Process Intensification

Bruce Eldridge
James R. Fair Process Science and Technology Center
The University of Texas at Austin

Process Science & Technology Center

An industry and government (NSF, DOE) supported center conducting fundamental and applied research targeted at reducing energy consumption and capital expenditures. The center consists of multiple collaborators from multiple institutions.

Shell
Chevron
ExxonMobil
Raschig Jaeger Technologies — Jaeger Products, Inc.
Air Liquide
UOP — A Honeywell Company
Texas A&M
BASF — The Chemical Company
Eastman
USC
Engineers India Limited (A Govt. of India Undertaking)
Sachem
Total
Phillips 66
Evonik Industries

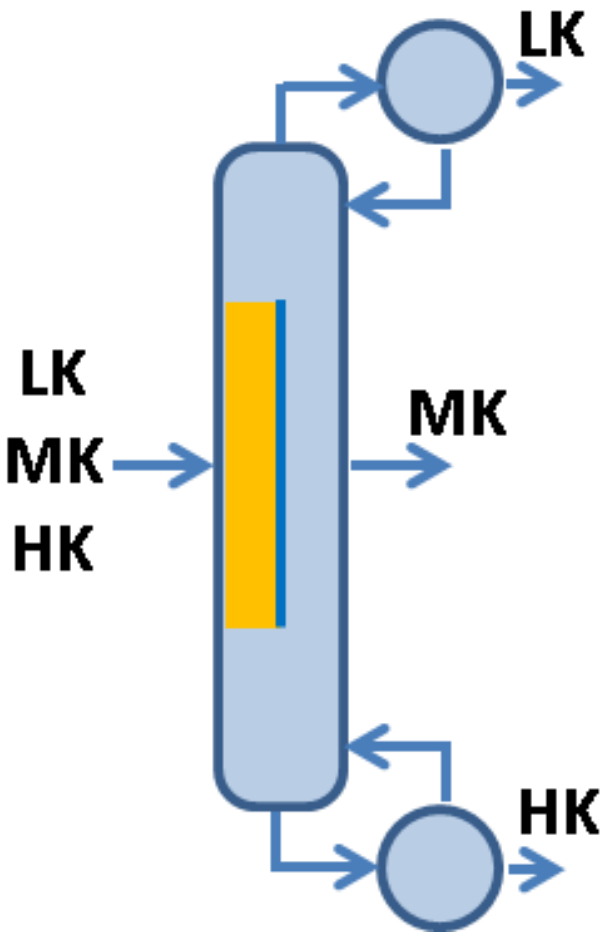
Process Intensification

Eldridge definition: Combining or optimizing multiple process steps to reduce energy consumption and /or capital cost.

Five examples from the PSTC / SRP / Eldridge Laboratories:

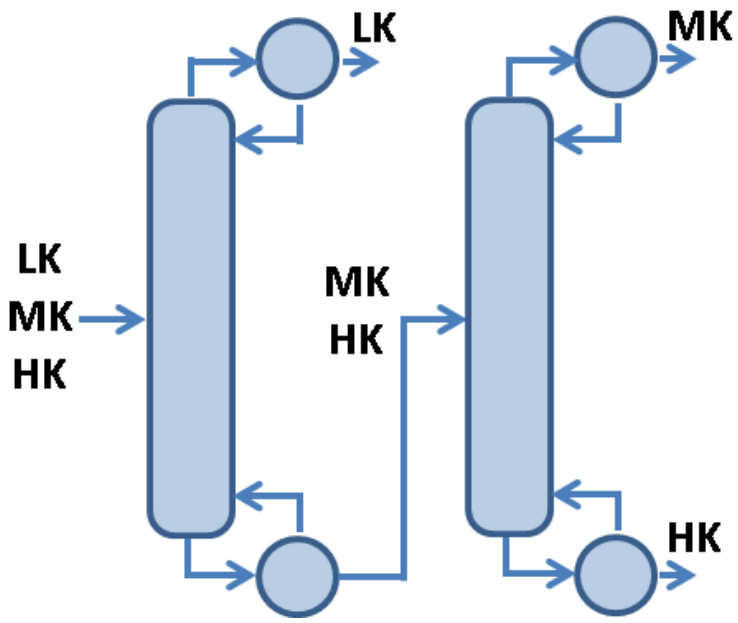
Divided Wall Distillation.
Membrane Reactors.
Reactive Distillation.
Chemically Enhanced Separations.
Rapid Prototyping of Mass Transfer Devices.

