Sociotechnical Synthesis

STS 4600-022

Spring 2022

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Signature ______________________________ Date 05/10/22
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Approved ______________________________ Date 08 May 2022
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Every year, more than 380 million tons of plastic waste is produced globally, and about half of that waste is derived solely from single-use plastics. If not disposed of properly, these plastics can pollute the environment and leach carcinogens into the environment and poison the surrounding ecosystems, causing detrimental and irreversible harm (“Plastic Pollution Issues | The Problems With Plastic,” n.d.). This emphasizes the need to decrease our reliance on these synthetic petroleum plastics and begin to find more sustainable alternatives. The solution to this problem is to gradually begin the transition over to bioplastics. Bioplastics are plastics that are both compostable and biodegradable and/or are made from biomass. One of those bioplastics is called polyhydroxybutyrate, or PHB, which is a non-toxic and biodegradable bioplastic that can be easily degraded in microbially active environments, ultimately reducing the plastic accumulation in landfills. As a result, my technical project focuses on maximizing the production of polyhydroxybutyrate (PHB) using genetically engineered bacteria. My STS research focuses on examining the current plastics that the food industry giants use, and examining the beneficial environmental impacts that would occur with the switch over to PHB.

The technical portion of my thesis aimed at being able to increase the production of PHB within genetically engineered bacteria that our sponsor had given us. The *E. coli* bacteria that our sponsor, Transfoam, gave to us consisted of two plasmids: the sty and pha plasmids, which gives the cells the ability to convert styrofoam into acetyl-CoA, which is the precursor molecule of PHB. Therefore, by maximizing the amount of acetyl-CoA within the cell, the subsequent production of PHB would increase as well. The project focused on using CRISPR-Cas9 in order to delete two genes within our genetically engineered *E. coli*, that consume acetyl-CoA. The two genes that were knocked down were acetyl-coA kinase (acka) and phosphate acetyltransferase (pta), together known as the Pta-Acka pathway. Our hypothesis was that by deleting this pathway, it could maximize the intracellular acetyl-CoA concentration and flux towards PHB production by inhibiting the conversion of acetyl-CoA into acetate which has been found to increase intracellular concentrations of acetyl-CoA.

In my STS research, I examined the companies that consume the most plastic within the food industry and the most common types of plastic that were used, which helps emphasize the need to transition over to PHB. Then I examined the benefits of using PHB over the types of plastics these companies currently use. The two companies I discovered that used the most single plastic are Coca-Cola and Nestle. Coca-Cola had by far the largest plastic footprint in 2002, with approximately 3 million tons of plastic packaging produced globally each year, which is equivalent to 200,000 bottles a minute (*• Chart: The Companies With the Largest Plastic Footprint | Statista*, n.d.). Nestle is the second largest consumer of single-use plastics in the food industry. The company was also named the worst plastic polluter following 2017 and 2019 waste and brand audits in the Philippines. However, Nestle has pledged to make all of its products and packaging recyclable or reusable by 2025. I then examined the most common plastics that these companies used which were polyethylene terephthalate (PET) and recycled PET (rPET) (*Big Companies That Are Getting Rid of Plastic for Good | Reader’s Digest*, n.d.).

Through both of these projects, I emphasized the importance of transitioning from the traditional petroleum plastics, PET and rPET, to bioplastics and specifically PHB. The technical portion of my project aims to show how to produce the PHB more affordably and efficiently, whereas the STS portion of my project shows the benefits and environmental impacts of using PHB over PET and rPET. By using PHB, the plastic accumulation in our landfills could be greatly reduced, and also lessen the possibility of detrimental effects such as ozone depletion, crop and forest damage, and the exposure to carcinogens. Therefore, it is crucial that both consumers and corporations begin the transition to PHB. Doing so will greatly benefit the environment and ensure the ethical sustainability that everyone should be held accountable for.

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Table of Contents