

Producing a Bioplastic from Biodiesel Waste: Polyhydroxybutyrate using Crude Glycerol
(Technical Paper)

How the Evolution of the News Industry Encourages Petrochemical Company Misconduct
(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Chemical Engineering

By
Allison Feeney

October 27, 2022

Technical Team Members:

Alexa Cuomo
Isabelle Deadman
Hamsini Murali
Justine Yun

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Eric W. Anderson, PhD, Department of Chemical Engineering

Bryn E. Seabrook, PhD, Department of Engineering and Society

Introduction

The petrochemical industry reaches almost every aspect of society. From soap, to plastic, to food additives, petrochemical products are in our daily lives for better or worse. These products make our lives easier and cleaner, but at the expense of greenhouse gasses, environmental pollutants, and safety concerns. For people that live near a petrochemical facility, the negative environmental and health implications are more concentrated (Gelles & Steel, 2021). Communities located near petrochemical plants are disproportionately affected by emitted waste in the air and groundwater (Gelles & Steel, 2021). One last line of defense for local communities is their local news outlets. Local news is instrumental in whistleblowing corporate misconduct (Governance, 2021). However, as the news industry transitions to national news and social media, will this make local communities more vulnerable to unchecked corporate misconduct (“The Loss of Newspapers and Readers - News Deserts,” n.d.)? The purpose of the STS research paper is to answer this question.

Another environmental side effect of the petrochemical industry is the plastics that they produce. As plastic waste builds up in our landfills and oceans, it is vital to find a cleaner alternative to petroleum derived plastics (US EPA, 2017). A potential solution is biodegradable plastic made from biodiesel waste (Posada et al., 2011). Biodiesel is made by reacting vegetable fats with alcohol to form fuel that can be burned by diesel engines (*Alternative Fuels Data Center: Biodiesel Production and Distribution*, n.d.). The waste from this process, glycerol, can be fermented to form biodegradable plastic, polyhydroxybutyrate (PHB), for consumer or medical uses (Hejna et al., 2016). Designing an economically viable biodegradable plastic plant is vital for increasing the value of a waste stream as well as producing an environmentally friendly plastic, which is the goal of the technical report.

Technical Prospectus

The sustainable materials group in Professor Anderson's chemical engineering capstone class intends to produce PHB using the crude glycerol co-product from a biodiesel plant. PHB is a biodegradable polymer that is produced by microorganisms (Akhlq et al., 2022). Posada et al. describes a process to produce PHB in Colombia that we will adapt to fit the specifications of glycerol waste stream from a biodiesel plant in Iowa. The general block flow diagram begins with purification of the crude glycerol using a distillation column to prepare it for the fermentation process (Figure 1).