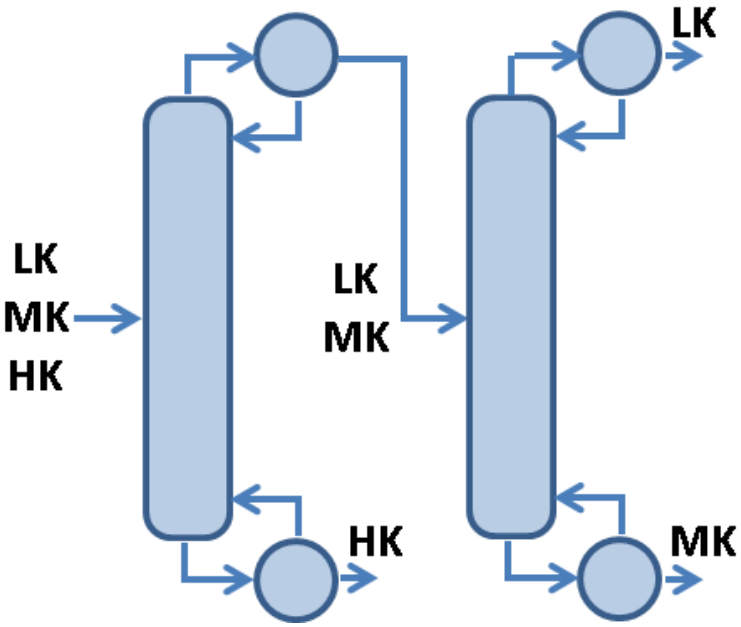
Divided Wall Column Distillation



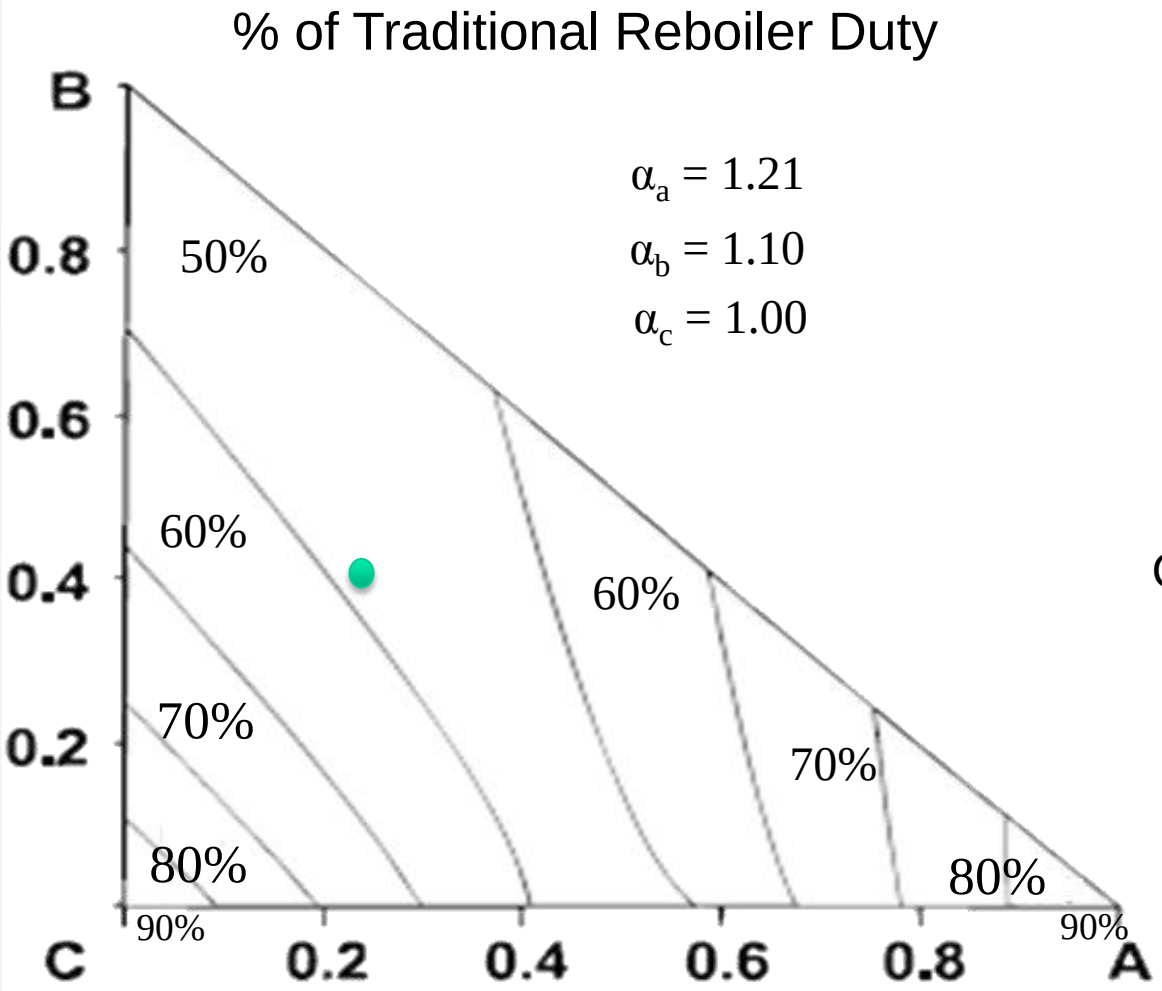
Divided Wall Column

Multicomponent Separations





Potential Energy Savings



Assumptions:

