Actionable Science for Communities

Techniques for Separating Organic Solvents to Facilitate Reuse and Remanufacturing (3.63 Task 2)

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Purpose/Utility of Research

The Remanufacturing Exclusion in the EPA's *New Definition of Solid Waste rule* promotes the reuse/reprocessing of 18 industrial solvents in four industrial sectors: paints & coatings, pharmaceuticals, plastics & resins, and basic organic chemicals.

Reclaiming solvents requires separation technologies to recover those solvents from their mixtures with other process materials, such as water, and to purify them to meet reuse specifications.

Conventional solvent separation technologies have significant energy and/or material demands. Thus, there is a need for efficient alternatives.

This research will focus on the in-house review, development, and evaluation of advanced separation materials/technologies for energy-efficient solvent re-processing.

Separation of solvent/water mixtures will be emphasized because most of the 18 solvents targeted in the *New Definition* form difficult-to-separate azeotropic mixtures with water.

Highlights

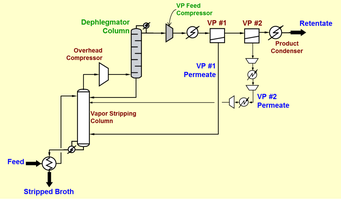
- Project will leverage team's experience developing membrane materials and processes for the efficient recovery and drying of alcohol-based biofuels.
  - Alcohol drying process researched by the team was included as an energy-saving "advanced technology" in the Renewable Fuel Standard.
  - Invented hybrid membrane process reducing separations energy by over 70%.
  - Biofuels research resulted in four patents, including three joint patents and license agreement with membrane technology CRADA partner.

•Evaluate & Develop Membrane Materials to Meet Demands of Solvents

"Preparation of water-selective polybutadiene membranes and their use in drying alcohols by pervaporation and vapor permeation technologies," L. Vane, V.V. Namboodiri, G. Lin, M. Abar, and F. Alvarez, *ACS Sustainable Chemistry & Engineering*, **4**, 4442-4450 (2016).

•Design Efficient Separation Processes

U.S. Patent 9,266,803 B2: "Liquid separation by membrane assisted vapor stripping process" (issued February 23, 2016), L.M. Vane and F.R. Alvarez.



•Demonstrate Innovative Technologies

CRADA with Membrane Technology and Research, Inc., "Membrane-based processes for the separation of solvent/water mixtures".

Application & Translation

- Technology transfer with potential end-users and separation technology developers.
- Engage separations community and end-users by participating in NIST-funded project to develop roadmap for implementing efficient separation processes.

Intended End Users

This research will provide scientific support regarding efficient separation technology options to EPA program & regional offices, states, tribes, and the regulated industries seeking to implement the remanufacturing exclusion or solvent reclamation in general.

The activity will foster collaboration between separations technology developers, university researchers, solvent end-users, and regulators to promote solvent recovery and reuse.

Lessons Learned

- Heat-driven distillation is the most common chemical separation process but has poor to dismal efficiency.
- Efficient alternatives are underdeveloped or expensive to scale up.
- There is a need for robust separating materials and processes that can handle a range of solvents and that are efficient, even in batch processing.
- For many industries, separation processes dictate sustainability and product cost:
  - "Separations vs. Sustainability – there is no such thing as a free lunch," by L. Vane in Sustainability in the Analysis, Synthesis and Design of Chemical Engineering Processes, ed. by G. Ruiz-Mercado and H. Cabezas (2016).