

Scale-Up of Laboratory-Verified Degradable Biopolymer Synthesis

(Technical Paper)

A Perspective on the Digitalization of the American Church

(STS Paper)

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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

Introduction

The American church is in the middle of a shift in how attendees engage in services. This shift is taking place within the context of two major technologies, namely the livestreamed church service and the YouVersion Bible Application (“The Bible App,” n.d.). Now, what was once a weekly Sabbath ritual, going to church, is being turned into a consumer service where people can tune into church online. Tim Hutchings, an assistant professor of religious ethics at the University of Nottingham, explains that LifeChurch.TV, an Oklahoma-based megachurch, created the first of these “online churches” in 2006 and have since sparked a movement of churches livestreaming their services (Hutchings, 2017a). This movement has stretched far beyond the scale of just megachurches, defined to be churches that reach over 2,000 people weekly (Thumma, n.d.), as now churches that reach only a few hundred people each week have begun streaming their services. Likewise, a similar shift is happening in how people engage with the Bible. Rachel Wagner, associate professor of religion and philosophy at Ithaca College, warns that what was once a sacred text can now be reduced to a fluid, ever-changing application (Wagner, 2012). In the proposed STS research paper, I will be sharing a perspective as to how the American church is undergoing a paradigm shift in how it adapts to modern technology in church services.

While there is no direct link between my STS topic and my technical topic, they showcase two very different extremes of sociotechnical integration. While my STS portion will focus on analyzing the impact of these technologies in the church, my technical topic will develop the production line for a biodegradable thermoplastic that could be used as a replacement for many single-use plastics. In this project, we will attempt to produce poly (dihydroferulic acid) using the waste stream from a paper production facility. These waste

streams contain a compound called lignin, which can be depolymerized to extract useful monomers for creating biodegradable polymers. Holmberg et al. argues that the production of biopolymers is an emerging industry that can compete financially with the current market for single-use plastics (Holmberg et al., 2016) and our team seeks to produce a product that is both sustainably sourced and competitive in price.

Technical Topic - Industrial Process Design for Production of a Naturally-Derived Thermoplastic

Current State of Biopolymer Research and Development

As national media sources intensify the spotlight on plastic pollution and the general public's distaste for non-sustainable materials heightens, the scientific community is expanding its efforts to innovate biologically-based, functionalized materials for polymerization. The search for useful and environmentally-friendly polymers is difficult for researchers, even those in groups that prioritize that field of study. Holmberg et al. summarize the primary issues, "Practical bio-based materials that can compete with petroleum-based plastics in both cost and performance are of growing interest yet are challenging to design due to trade-offs between cost, feedstock sustainability, and macromolecular properties" (2016, p. 1286). Kristufek, Wacker, Tsao, Su, and Wooley, researchers from the chemistry and chemical engineering departments at Texas A&M University, contended that recent advances in natural product synthesis and isolation bolster the development of scalable reaction schemes for bio-derived polymeric materials (2016, p. 433).

A myriad of review articles, exemplified by University of Florida chemist Stephen Miller's 2013 publication, extol the benefits of sustainable polymers supported by laboratory-scale research on the production and degradation of the materials. One such reaction that is

gaining particular interest from researchers involves the depolymerization of lignin to obtain aromatic compounds for continued processing (Nicastro, Kloxin, & Epps, 2018, p. 14812; Ganewatta, Lokupitiya & Tang, 2019). Lignin is a natural polymer representing 30% of the world's biomass and is generated as waste in the pulp and paper industry on the scale of millions of tons annually (Ganewatta et al., 2019, p. 2).

Laboratory Research Basis for Process Design

Mialon et al, researchers at The George and Josephine Butler Laboratory for Polymer Research at the University of Florida, reported a novel, biodegradable, and potentially lignin-derived thermoplastic replacement for polyethylene terephthalate (PET) in 2010. The final product of their reported reaction, poly(dihydroferulic acid) (PHFA), exhibits thermal and mechanical properties comparable to those of PET, the third most common synthetic polymer, accounting for nearly twenty percent of global plastic production (Mialon et al., 2010, p. 1704). The monomer, dihydroferulic acid, is a modified form of vanillin, a product of wood-derived lignin depolymerization. The other reagent, acetic anhydride, also can be derived from wood, resulting in a fully wood-sourced material (Mialon, et al., 2010, p. 1704). A patent and trademark (Gatoresin™) for the product followed its discovery, indicating its perceived viability (Mialon & Miller, 2015; Florida Institute for Commercialization of Public Research, 2014). The technology then led to the founding of US Bioplastics, with Miller as the CTO. The company received initial funding, but never acquired the resources to build a pilot facility for the production of the material (Wayback Machine, 2019). Given the promise of the bioplastic itself, and the recent increase in demand for bioplastics, it is worth considering the development of a new design for industrial scale production of this sustainable material.