Ideal vapor

Ideal liquid

No pressure losses

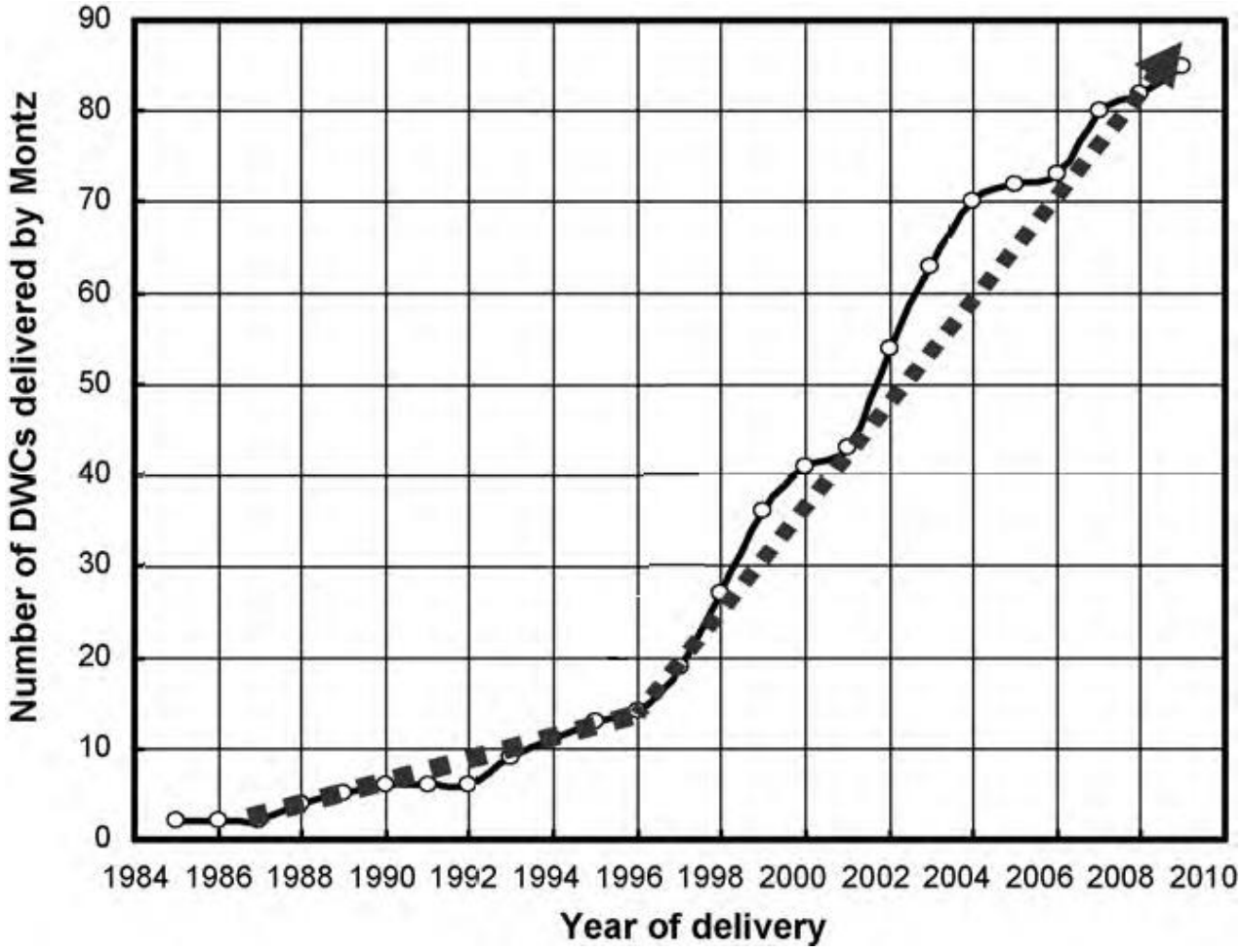
No wall heat transfer

Constant relative volatilities

A:30
B:40
C:30

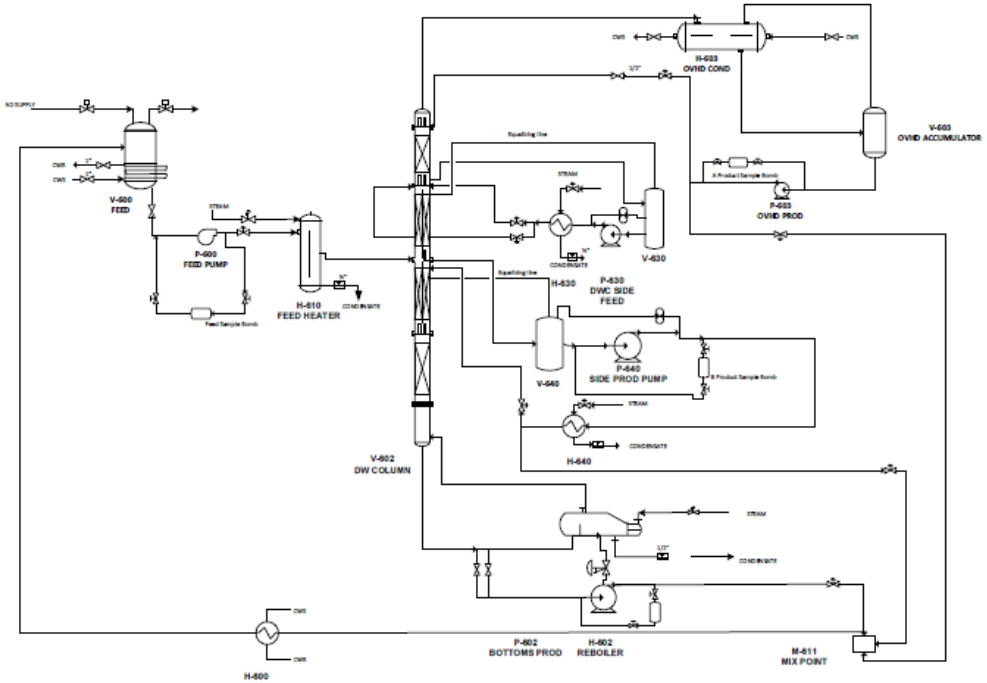
Agrawal R and Fidkowski ZT (1998) Are Thermally Coupled Distillation Columns Always Thermodynamically More Efficient for Ternary Distillations? Ind. Eng. Chem. Research, 37, pg 3444-3454.

