



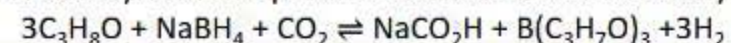
University
of Idaho

Carbon Dioxide Conversion to Sodium Formate and Triisopropyl Borate

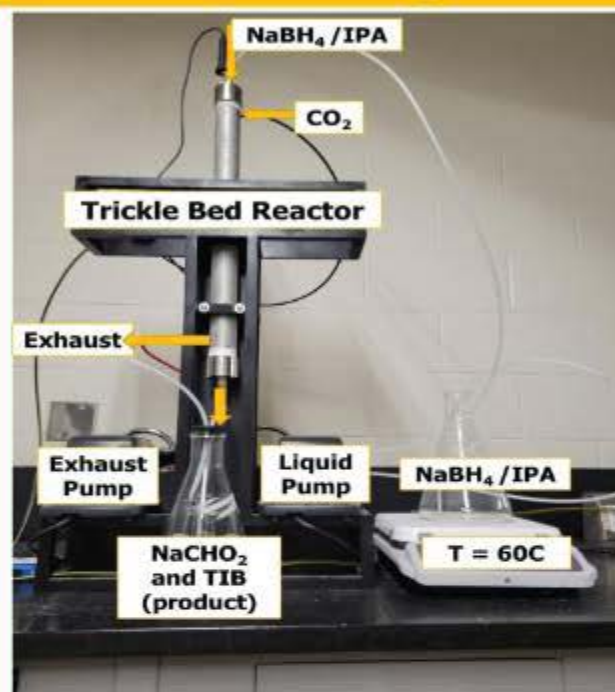
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Problem Statement: Reduce carbon dioxide emissions from a natural gas powerplant that produces 900 pounds CO₂ per megawatt-hour by converting CO₂ into a viable product. Demonstrate the approach with a bench-scale system and determine its economic viability through a techno-economic analysis.

Solution: The reaction of isopropyl alcohol (IPA), sodium borohydride (NaBH₄), and carbon dioxide (CO₂) produces triisopropyl borate (TIB), sodium formate (NaCO₂H), and hydrogen gas (H₂). A techno-economic analysis of this process demonstrates its viability as a solution.

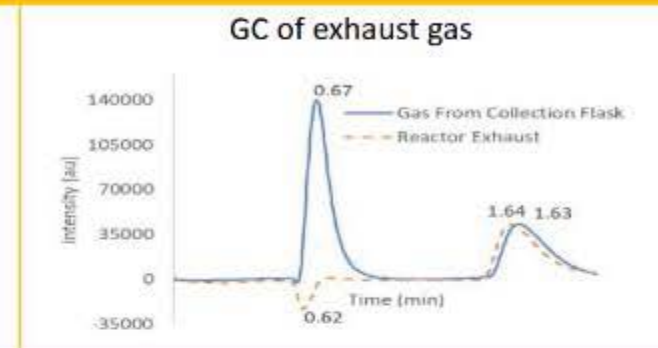
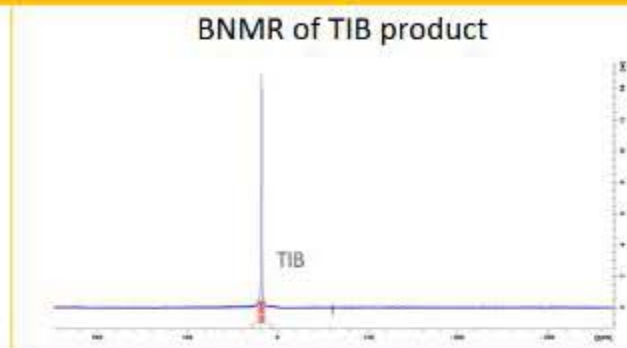
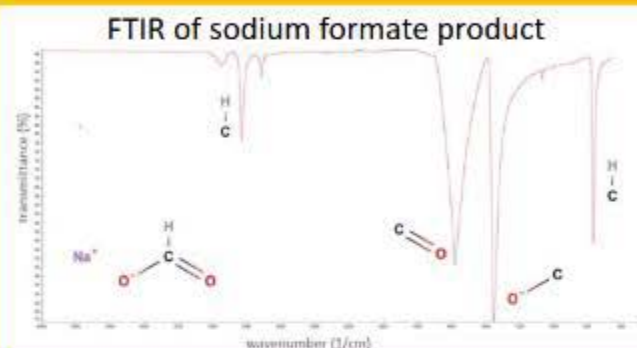


