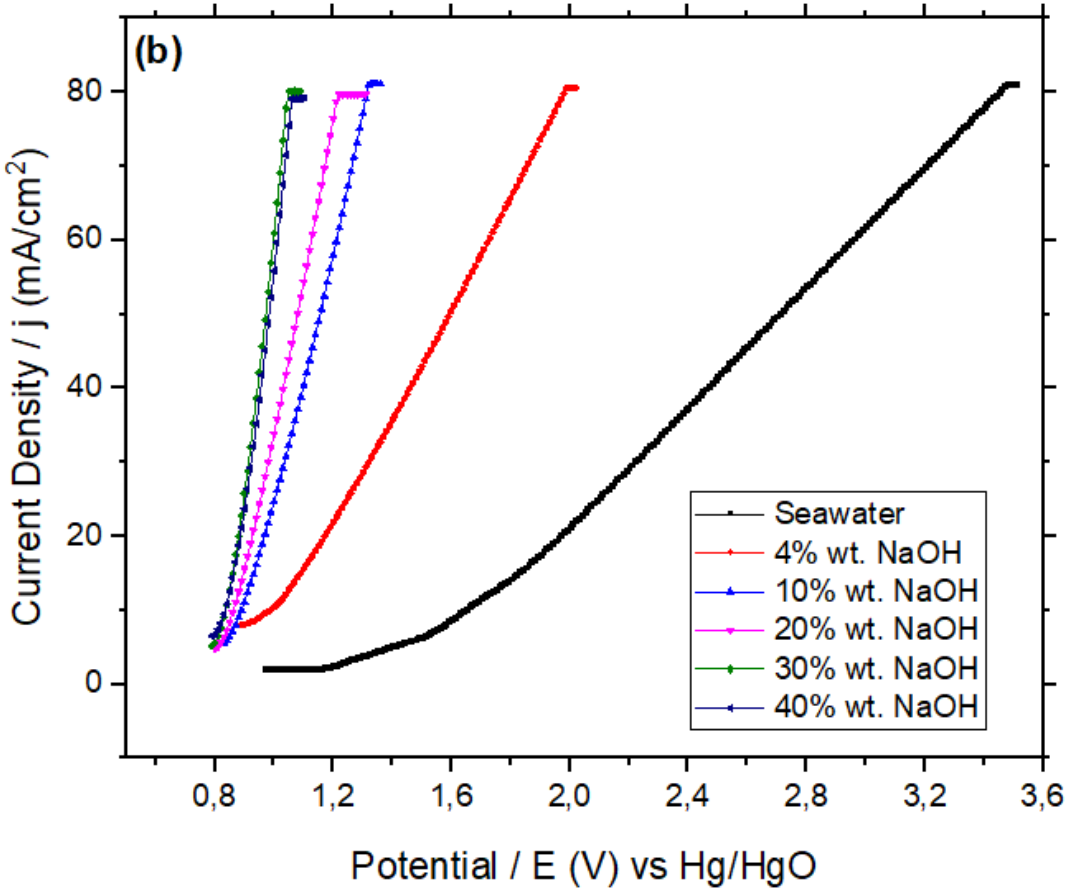
Typical Beaker Experiments to observe the field effect

