Thesis Project Portfolio

Producing Bioplastic from Biodiesel Waste: Poly(hydroxybutyrate) using Crude Glycerol

(Technical Report)

Examining Inequality in the Vaccine System in the COVID-19 Pandemic Era

(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

Hamsini Muralikrishnan

Spring, 2023

Department of Chemical Engineering

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Sociotechnical Synthesis

The motivation for the STS research came from reviewing COVID-19 data and reading the news to learn how minority communities were disproportionately affected by this pandemic. Although the pandemic struggle was mutually shared amongst the nation, some groups had access to services such as hospitals, local clinics, and pharmacies to get tested, vaccinated, and learn about the current state of the pandemic while others did not. The development of the vaccine stood as a glimpse of hope for the nation; however, only some could share this sentiment. The bias linked with the healthcare system along with structural barriers such as redlining, internet access, and residential segregation, influences factors such as healthcare and vaccine access, vaccine literacy, and even insurance affordability. This makes it more difficult for some racial and ethnic groups to interact with these services than others, namely the Black population. For the capstone project, the unsustainable nature of plastics has motivated investment in alternatives to conventional plastics produced from petrochemicals. In the face of massive amounts of plastic pollution in today's world, we sought to design a plant to repurpose a waste stream from the biodiesel industry to produce a biodegradable plastic. Essentially, we will be using crude glycerol to produce Poly(hydroxybutyrate) (PHB) to contribute to a circular and more sustainable economy.

There are two parts to the capstone design: the upstream process, where PHB is produced within *C. necator* cells using glycerol as a substrate, and the downstream process where PHB is isolated from *C. necator* and purified. The goal of the upstream process is to provide optimal conditions to grow the maximum amount of PHB. The fermentation substrate is crude glycerol (80 wt%), a byproduct of biodiesel production. First, *C. necator* will be grown in a seed train to provide high cell density inoculum to the large fed batch bioreactors. Then, the inoculate will be transferred to large fed-batch reactors where *C. necator* will be further grown to accumulate PHB. Over the growth phase, *C. necator* grows in the glycerol media and PHB slowly accumulates with the supply of nitrogen in the form of ammonium hydroxide. Around two-thirds of the way through the fermentation process, the nitrogen source to the reactor is replaced with potassium hydroxide (KOH), which causes the microbes to store mass amounts of

substrate. Then, the microbes produce mass amounts of PHB in the nitrogen depletion phase. Once the maximum concentration of PHB is achieved at 33.5 hours, the contents of the reactor are sent downstream to separate, purify, and package the PHB to be sold to plastic manufacturers. First, the fermenter effluent is sent through two homogenizers to perform cell lysis. Then the disrupted cells are sent through a series of two disc-stack centrifuges to isolate the PHB. Then, the PHB and water mixture is sent through a spray dryer and the 99.9% pure PHB is then sent through a plastic extrusion process to produce 25 kg bags of 3 millimeter (mm) plastic pellets.

The STS research explores the political ramifications of the vaccine system, a large sector of the overarching healthcare system, on the Black community. The dynamic between the vaccine system and the Black community has posed disproportionate effects on this community compared to the White majority. These health disparities were particularly exacerbated during the COVID-19 pandemic, so it was important to explore how the vaccine system played a role in this. The premise of this paper focuses on how during COVID-19, inequality amongst the Black community rose through multiple venues surrounding the vaccine system, notably vaccine hesitancy, literacy, and rollout/access practices. As found through the analysis, there is low vaccine/health literacy, high vaccine hesitancy, and limited vaccine rollout/access amongst the Black community, which contribute to low observed vaccination rates, producing high susceptibility to COVID-19 effects and a peak in COVID-19 disparities.

Working on the STS research while also completing the capstone project was rewarding and informative, even though the projects were not explicitly linked. The STS research focused on how the vaccine system aided the development COVID-19 disparities due to the precedence of structural barriers and racism. Exploring factors such as vaccine hesitancy, literacy, access/rollout practices helped me understand the depth of discrimination that has permeated the walls of the overarching healthcare industry. Furthermore, while the vaccine and healthcare system stand as a service to the community, it is important to consider the politics of the system's function and design. Essentially, I learned to consider inclusivity in design for the capstone project in regards to safety and product pricing. With social and political

implications in mind, we designed the project to address the larger issue of global warming and climate change in our nation. We followed inherently safer design by producing this sustainable material and relying on mechanical separation instead of chemical extraction methods.