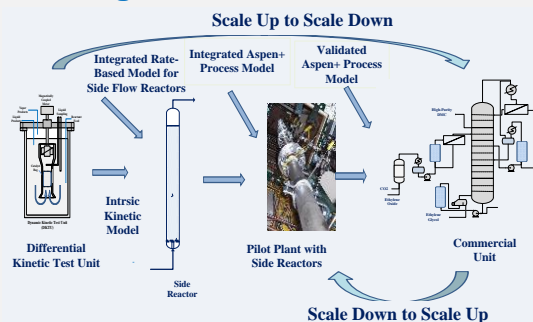


Core Competency

Accelerated chemical process development and scale-up from laboratory to industry pilot plant to commercial unit.

E³Tec Team has decades of experience successfully developing & demonstrating technologies.

- Process analysis based on ASPEN Plus® with integrated rate-based models.
- Design methodologies for rapid process development and scale up based on “Scale-Down to Scale-up” criteria.
- Pilot scale HIRD test facility at Michigan State University (MSU) for validating ASPEN Plus® design model.



Partnership Opportunities

- Funding and Investment: Pilot plant demonstration of the technology
- Industry Partners: Licensing and/or strategic alliances to advance the process to TRL-7 of *Integrated Pilot System Demonstrated*
- Facilities: Industrial site for pilot plant demonstration
- Collaboration for Marketing: DMC Off-takes
- Path Forward: Commercial demonstration to validate techno-economic merits

Contact Information

Dr. C. B. Panchal

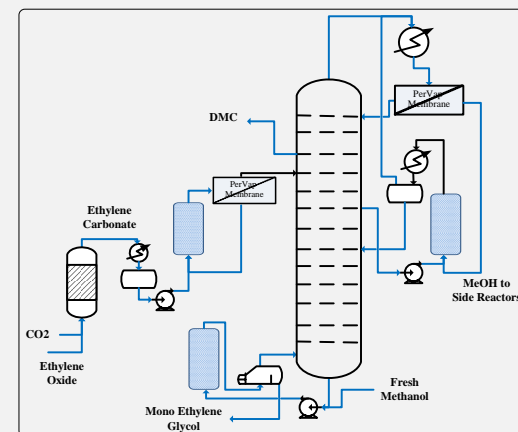
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E³Tec Service, LLC



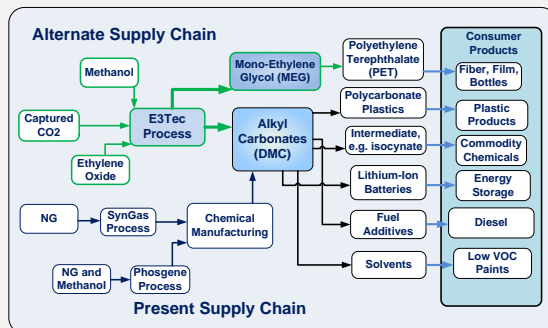
Conversion of Captured CO₂ to Dimethyl Carbonates (DMC)



Patent US 9,518,003 B1 Dec 2016 and 9,796,656 B1 Oct 2017

Conversion of CO₂ to Alkyl Carbonates

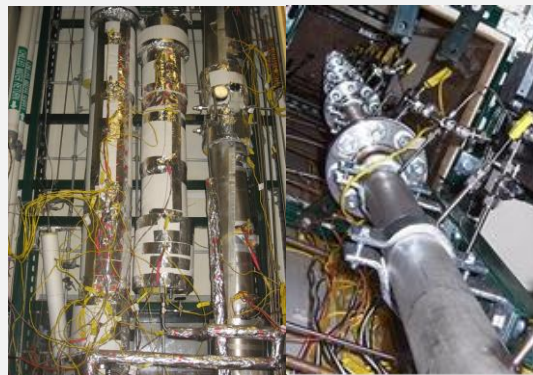
Two processes have been developed to the pilot-plant stage. In one process ammonia is the chemical carrier, while in the other process ethylene oxide is chemical carrier with co-production of mono ethylene glycol selectively. The Heat Integrated Reactive Distillation (HIRD) process equipped with side reactors and PerVaporization (PerVap) membrane is demonstrated at the pilot-scale test unit and ASPEN Plus® design model has been developed.



Alkyl Carbonate Supply Chain

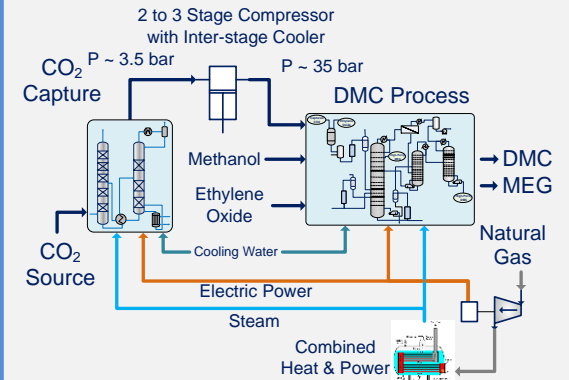
Technology Readiness Level (TRL)

- Heat Integrated Reactive Distillation (HIRD) with DOE project at Argonne National Laboratory.
- Advanced from TRL-3 of *Concept of Proof Established in 2014* to TRL-4 of *Lab Testing of Alpha Prototype* and ASPEN Plus® process model in 2016.
- Advanced from TRL-4 to TRL-5 of *Lab Testing of Semi-Integrated Process* in 2018.
- ASPEN Plus® model for scale up from pilot-scale test unit at Michigan State University (MSU) to integrated pilot plant.



MSU Pilot-Scale 10-m Test Unit

Integrated Process of CO₂ Capture and Conversion to DMC



Game-Changing Process

- Low C-footprint with potential net consumption of CO₂.
- DMC is an ideal value-added specialty chemical with expanding market for polycarbonates, Li-ion batteries and intermediates for polyurethanes.
- Selective co-production of mono-ethylene glycol (MEG) enhances competitiveness.
- Product margin offsets CO₂ capture costs.