Bench Scale Design

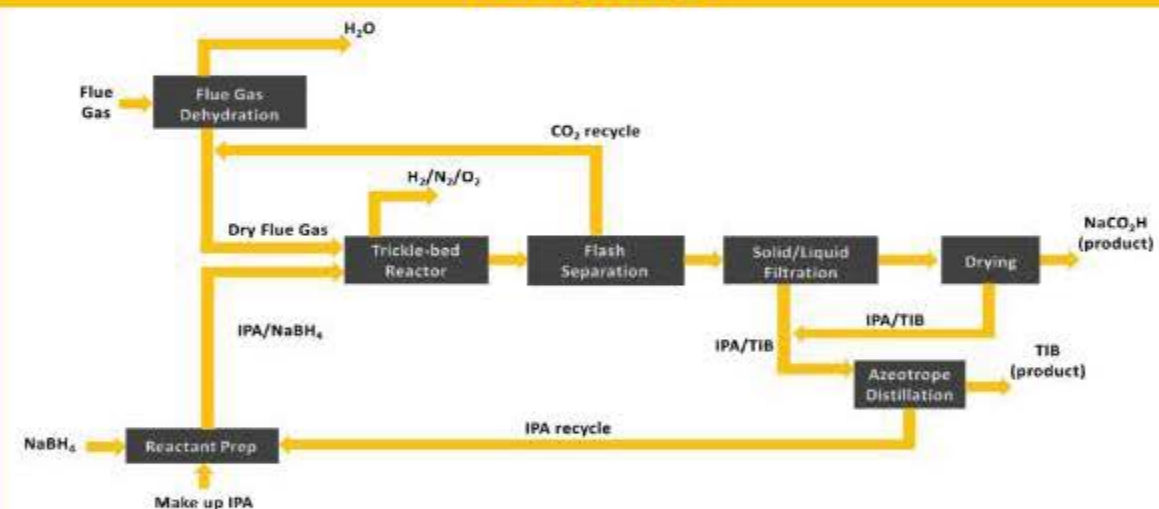


The trickle bed reactor is a stainless-steel pipe, with a 4 cm diameter, packed with 2-2.5 mm silicon zirconia beads. The packing increases the contact between the liquid NaBH₄/IPA and CO₂ improving the reaction kinetics.

Bench Analysis Results



Scale Up Design



Capital Investment and Expenses

Fixed Capital Investment	\$7.46 million
Working Capital	\$24.86 million
Cost of Manufacturing	\$141.50 million

Revenue

Overall	\$298.30 million
NaCO ₂ H (\$3.57/kg)	\$8.31 million
TIB (\$19.75/kg)	\$ 289.99 million

Profitability

Pay Back Period	0.08 year
Rate of Return on Investment	1160%
Net Present Value	\$421 million

Development Plan

	Y1				Y2				Y3			
Task	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Research/Bench												
Pilot Testing												
Commercial Demo.												
Building Design												
Permits/Approvals												
Construction												
Order Equipment												
Equipment Set up												
Populate Plant												
Start up												

Conclusion

- Converting CO₂ into NaCO₂H, along with H₂ gas and TIB is more economical and beneficial than capture and storage.
- Design safety, feasibility, and profitability are primary benefits of the selected design.
- The optimal parameters for the reaction to take place are 60°C, and a 1.5 molar feed ratio of CO₂ to NaBH₄.
- The results indicate the process effectively converts CO₂ into highly pure NaCO₂H, B(C₃H₇O)₃, and H₂.
- Analysis results also confirm the reaction reaches completion within the reactor, indicating favorable kinetics.
- The sodium formate and triisopropyl borate market is expected to expand in the coming years; pay back period is within 1 month of startup.
- The process remains profitable even with product price fluctuation of up to 50%.

WERC Team

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