Implementation

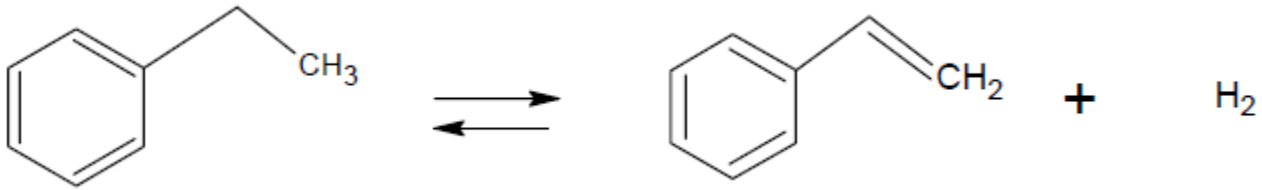


Dejanovic, L., Matijasevic, Z. & Olujic, Z. Dividing wall column - a breakthrough towards sustainable distilling. *Chem. Eng. and Pro.*, **49**, 559–580 (2010).

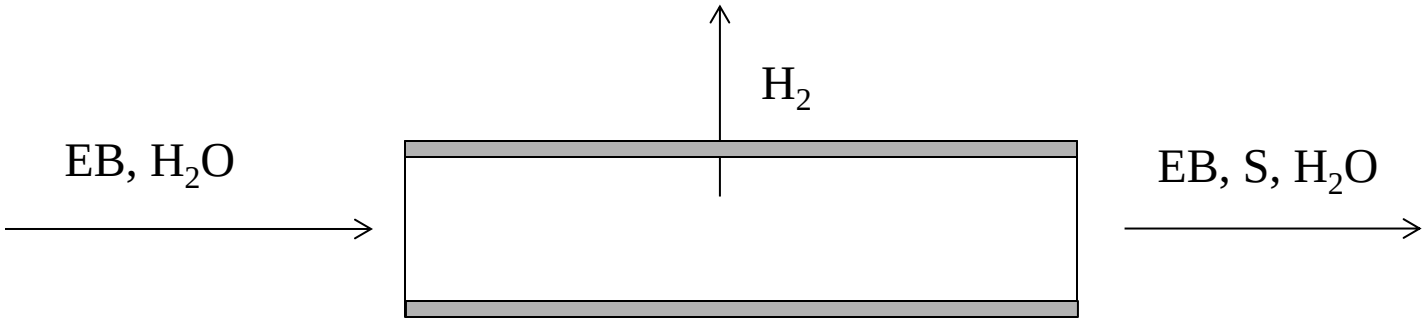
Separations Research Program
DWC Pilot Plant