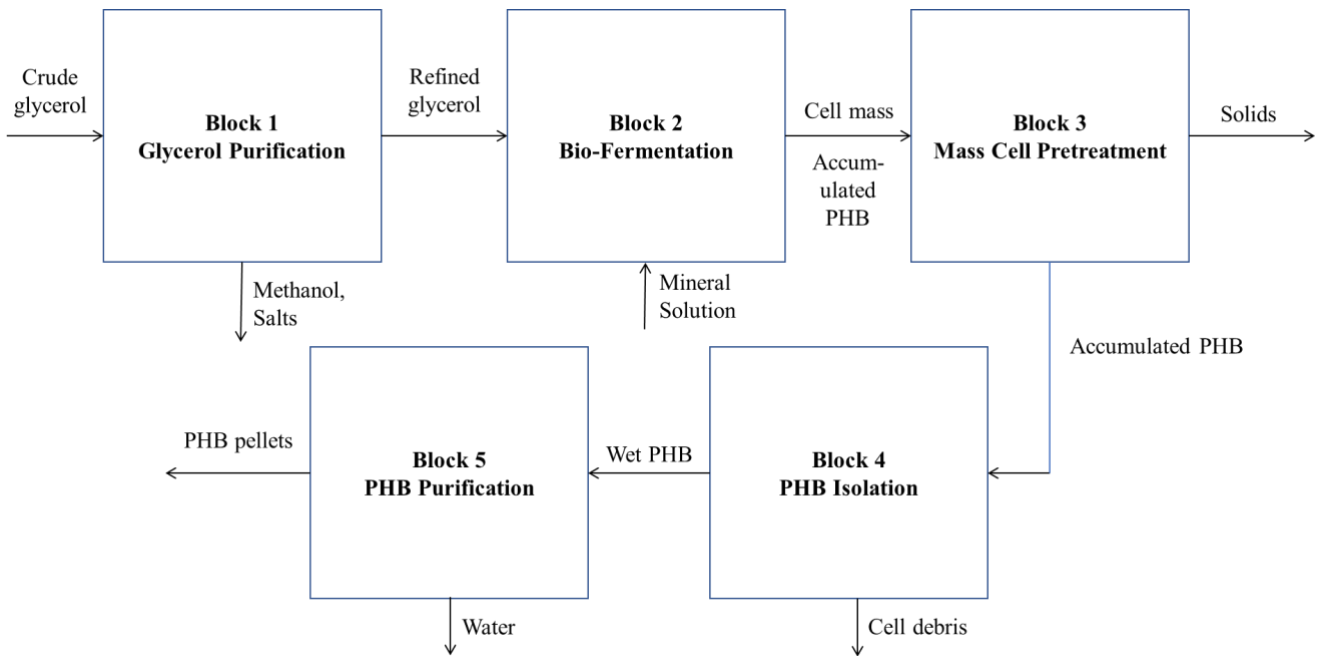


Figure 1. Block Flow Diagram of Overall Process for PHB Production (Feeney et al, 2022)

In the fermentation process, a growth fermenter and an accumulation fermenter will be used to cultivate mass cell growth and promote PHB synthesis, respectively. In the growth fermenter, glycerol will serve as the carbon source for the cultivation of the microorganism *Cupriavidus necator*. The fermentation is a fed batch process, and the first fermenter will be at optimum nutritional conditions to achieve high cell density. Restricting nitrogen in the accumulation

fermenter will then promote PHB synthesis. During the second fermentation stage, cell density remains constant while PHB concentration increases. After the fermentation process, the PHB is extracted from the microorganisms and purified. Cells are pretreated in a high-pressure homogenizer and centrifuged to extract excess water. Following pretreatment, the product stream undergoes solvent extraction. Once isolated, the PHB stream is treated to reach 99.9% product purity. For commercial sale, the PHB stream is extruded to form pellets.

Biodiesel is a growing commodity as the transportation sector transitions to low carbon fuel sources (Hejna et al., 2016). Glycerol is the main byproduct (10 wt%) of biodiesel production, and there is currently an untapped market for turning this waste into a profitable end-product (Posada et al., 2011). Glycerol is mostly produced synthetically and is used in many consumer products. It can also be used as a carbon source to produce PHB, a biodegradable plastic. Transitioning to the use of biodegradable plastics will decrease the amount of waste in landfills and will avoid the release of harmful substances into the environment from the breakdown of plastic (Mostafa et al., 2020). Currently, the total capacity for PHB production is 30 kilotons per annum (ktpa) and is produced by Monsanto through the genetic modification of plants (Koller & Mukherjee, 2022). Our proposed method is more sustainable and uses a lower price material as a feedstock, making it price competitive with Monsanto's process (Koller & Mukherjee, 2022). The PHB plant would be in Iowa, where US biodiesel production is concentrated, to maximize access to waste glycerol and limit transport costs. To produce 0.130 ktpa of PHB, we would need 12 ktpa of crude glycerol feedstock. REG is one of the major biodiesel producers in Iowa with a total glycerol production capacity of about 30 ktpa. REG operates 3 plants within 150 miles of each other and we would buy waste glycerol from one or more of their biorefineries (Table 1).

	Location in Iowa	Biodiesel Annual Capacity (ktpa)	Glycerol Annual Capacity (ktpa)
REG Ralston LLC	Ralston	99.55	9.95
REG Newton LLC	Newton	99.55	9.95
REG Mason City LLC	Mason City	99.55	9.95
		Total Supply	29.86
		Maximum PHB Production Capacity	1.856

Table 1. Feedstock Sources for PHB Plant in Iowa (US Biodiesel Plants, n.d.)

