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New electrochemical technology could de-acidify the oceans

In the effort to combat the catastrophic impacts of global warming, we must accelerate carbon emissions reduction efforts and rapidly scale strategies to remove carbon dioxide (CO_2) from the atmosphere and the oceans. The technologies for reducing our carbon emissions are mature; those for removing carbon from the environment are not, and need robust support from governments and the private sector.

Only 45 percent of carbon dioxide emissions remain in the atmosphere; the remainder is absorbed through two cycles: 1) the biological carbon cycle stores CO_2 in plant matter and soils, and 2) the aqueous carbon cycle absorbs CO_2 from the atmosphere into the oceans. Each of these cycles accounts for 25 percent and 30 percent of emitted CO_2, respectively.

CO_2 that dissolves in the oceans reacts to form chemicals that increase the acidity of the oceans. The dissolution of minerals from rocks along coastlines act to counterbalance this acidity, in a process called geological weathering, but the extreme increase in the rate and volume of CO_2 emissions, especially over the last 60 years, has far exceeded the rate of geological weathering, leading to a 30 percent increase in ocean acidity. As the oceans acidify, millions of marine species and whole ecosystems—especially coral reefs—will be unable to adapt.

We are overwhelming the Earth's natural re-balancing systems and harming its ecosystems in the process. The good news is it is possible to re-balance the pH of the oceans using a process called ocean alkalinity enhancement (OAE). What's more, this rebalancing will also encourage additional CO_2 to be absorbed from the atmosphere. By carefully and continually restoring the ocean's alkalinity, ocean acidification and excess atmospheric CO_2 concentrations can be tackled simultaneously.

The most obvious approach would be to add finely ground alkali minerals into the ocean to directly lower the acidity of the water. However, the massive scale at which these processes would have to be enacted is staggering. It is conceived that an electrochemical approach operated on decarbonized energy is one of the best ways to combat ocean acidification. Using a process called bipolar membrane electrodialysis (BMED), the acidity of seawater is removed directly without the addition of other substances. This technology only requires seawater, electricity and specialized membranes. The simplicity and modularity inherent to the BMED technology allows a flexible, scalable and potentially cost-effective method of carbon dioxide removal.

BMED technology is limited in part by the specialized membranes that are commercially available. What's more, these membranes account for a significant portion (around 30 percent) of the capital cost and have short lifetimes as they are susceptible to degradation. The present work aims to develop scalable, ultra-thin membranes for use in a modified BMED process, while also identifying efficient operational conditions, optimal industrial couplings, and ideal global locations to cost-effectively implement this OAE technology around the world. The ultra-thin membranes will extract acidity more efficiently than existing commercial membranes, while their manufacturing technique and optimal usage will dramatically decrease their production and operational costs. (Source: Conversation)