Small gradient field configuration

Comparison all solutions for HER



Comparison of all solutions for OER and CER

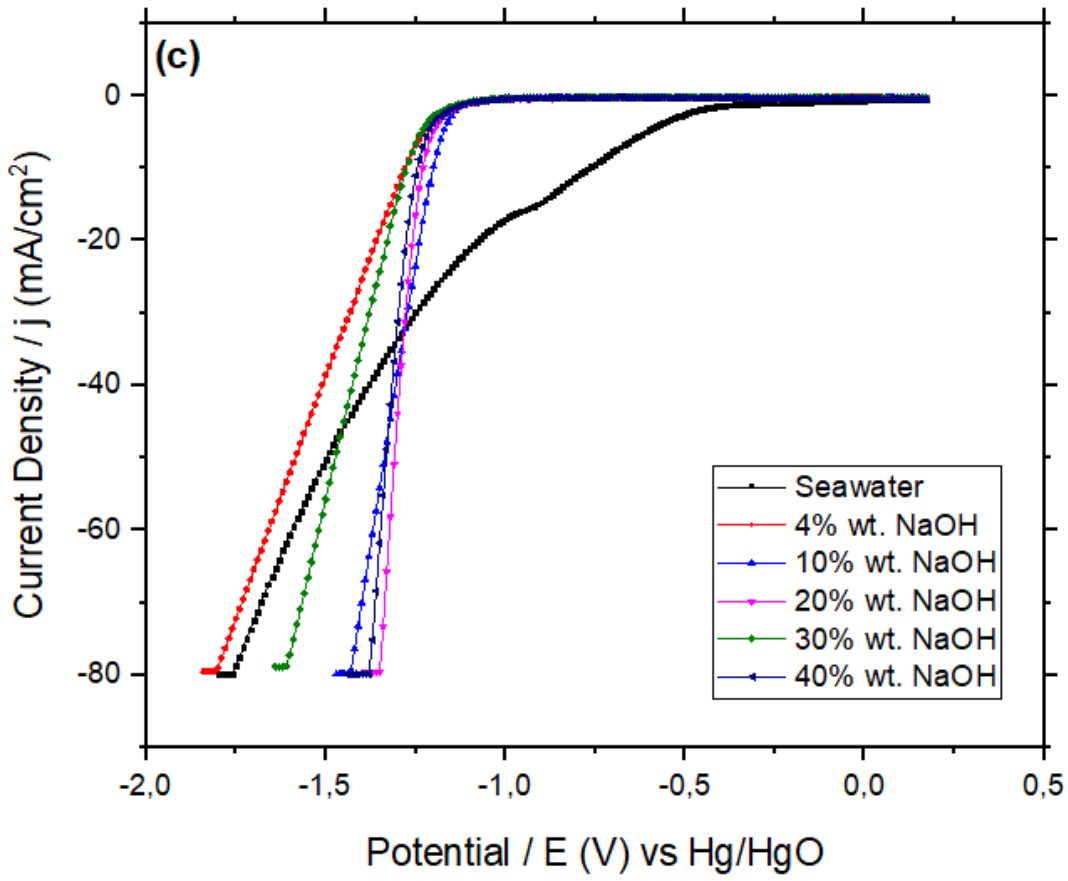


Better performance for HER, OER and CER 30% and 40% wt. NaOH in seawater

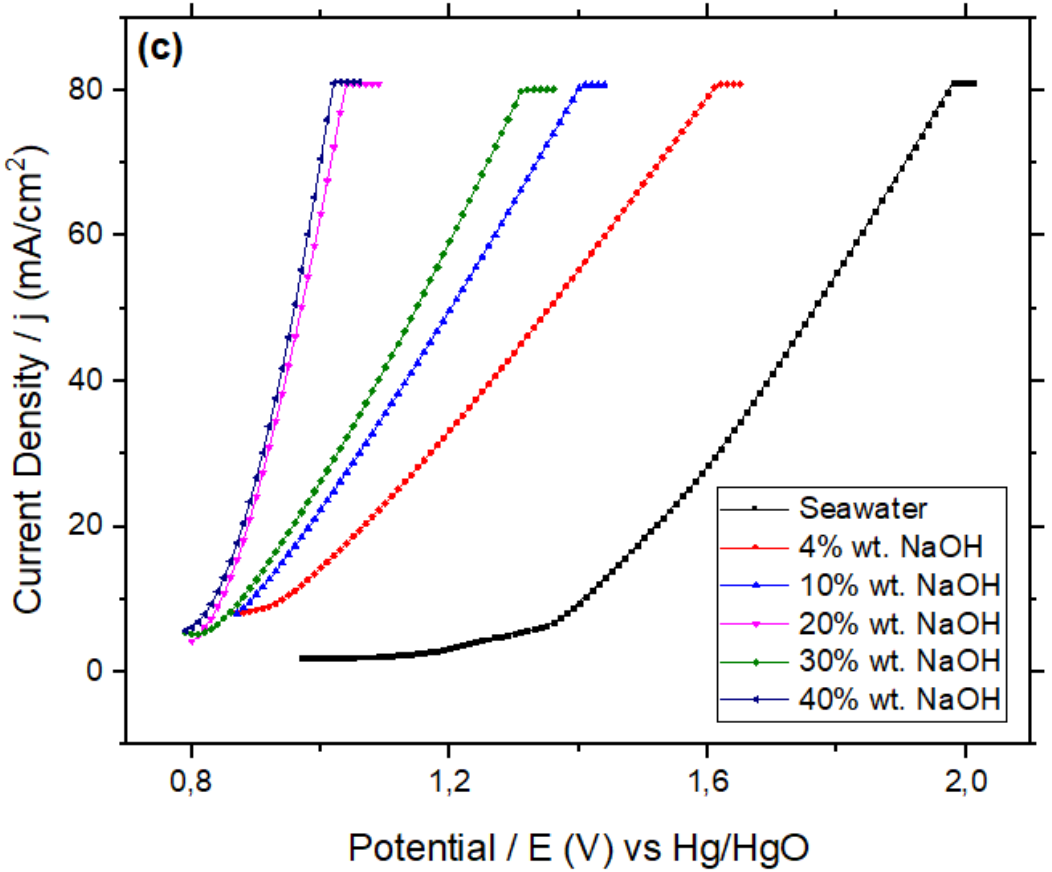
Typical Beaker Experiments to observe the field effect

High field Gradient

Comparison of all solutions for HER



Comparison of all solutions for OER and CER



Better performance for HER, OER and CER 20% and 40% wt. NaOH in seawater

Conclusions

- Hydrogen production is acceptable for 4% salinity and for Greek seawater (3,4%)
- Hydrogen production is optimized for 40% NaOH
- The production of O_2 and Cl_2 is controllable
- Cl_2 and ClO_2 solution may be produced intrinsically during the second electrolysis stage
- Low power consumption (43-47 kWh/kgH_2) has been achieved
- In-seawater CO_2 is trapped and transformed to $CaCO_3$ (continuous CO_2 reduction)
- The production can be realized at the seaside to use both products for maritime

➔Two stage electrolysis is preferred for enhanced hydrogen production

➔The final by product is useful and valuable disinfectant

Suggested methods of storage: methanation, ammonia and methanol production