Carbon Capture by Liquid Metal Catalysis

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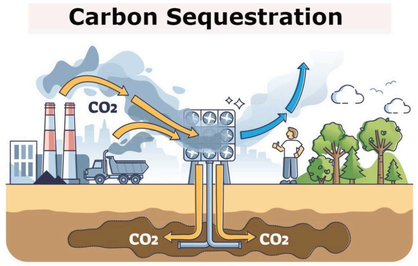
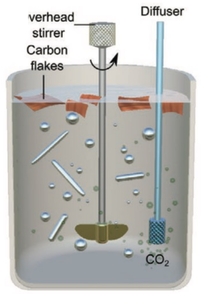
1. Overview

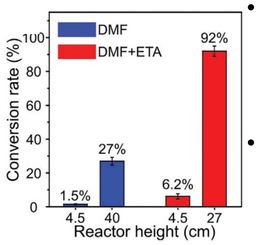
- Microsoft's Climate Research Initiative seeks to aid in the growing climate crisis by conducting cross-disciplinary, collaborative research projects.
- One such research project involves the investigation of liquid metal catalyzed CO_2 reduction that produces a storable, value-added product.
- Current methods of CO_2 reduction are costly, inefficient, or produce products that are not easily stored.



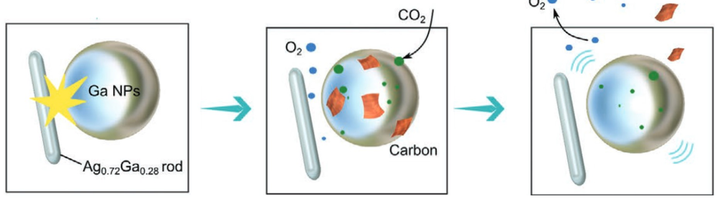
2. Technical Background

- Traditional carbon dioxide reduction requires large amounts of energy to activate CO_2.
- A newly proposed method of CO_2 reduction requires only mechanical energy for activation.
- When two liquid metal particles collide in an organic solvent, they generate a triboelectric voltage difference.





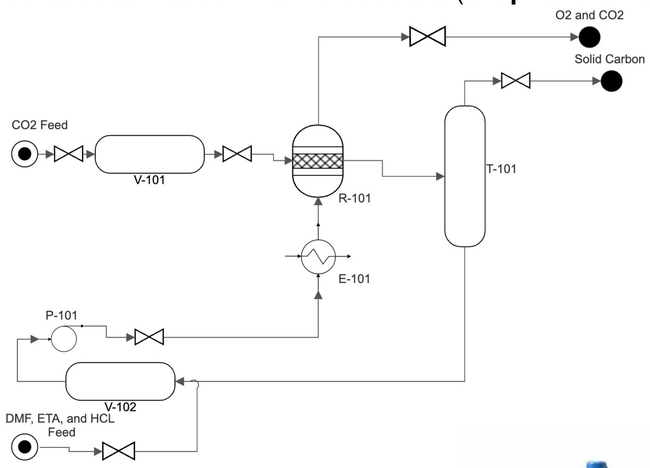
- The voltage difference on the catalyst surface allows dissolved CO_2 to be converted to solid carbon and O_2
- Using an organic solvent mixture of 90% DMF and 10% ETA, a conversion rate of 92% was achieved.



3. Process Design

Process Considerations

- CO_2 Source: **Direct Air Capture** vs Flue Gas
- Mechanical Energy Source: **Overhead Mixer** vs Ultrasound Sonication
- Liquid Metal Catalyst: **AgGa** vs EGaIn
- Carbonaceous Product: Atomic Structure (**Graphene Oxide**)

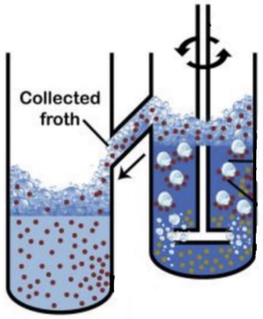


Rate of Reaction vs Diffusion

- Diffusion rate: 0.71 mol CO_2/m^2s
- Reaction Rate: 60 mol CO_2/m^3h

Reactor Design

- 40,000 L Glass-Lined Reactor
- Throughput: 966 metric tonnes of CO_2 per year
- Electrical Costs: 18,400 USD per year



Solid Carbon Separation

- Carbonaceous material can be extracted without removing the catalyst.
- Organic solvent collected with solid carbon is evaporated, condensed, and recycled.

4. Economic Assessment

Capital Costs

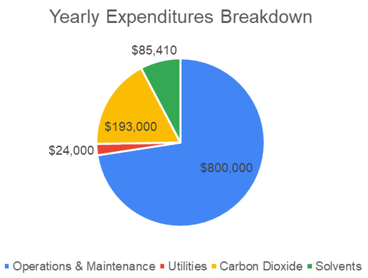
- 9.5 million USD (One 40,000L Reactor)

Operating Costs

- 1.1 million USD per year

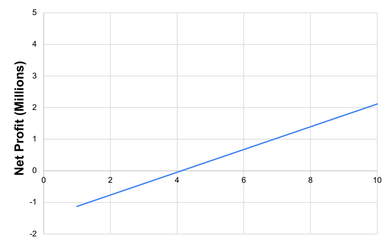
Cumulative Cash Flow

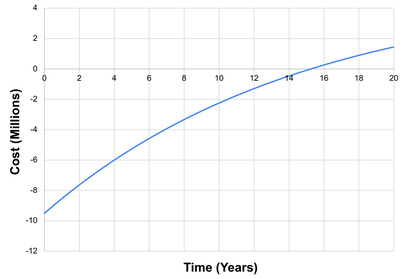
- At 6 USD per kg graphene oxide: 673,000 USD



Net Present Value

- At 6 USD per kg graphene oxide:





5. Conclusions

From the lab data analyzed, gallium has proven to be capable of reducing CO_2 at low costs and high efficiency.

Further research is needed to determine the process's viability at large scales.

- The current reaction rates is promising, but little is known about how it will scale with increased volume or changes in operating conditions
- Investigating the structure and value of the graphene oxide product remains a crucial aspect in determining the economics of the process.
- Increases in the number of processing units or reactor throughput will greatly improve the process capabilities.