Thesis Project Portfolio

Allergy Relief at Scale: Plant Design for Diphenhydramine Hydrochloride

(Technical Report)

How have chemical and industrial accidents shaped the evolution of safety education in chemical engineering programs?

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2025

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Sociotechnical Synthesis

Introduction

My technical work and STS research are both centered around safety in chemical engineering. My technical project focuses on a newer synthesis of diphenhydramine hydrochloride, better known as the brand name Benadryl, without the use of bromine. Bromine is a hazardous chemical that proposes risks to both the environment and workers. The decision to eliminate bromine was to explore a solvent free, safer synthesis for diphenhydramine hydrochloride. My STS research investigates how safety education has evolved for chemical engineers due to industrial accidents. The connection between the two projects is not direct, but they both are motivated by wanting to understand and improve safety in chemical processes whether it be for small molecule synthesis or education.

Technical Report

My technical project was the design of a newer synthesis for diphenhydramine hydrochloride. Current processes use bromine, so we took newer lab scale synthesises and scaled them up to propose our project. We designed a plant to produce 457,320 kg per year of diphenhydramine hydrochloride using a process that was split into 4 blocks. Block 1 is where benzophenone is reduced to benzhydrol which then goes to block 2. Block 2 is where benzhydrol is chlorinated to form chlorodiphenylmethane. In block 3, esterification occurs to create an unpurified diphenhydramine hydrochloride, which is then purified in block 4. All unit operations including reactors, crystallizer, and decanters were all designed to fully model the process. The final design is an operating diphenhydramine hydrochloride plant with the primary goals of safety and

sustainability. An economic analysis was also conducted to see if the plant would be economically feasible to build and operate.

STS Project

My STS project focuses on how safety education has been changed and implemented due to chemical accidents that have happened in industry or academic labs. By analyzing case studies such as the Bhopal disaster, the Texas City refinery explosion, and the death of a UCLA grad student, I was able to see how safety education reacted to each case study. I examined the gaps that these case studies exposed in the system and how education was changed to address them. Throughout the research, I argue that change has been made, but safety education is very reactive to incidents so there are still gaps that need to be addressed before more accidents occur.

Conclusion

Working on my technical project and STS research simultaneously gave a deeper understanding of the role safety plays in chemical engineering. Before this year, I believed that safety education was always common sense, and thought it did not need to be taught as in depth as it is. However, while designing a plant it showed me how much of the processes can be dangerous conditions for workers and any misstep can cause a fatal accident. Studying those real life accidents for STS made me even more conscious of hazard identification and risk mitigation in the process design for my technical work. It also helped me appreciate why my process safety course was implemented into my education this year and went beyond rules and regulation. Engineers need to understand why safety decisions are made to fully appreciate and take them seriously. Conducting my STS research while working on my technical project was a rewarding experience that redefined my mindset on safety and decision making in design.