Membrane Reactor



Ethylbenzene Styrene Hydrogen

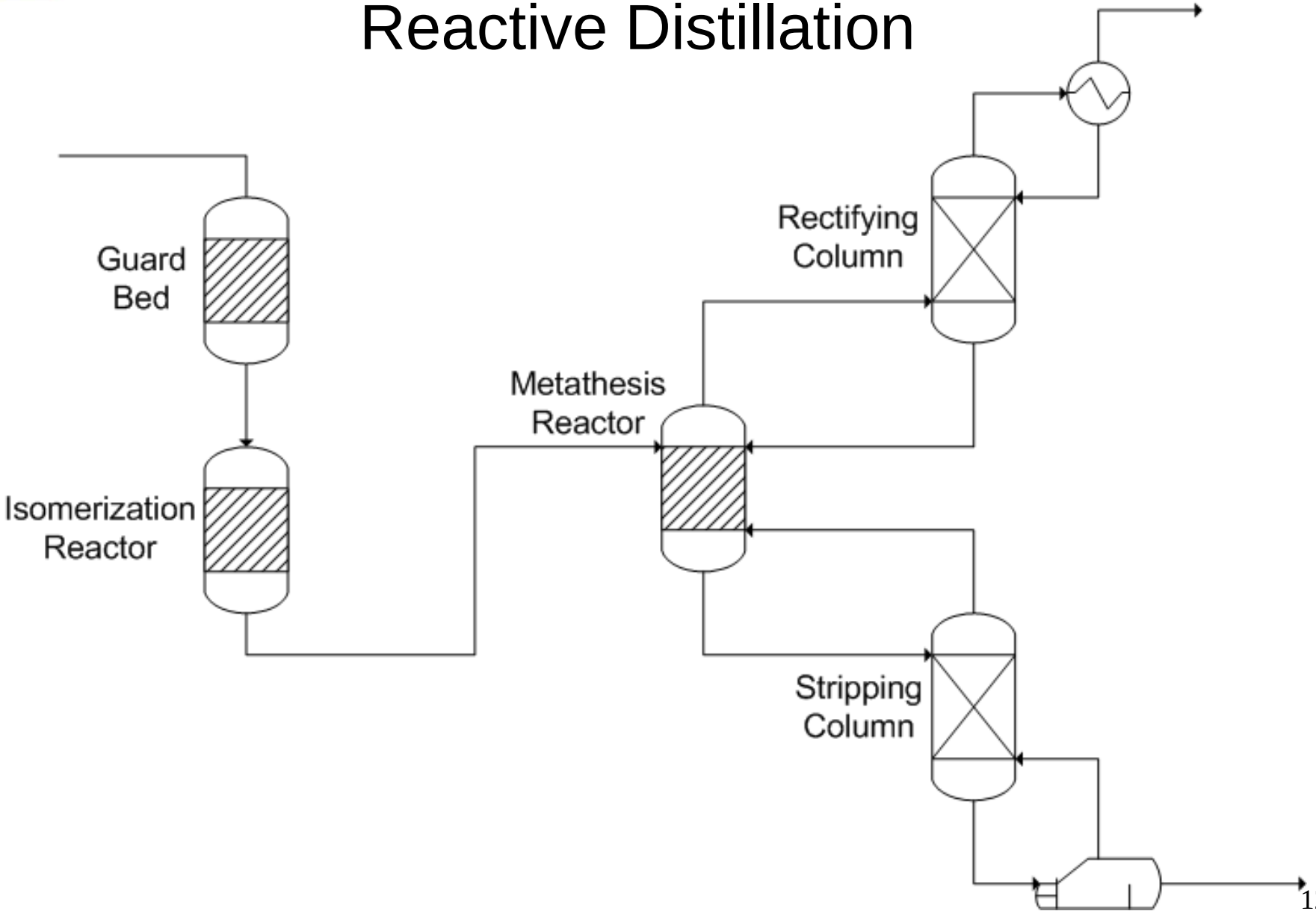


Experimental Unit

Open Literature Data

Reference	Membrane	H_2 permeance $cm^3/cm^2/min/Psi$ (500 C)	H_2/N_2 selectivity	H_2/H_2O selectivity
B.K Sea	SiC	$9*10^{-2}$	4.3	4.5
B.K Sea	SiO2	$5.4*10^{-3}$	2400	11
M. Kanezashi	Ni doped silica	$1.1*10^{-6}$	400	37
Membrane A	Separative layer Al_2O_3	$9*10^{-2}$	5	1.8

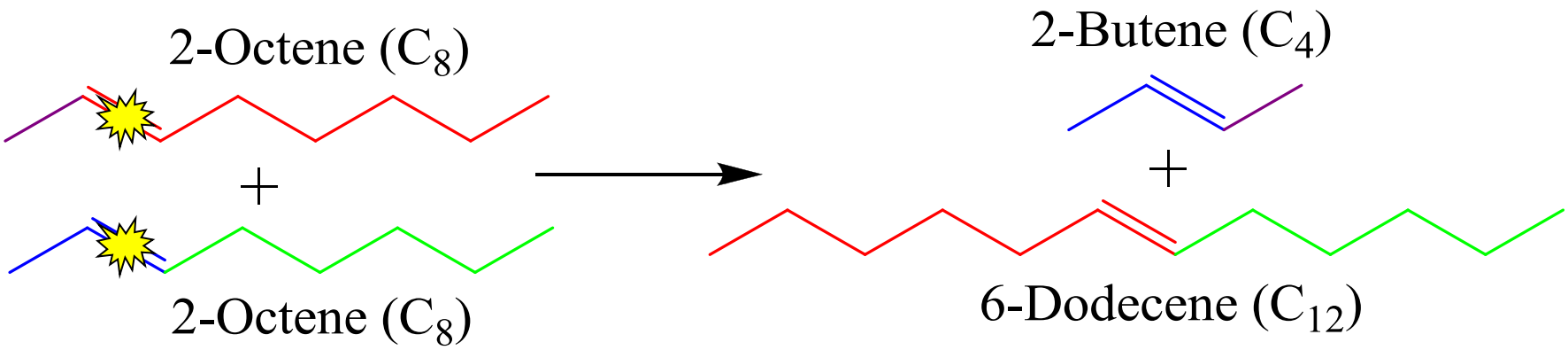
Reactive Distillation



Reaction: Olefin Metathesis

- Catalyzed equilibrium reaction that cleaves double bonds in alkenes and redistributes the alkene fragments

