Thesis Project Portfolio

Production Plant of Nanoparticle Mineral Oxide Sunscreen

(Technical Report)

Multinational Moral Responsibility: An Analysis of the Bhopal Disaster

(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

My technical research project and my STS research are connected through the responsibilities that come with designing large, potentially hazardous chemical systems. My capstone project focuses on the design of a nanoparticle mineral sunscreen manufacturing plant, emphasizing safety and environmental considerations in a chemical process. In contrast, my STS research investigates the Bhopal disaster, analyzing the ethical failures that contributed to the tragedy. While my technical work aims to design an efficient chemical system, my STS research critically examines what happens when key responsibilities are neglected. Though the projects approach chemical engineering in either a forward-looking and design-based perspective or a retrospective and ethical perspective, they are both grounded in the importance of responsible engineering practice.

My technical work explores the idea of using chemical engineering principles to design a large-scale production plant for nanoparticle mineral sunscreen. This plant is designed to manufacture a broad-spectrum sunscreen using zinc oxide and titanium dioxide nanoparticles, which are effective at filtering UV rays while eliminating the white cast typically associated with mineral sunscreens. Our design includes three main processes: nanoparticle synthesis for both metal oxides and final product emulsification. We also considered regulatory constraints set by the FDA and prioritized safe, non-irritating, and non-comedogenic ingredients that appeal to a wide range of skin types. The project combines technical process design with broader social goals of accessibility and equity in skincare.

My STS research also explores a chemical process facility, but from a different angle. Rather than focusing on process design, my paper examines the ethical responsibilities of engineers in the context of the 1984 Bhopal gas leak. Using Ibo Van de Poel and Lambèr Royakkers' moral responsibility of engineers framework, I analyze how the actions of Union

Carbide Corporation (UCC), its Indian subsidiary UCIL, and the Indian government collectively contributed to the disaster (Poel & Royakkers, 2011). In my research, I argue that the Bhopal tragedy was not the result of individual negligence, but a systemic moral failure enabled by a transnational network lacking clear accountability. The goal of my paper is to clarify how moral responsibility functions across complex industrial systems and to emphasize the importance of ethical oversight in global chemical manufacturing.

Working on both my technical and STS projects allowed me to approach engineering design with a more critical and ethically informed mindset. As my team designed a nanoparticle sunscreen plant, I used my analysis of the Bhopal disaster and the systemic moral failures it revealed to inform our design choices. This perspective encouraged my team to prioritize not just economic feasibility, but also safety and social responsibility in our design. Conversely, the technical challenges of our capstone project gave me a deeper understanding of large-scale chemical manufacturing, reinforcing how easily ethical oversight can be lost in such systems. Moving forward, I will carry the insights from my STS research into future engineering work, ensuring that questions of responsibility and long-term impact are integral to my approach as a chemical engineer.

References

Poel, I. van de, & Royakkers, L. (2011). Ethics, technology, and engineering: An introduction. Wiley-Blackwell.