Sustainable Manufacturing of Gamma Butyrolactone

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Due to its unique physicochemical properties, gamma-Butyrolactone (GBL) is regarded as a universal solvent and an important precursor for many pharmaceuticals. However, the current industrial manufacturing procedures for GBL, Reppe Chemistry, has caused detrimental environmental impacts, due to its dependency on Acetylene, an extremely flammable compound generated from natural gas, and Formaldehyde, an EPA-classified carcinogen. Recent developments in bio-synthesis of intermediates suggested the possibility of a continuous fermentation process utilizing glucose and CO2 as production feedstocks for the generation of an intermediate of GBL, succinic acid (SAC). SAC can then be processed through hydrogenation, dehydration, and purification to form liquid GBL; to investigate the industrial feasibility and mass-production conditions, a pilot plant was designed with necessary unit operations in DWSIM v5. Optimization targeting ideal yield and energy efficiency were performed and the process simulation demonstrated adequate feasibility of the proposed design. A single-pass conversion exceeded 32.8%, and recycling of over 95% unreacted materials drastically minimizes waste and pollution. Carbon sequestration through consumption of CO2 in fermentation reactions further decreases the level of greenhouse gases. Compared with Reppe procedures, the proposed method operates at significantly lower temperatures and pressure, minimizing initial hazards and risk. Instead of utilizing lethal reactants and fossil-fuel derivatives, a bio-engineered pathway with renewable feedstocks eliminates initial environmental hazards. This proposed design takes into account economic systems, utilizes minimal energy/materials, and provides for human needs while preserving ecosystem services.

Awards Won:

Third Award of $1,000

American Chemical Society: Certificate of Honorable Mention