- With two asymmetric alkenes

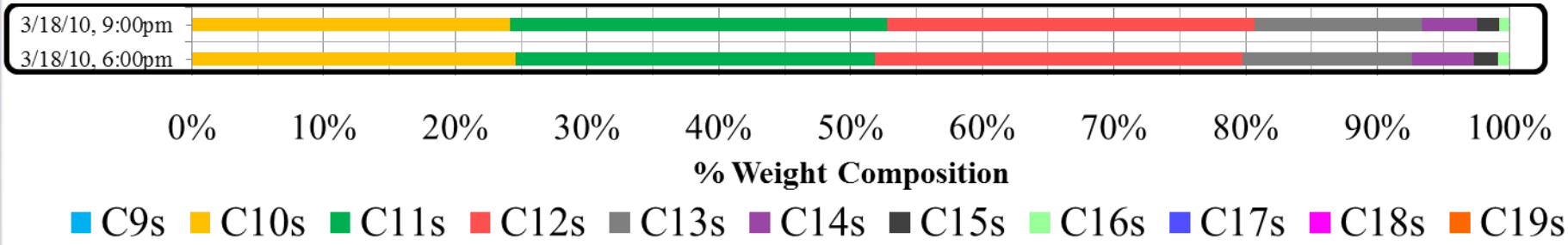


- Further isomerization and subsequent metathesis can be used


Metathesis
Reactor

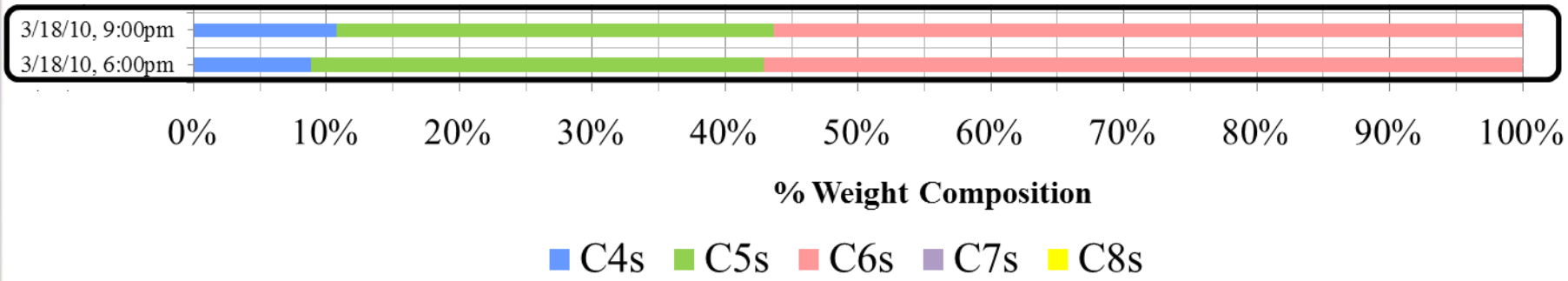

Stripping
Column
Rectifying
Column

Bottoms Concentrations



C8s	0.00%
C9s	0.00%
C10s	24.00%
C11s	28.00%
C12s	28.00%
C13s	13.00%
C14s	4.00%
C15s	2.00%
C16s	1.00%

Reflux Concentrations

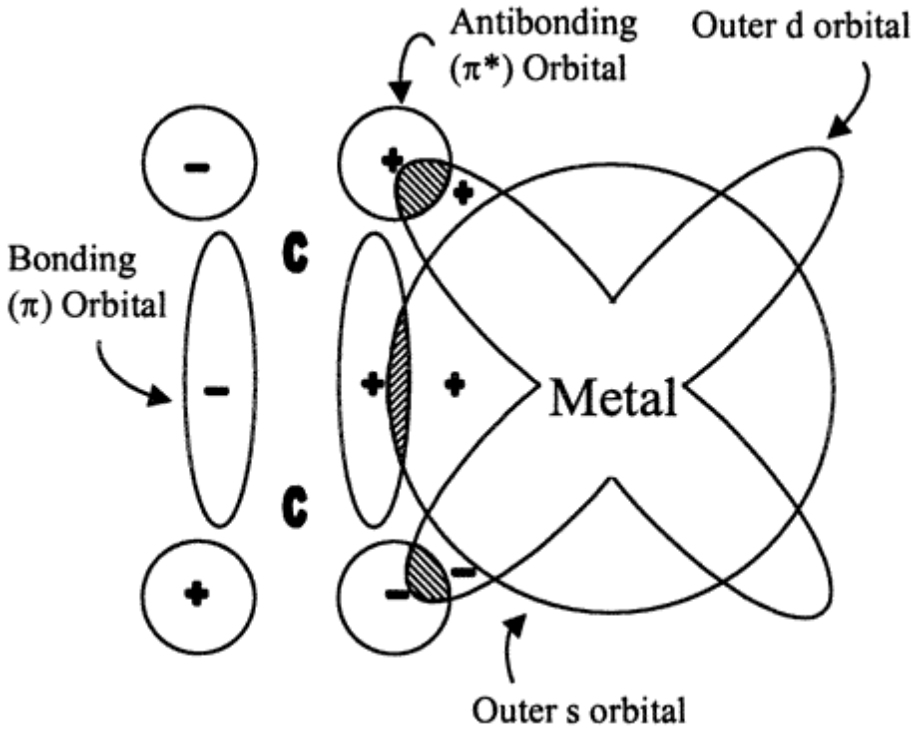


Compound	Reflux
C2s	0.00%
C3s	0.00%
C4s	10.00%
C5s	33.00%
C6s	57.00%
C7s	0.00%
C8s	0.00%
Total	100.00%