We will execute the technical project as a team over the course of two semesters. Aspen, a unit operations modeling software, will be utilized to model the different unit operations such as the fermenter and distillation column for purification. Along with modeling, material stream analysis will be done in Aspen. Excel will be used to perform further analysis on the process data (purity, stream flow rates, compositions) and for economic analysis of the entire process. A Design Basis Memorandum, including a description of the starting materials, products, scale, and process as well as a brief economic appraisal, will be completed in the fall semester. The remainder of the research and complete design of all equipment, plant specifications, and full economic analysis will be developed in the Spring semester. The design data will be derived from multiple journal articles that detail process steps and parameters.

STS Prospectus

Background

Today, the world has access to more news stories than ever before thanks to the internet (Sagan & Leighton, 2010). However, as local news coverage decreases, the news industry is shifting to national news and social media. Between 2004 and 2018, 1800 local newspapers closed or merged in the United States, decreasing the number of active circulations by 20 percent. 1700 of these newspapers were weekly papers and 60 were daily. Almost all these

closures were newspaper mergers to form larger newspapers with a larger readership, losing a local lens. These closures were due in part to a 40% decrease in print readers as readers have switched to online news through the internet and social media (“The Loss of Newspapers and Readers - News Deserts,” n.d.). Local news has been at the forefront of protecting local communities from corporate misconduct. Journalists reporting chemical dumping and other misdeeds has been crucial to keeping people safe. The weakening of local news has been correlated to a 1.1% increase in corporate misconduct from all industries (Governance, 2021). While this number may seem small, left unchecked this correlation will likely only increase. The STS research paper will analyze how access to local news protects citizens from corporate misconduct from chemical companies.

Technological Determinism is a STS theory developed by Tench Coxe in the late 1700s that describes how technology, such as news outlets, is the ultimate driving force in societal change. Tench Coxe uses the theory to describe how the industrial revolution has impacted society. More specifically, he believed that the best way for the United States to gain political independence after the American Revolution would be through economic independence via mechanization. Other historians have returned to technological determinism to describe how technology shapes society. For example, Boyd’s *Triumphs and Wonders of the 19th Century* described with awe and enthusiasm the latest developments in electricity, naval engineering, architecture, and chemistry. Artists such as John Gast showed symbolically through, railroads and telegraph lines, the impact of technology on US western migration characterized by Manifest Destiny (Smith, n.d.). The theory is not without its critics. Some such as Nye and Hughes believe that technological determinism over-simplifies the complex relationship between technology and society (Hughes, n.d.; Nye, 2006). However, this simplification helps understand an important

aspect of how changing news outlets affects society. Further research could be done to understand how changing society affects news outlets. This research is important because the trend in nationalization of news is only increasing. Paying attention to how a decline in news sources impacts local communities will be vital to protect future generations from more inevitable corporate misconduct.

Methodology

The research question is: How has the evolution of the media industry made communities more vulnerable to misconduct by the petrochemical industry?

To answer the research question, I will study the history of chemical corporate misconduct including environmental pollutants and safety incidents. I will especially focus on case studies in the PFAS pollution in Fayetteville, North Carolina by Chemours and DuPont, as well as the federal case *Anderson vs Cryovac* concerning toxic contamination of groundwater in 1986 in Woburn, Massachusetts (Gelles & Steel, 2021; Harr, 1996). Next, I will conduct more research into how a transition away from local news to national news and social media has affected the average American. I will be investigation secondary sources with keywords such as newspaper closures, nationalization of news, local news, and impact of social media. Lastly, to answer the proposed research question, I will put these analyses together to see how the two are connected.

Conclusion

In summation, the goal of this research portfolio is to address the challenges of sustainability in the petrochemical industry from two sides. The technical capstone proposes a sustainable alternative to traditional petroleum derived plastics, making biodegradable plastic from biodiesel waste (Posada et al., 2011). The STS research paper addresses the impact of

petrochemical plants on local communities, and how these communities could become more vulnerable to misconduct as the news industry evolves. The PHB plant design project will determine the economic and technical feasibility of an industry scale biological production facility in the United States which will be useful as the scale up of this technology is considered. The social analysis of the effect of the news industry on petrochemical company misconduct will raise awareness of the unforeseen consequences of the digitization and nationalization of news.

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