Electrochemically enhanced carbonate precipitation into building materials: a scalable carbon sequestration strategy

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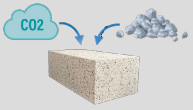
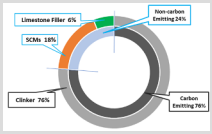
CO_2 to Carbonate is a Scalable C Storage Strategy

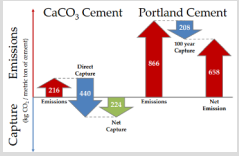
- *There is a pressing need for gigaton-scale carbon capture*
- *Cement/concrete can meet the scale of need*
- *Industrial waste can be used as feedstock*



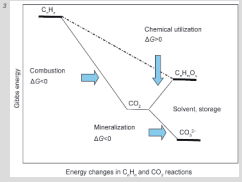


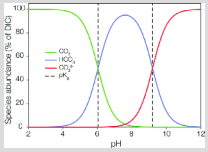
Methods to decarbonize cement:

- *Utilize waste sources of C (mine tailings)*
- *Replace clinker in Portland Cement with $CaCO_3$*
- *Form $CaCO_3$ cement*



Carbonate Mineralization is Limited by Kinetics



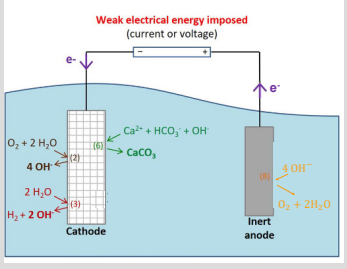


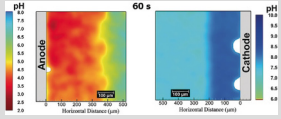
$$CO_2 + H_2O \leftrightarrow H_2CO_3$$
$$H_2CO_3 \leftrightarrow HCO_3^- + H^+$$
$$HCO_3^- + H_2O \leftrightarrow CO_3^{2-} + H^+$$
$$CO_3^{2-} + Ca^{2+} \leftrightarrow \mathbf{CaCO_3(s)}$$

Thermodynamically favorable, but kinetically limited

Alkalinity is needed for $CaCO_3$ precipitation

Electrochemical route to overcome kinetic limitations





Local alkalinity at electrode surface

Electrochemically stimulated environment favorable for $CaCO_3$ nucleation and growth

Experimental Set-up

Electrolyte: 0.5M $CaCl_2$ saturated w/ CO_2

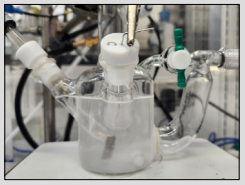
Working Electrode: Stainless Steel

Counter Electrode: Pt

Reference Electrode: Ag/AgCl

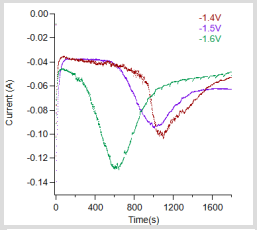
Chronoamperometry at -1.4-1.6 V vs Ag/AgCl

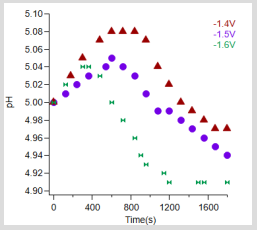
Before Test

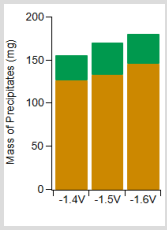


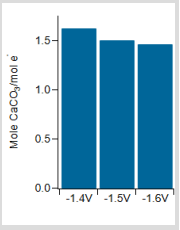
After Chronopotentiometry

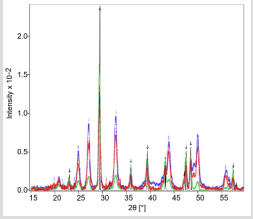
Results

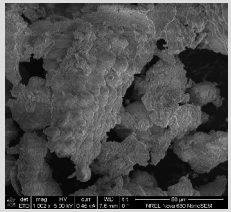


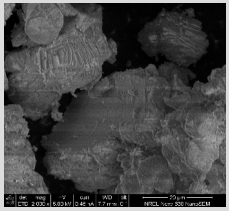










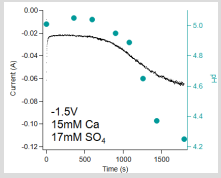


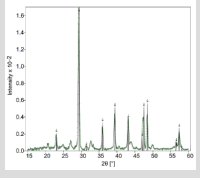
- *Precipitates identified as Calcite/Vaterite*
- *No clear potential effect on morphology*
- *High efficiency*

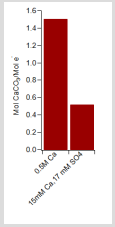
Towards realistic tailing compositions

Mine tailings are often low in Ca and contain impurities-SO_4

Test electrochemical set up with 15 mM Ca and 17 mM SO_4







Key Takeaways

- *Electrochemically-enhanced carbonate mineralization occurs at mildly acidic conditions with high efficiencies*
- *Calcite is the main polymorph*
- *Industrially relevant concentration of SO_4 do not co-precipitate*

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