PROPIONIC ACID PRODUCTION

Production of 100,000 metric tons of propionic acid yearly for use in the food industry.

BACKGROUND

Propionic acid is primarily used in the food industry as a preservative. This is due to its effectiveness in combatting bacterial and fungal growth.

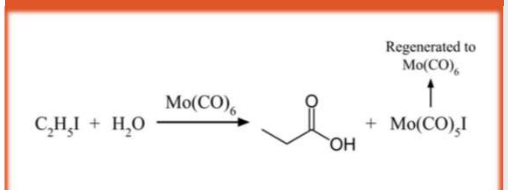
Propionic acid is produced via four main chemical pathways. This includes the oxidation of naphtha, propionaldehyde, or ethylene/syn-gas. However, the most common industrial method for producing propionic acid is the carbonylation of ethylene using carbon monoxide and water. Fermentation is also a viable production method using the Propionibacterium strain.

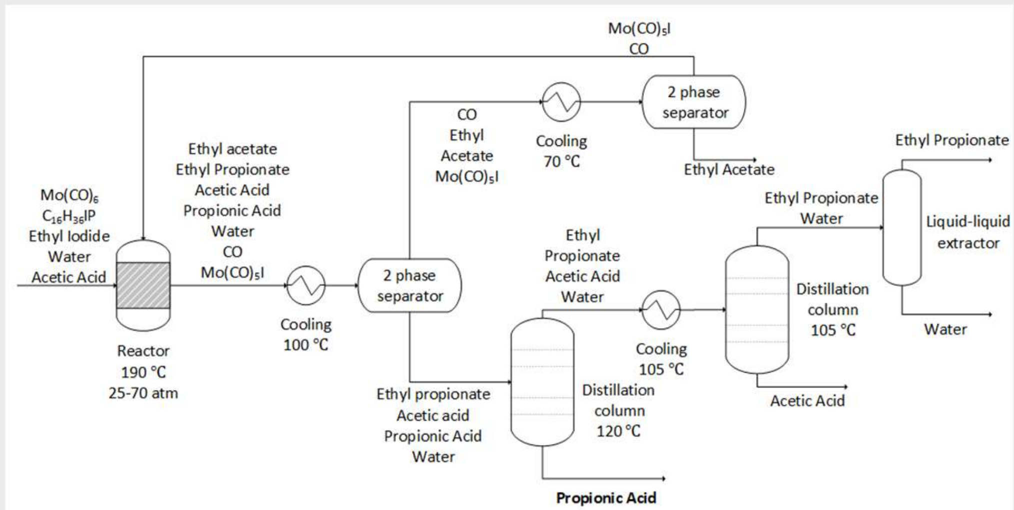
The demand for propionic acid is expected to grow. As global populations continue to increase, the demand for food production and preservation will grow alongside it.

The product is market viable at its current selling price. It sits at $1,250 per metric ton, which would result in a profit of $125 million a year at full plant capacity.

The proposed method for production is the carbonylation of ethyl iodide using a molybdenum hexacarbonyl catalyst and water. It follows the simplified scheme below.

BASIC REACTION SCHEME





PROCESS OVERVIEW

1. Ethyl iodide, water, and acetic acid enter a molybdenum-based catalyst filled reactor to produce propionic acid and other by-products.
2. All products are cooled to 100 °C and separated based on phase.
3. Vapor phase products are further cooled to 70 °C and separated based on phase. A minute amount of molybdenum-based catalyst is recycled back into the reactor and high purity ethyl acetate exits system.
4. Liquid phase products are distilled, and propionic acid exits the system. The remaining products are cooled to 100 °C and distilled again, and acetic acid exits the system. The ethyl propionate and water enter a liquid-liquid extractor and are separated based on density. High purity ethyl propionate exits the system and water is transferred to wastewater treatment.
5. The wastewater is treated and recycled back into the reactor.

TECHNICAL WORK

- The primary form of technical work for this project was completed in the modeling software HYSYS. This included case studies on individual units for process optimization.
- Initial P&ID work was performed in Visio and was used to outline the general flow of the process as well as side streams.
- A rudimentary controls scheme was created for the operation of major units. These units include the reactor and distillation columns.
- Pressure vessels were properly sized according to their operating conditions and ASME BPVC. Pressure relief valves were similarly sized as safety checks for the process.
- A cost analysis on the plant including determining manufacturing, sales, and maintenance costs associated with operating the plant was performed.

RESULTS AND FUTURE WORK

The reaction scheme selected converts ethyl iodide, water, and acetic acid into propionic acid and other by-products in the presence of a molybdenum-based catalyst. Through the separation processes shown in the PFD (center), high purity by-products ethyl acetate, acetic acid, and ethyl propionate can be obtained for additional profit. The effluent water from the liquid-liquid extractor can be treated and recycled for further use. The molybdenum-based catalyst can be separated and recycled back into the reactor to lessen raw material costs. Future work on this chemical plant include the following:

- Simulating the entire process in HYSYS modeling software to assess feasibility.
- A cost analysis to estimate the profitability of the plant.
- An energy savings analysis to assess where more energy efficient processes can be implemented.
- Further safety analysis including pressure vessel and relief valve sizing on non-major equipment.
- Develop more complex control schemes including alarms and control room monitoring.
- Creating a cohesive P&ID that includes all control schemes and safety features.

ACKNOWLEDGEMENTS

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