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Electrochemical alkalinity production using seawater

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Electrochemical alkalinity production is a promising method for removing and storing carbon dioxide (CO_2) from the atmosphere. It involves splitting water into hydrogen (H_2) and oxygen gases and creating hydroxide (OH^-) and hydrogen (H^+) ions. The alkalinity associated with the process is then discharged into the ocean to facilitate atmospheric CO_2 removal (CDR). Here, we present results for an electrochemical system that produces hydrogen and allows for the removal of CO_2 via alkalinity production. Our bench-top system was stable for 40+ hours, with seawater flowing through the system continuously. CO_2 removal was verified with gas and solution measurements of *p*CO2, total alkalinity (TA) and seawater pH. TA on the cathodic seawater stream was increased from 2612 umol kg^{-1} to an average of 3247 ± 112 umol kg^{-1} while TA was lowered on the anodic seawater stream to 1988 ± 61 umol kg^{-1}. The reaction of the cathodic seawater stream with ambient air lowered pCO_2 from 442 ± 15 uatm to 364 ± 16 uatm, while the reaction of the anodic seawater stream with commercially ground garden lime raised TA to 2785 ± 62 umol kg^{-1}. Overall, the discharged seawater had a TA and dissolved inorganic carbon (DIC) concentration of 3016 ± 83 umol kg^{-1} and 2591 ± 51 umol kg^{-1}, respectively, resulting in a seawater discharge pCO_2 concentration of 424 ± 42 uatm, a saturation state of 5.1 (wrt aragonite) and it having an extra 70 umol kg^{-1} of carbon (as DIC) associated with CO_2 capture. The system has a calculated CO_2 to H_2 removal ratio (CO_2:H_2, kg:kg) of 9:1. While this value is lower than the practical ratio of 26:1 and the theoretical ratio of 44:1, it shows the system has great promise as a CDR technique and has excellent MRV (measurement, reporting and verification).