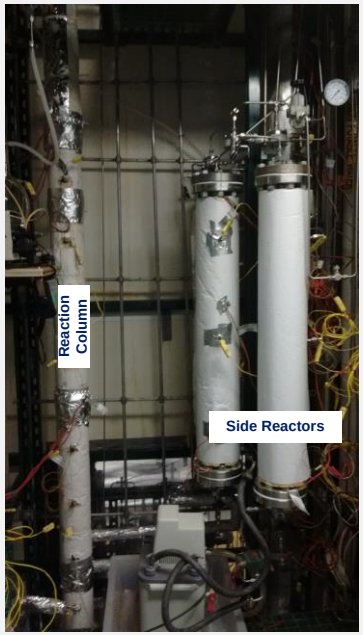
Core Competency

Accelerated chemical process development and commercial scale-up

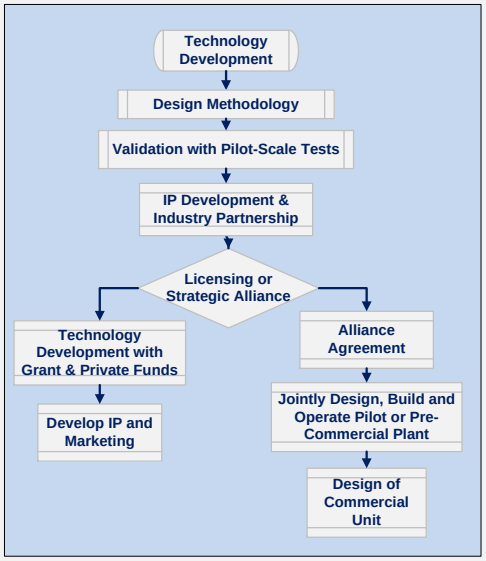
E^3Tec team has decades of experience of process development and demonstrating new technologies.

- ASPEN Plus® HIRD process simulation with integrated kinetic and component models
- Design methodologies for rapid process development
- Laboratory and pilot scale test facility at Michigan State University



Commercialization Pathways

- Technology Development
- IP Development
- Technology Licensing
- Strategic Alliance



Business Strategy

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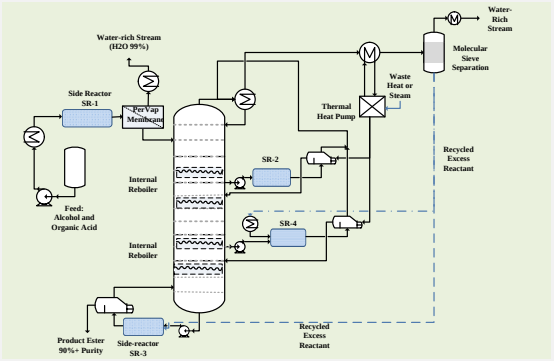
E^3Tec Service, LLC

Synthesis of Bio-based Plasticizers, Solvents, and Coatings

Heat Integrated Reactive Distillation (HIRD) for Synthesis of Succinic Acid Esters

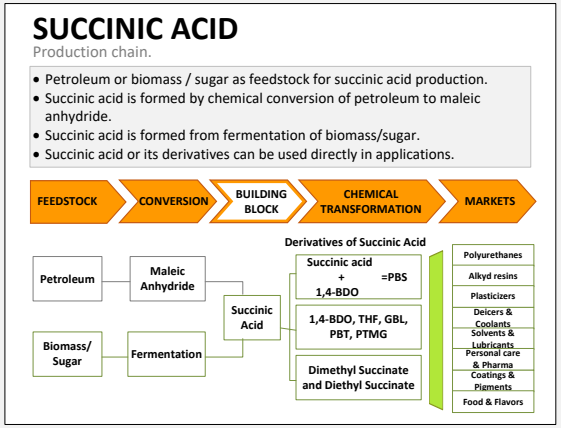


Patent US 9,174,920 B1 November 2015

Chemical Synthesis of Organic Acid Esters

Bio-based Organic Acids and Alcohols → Esterification via E3Tec's HIRD Process → Bio-based Specialty Chemicals

Bio-based Succinic Acid & Plasticizer Market Projection



The project is supported by the National Institute of Food and Agriculture of US Department of Agriculture (NIFA-USDA) through the SBIR program.

Esterification of Organic Acids to High-Value Products

This process technology was demonstrated at the pilot scale for esterification of citric acid to tri-ethyl citrate. The economic analysis indicated potential savings in CAPEX and OPEX over the conventional batch processes. This technology is being applied to the synthesis of dioctyl succinate (DOSX), one of the leading bio-based plasticizers replacing petroleum based phthalates.

Phthalates as plasticizers are increasingly being phased out from consumer products

Technology Opportunity

- **There is strong motivation for bio-based "green" chemicals**
- **Organic acid esters are alternate plasticizers to phthalates**
- **Succinate-di-esters are used as solvents and in coatings**
- **Chemical synthesis processes developed for petroleum based chemicals cannot be directly applied to synthesis of bio-based chemicals**

E3Tec's HIRD Process Ideally Suited for Synthesis of Esters of Organic Acids