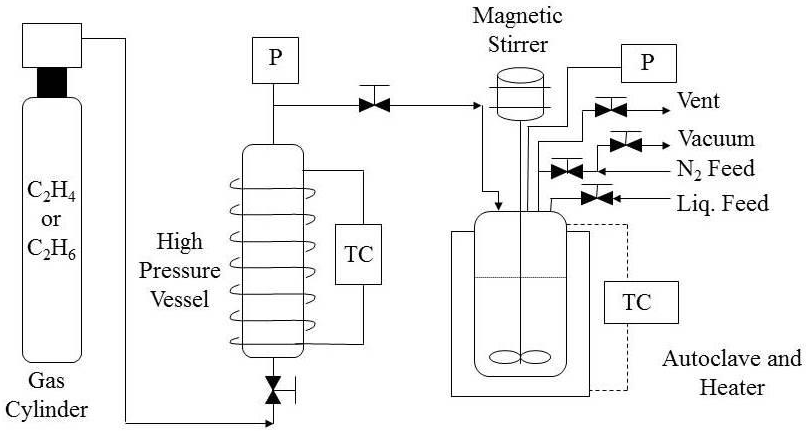
Chemically Enhanced Separations

π bond complexation

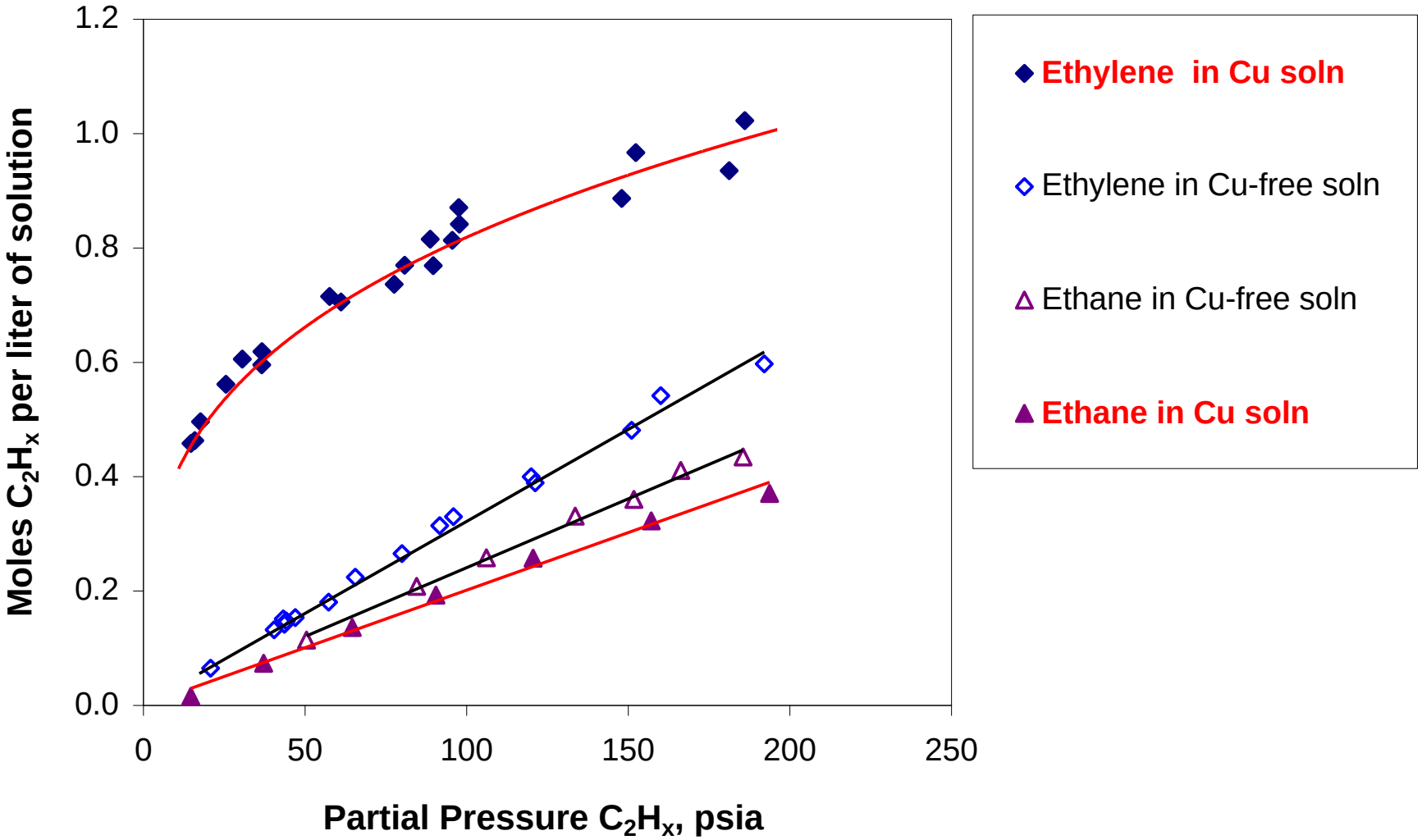
- Weak reversible chemical bond
- Complexation favored by high pressures and low temperatures



