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Novel Bioinspired Design to Capture Smoky CO2 by Reactive Absorption with Aqueous Scrubber

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Abstract : In the next 20 years, energy production by burning fuels will increase and so will the atmospheric concentration of CO2 and its well-known threats to life on Earth. The technologies available for capturing CO2 are still dubious and this keeps fostering an interest in bio-inspired approaches. The leading one is the application of carbonic anhydrase (CA) –a superfast biocatalyst able to convert up to one million molecules of CO2 into carbonates in water. However, natural CA underperforms when applied to real smoky CO2 in chimneys and, so far, the efforts to create superior CAs in the lab rely on screening methods running under pristine conditions at the micro level, which are far from resembling those in chimneys. For the evolution of man-made enzymes, selection rather than screening would be ideal but this is challenging because of the need for a suitable artificial environment that is also sustainable for our society. Herein we present the stepwise design and construction of a bioprocess (from bench-scale to semi-pilot) for evolutionary selection experiments. In this bioprocess, reaction and adsorption took place simultaneously at atmospheric pressure in a spray tower. The scrubbing solution was fed countercurrently by reusing municipal pressure and it was mainly prepared with water, carbonic anhydrase and calcium chloride. This bioprocess allowed for the enzymatic carbonation of smoky CO2; the reuse of process water and the recovery of solid carbonates without cooling of smoke, pretreatments, solvent amines and compression of CO2. The average yield of solid carbonates was 0.54 g min-1 or 12-fold the amount produced in serum bottles at lab bench scale. This bioprocess could be used as a tailor-made environment for driving the selection of superior CAs. The bioprocess and its match CA could be sustainably used to reduce global warming by CO2 emissions from exhausts.

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