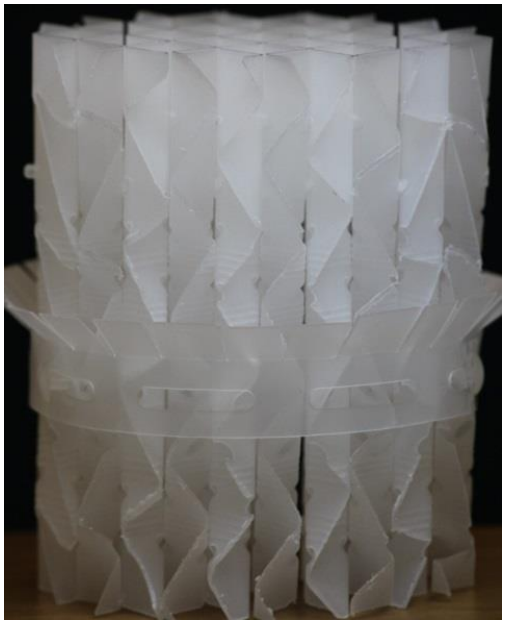
Experimental Apparatus

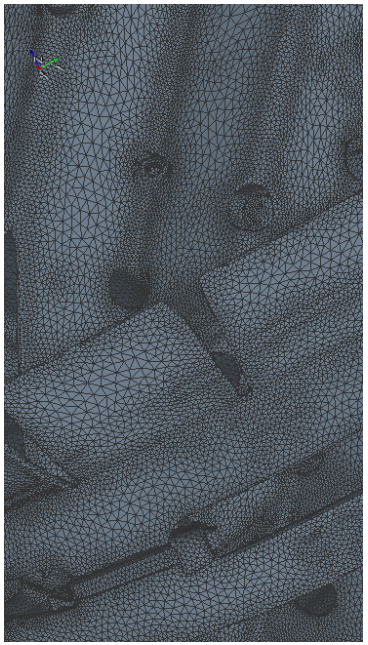


Chemical Complexation

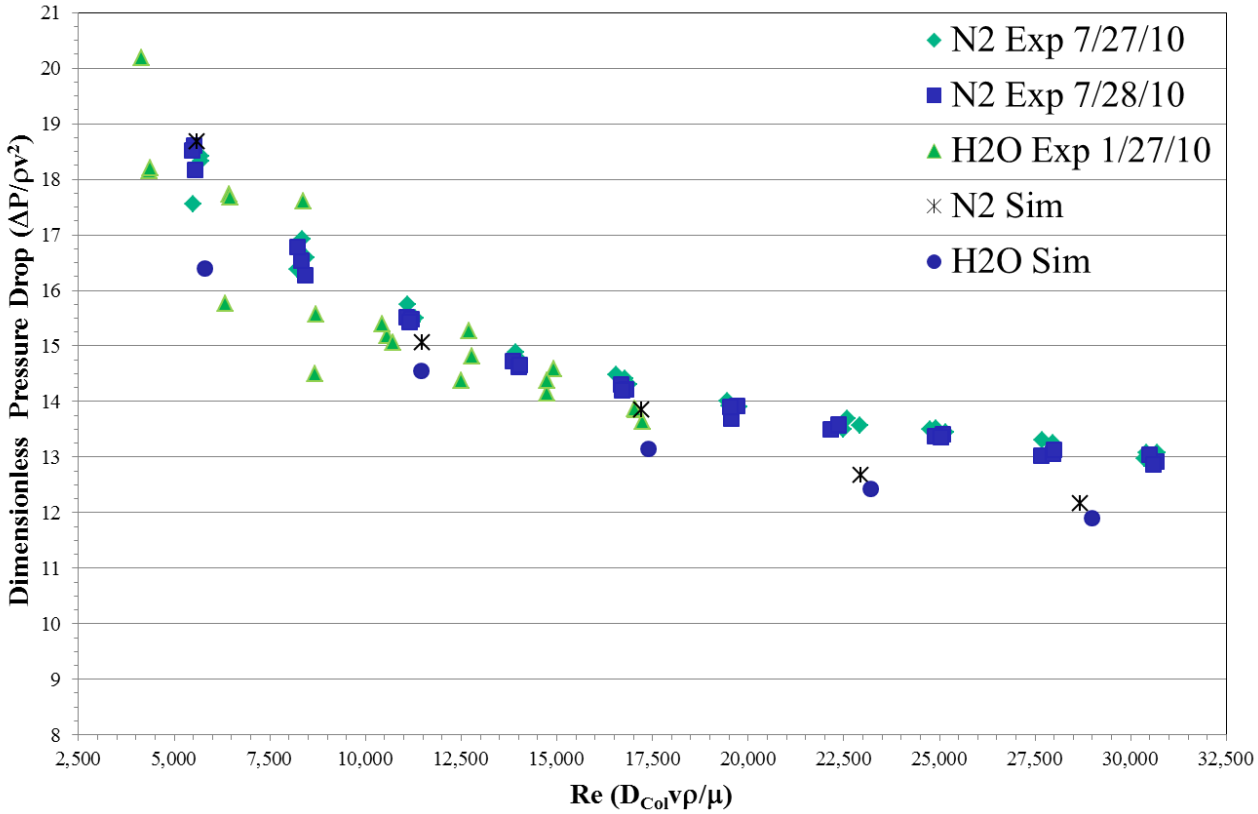


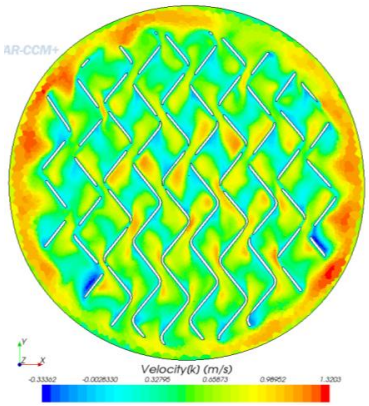
Rapid Prototyping of Mass Transfer Internals



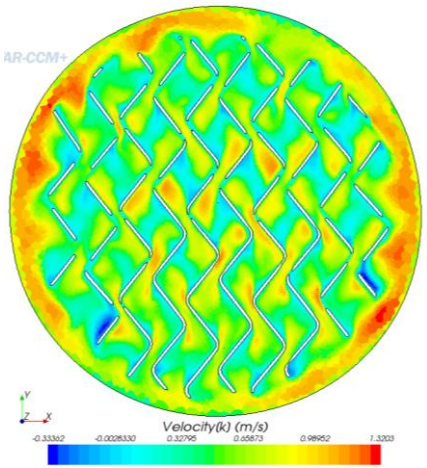


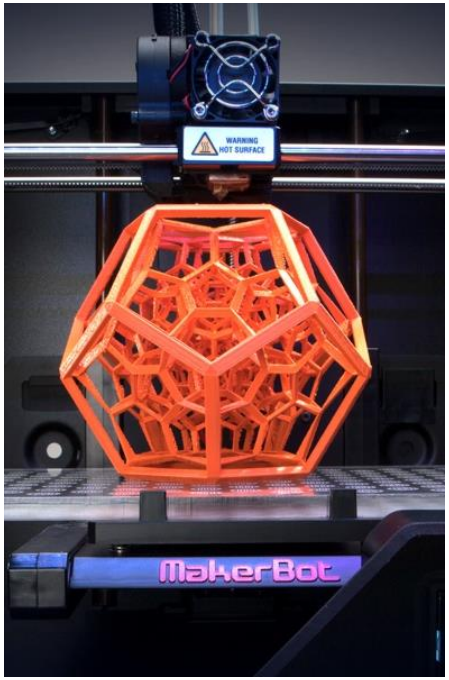
CFD Geometry Generation





CFD Simulation Results





Rapid Prototyping / Testing