Thesis Project Objectives and Methods

The objective of the technical project is to design a fully-operational plant to mass-produce a bioplastic using the vanillin synthetic scheme described by Mialon et al., and the corresponding patent of Mialon and Miller (2010; 2015). A proposed high-level block flow diagram for the process is shown in Figure 1. By transitioning the synthesis from a batch to the continuous process portrayed below and addressing issues of energy efficiency, operational safety, and waste abatement, the design will allow for profitable production of the bioplastic in quantities required for commercial applications. In addition to producing a sustainable product, it is crucial that the process design itself sustainable to ensure that the environmental good of the PHFA polymer is not diminished by the production phase.

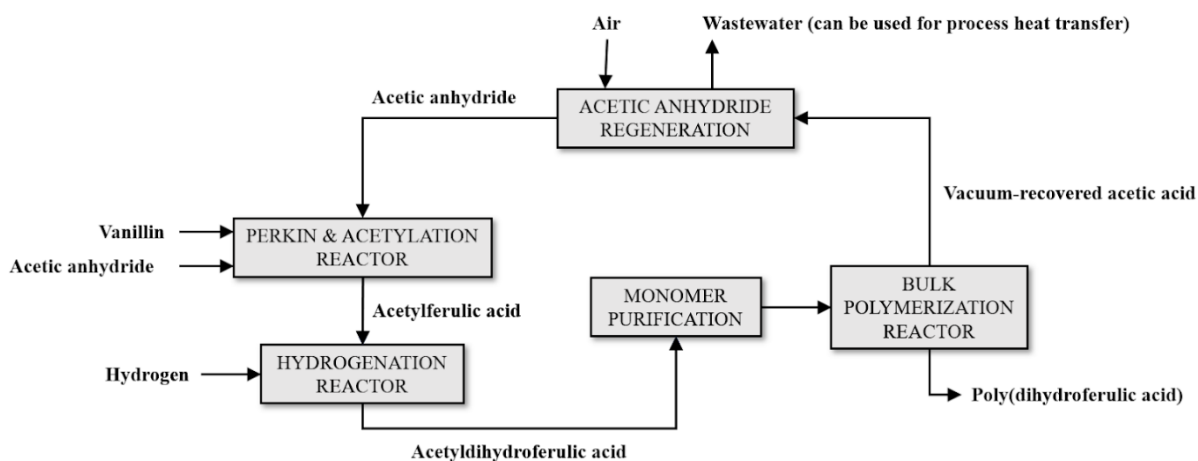


Figure 1. Block Flow Diagram for Proposed Process (Created by Bush, 2019). Presents essential operations, feeds, products, and intermediate flows. Poly(dihydroferulic acid) is the desired thermoplastic product. Vanillin, acetic anhydride, hydrogen, and atmospheric oxygen must be continuously supplied, and the regenerated acetic anhydride flow will at best be equal to the rate of fresh acetic anhydride feed.

The Aspen Plus software suite will be used to simulate the unit operations required of the process (AspenTech, 2019). Other computer programs, including MATLAB, will supplement the modeling done in Aspen Plus (MathWorks, 2019). Specifically, since Aspen Plus excels in

thermodynamic calculations but lacks in its reaction kinetics modeling, MATLAB will be used to design the reactors essential to the process.

The technical project will last the entirety of the 2019-2020 academic year, in a two-semester senior design sequence directed by Professor Eric W. Anderson. The design group is comprised of fourth-year chemical engineering students Christopher Brodie, Ethan Bush, Jillian Dane, Gavin Restifo, and Rebecca Richardson. By the end of the fall semester, the initial plans for a plant will be detailed in a design basis memorandum. This document will include a description of feedstocks and final products and a high-level overview of the material and energy balances and purification techniques relevant to the process. Additionally, an economic appraisal will be included as a proof-of-concept for financial feasibility. At the end of the spring semester, a technical report will be authored, fully defining the bioplastic production process.

Role of Deliverable in the Future of Sustainable Materials

This project will contribute to the progress of chemical industries: biomass-derived plastic is valuable not only for its lower environmental impact compared to fossil-fuel-derived equivalents, but as an element of cross-industry sustainability. As the transition to renewable resources is driven by the rapid consumption of nonrenewable oil and gas, future material feedstocks could be made in biorefineries that utilize biologically-generated molecules in real time, rather than millions of years after the fact. Lignin would be one component of this system.

Biofuels from Algae, which details the algal component of a biorefinery vision, points out, “[E]conomic analyses have consistently indicated that algal-based biofuel feasibility hinges on the possibility of production coproducts with a market value from the spent biomass” (Guedes, Amaro, Sousa-Pinto, & Malcata, 2014, p. 206). In this context, failing to scale bioplastic

production will not only result in continued issues with conventional plastics, but will obstruct the future of sustainability in all other chemical industries currently based on fossil fuel inputs.

STS Topic

Church online, what sounds almost like an oxymoron is now becoming a present reality in American Christian circles. In 2006, LifeChurch.TV, the third largest church in the United States (“America’s biggest megachurches, ranked,” n.d.), created an online “campus” that started a movement of creating a digital space for religious services (Hutchings, 2017a). This online campus serves now as the largest grossing weekly digital church service, reaching over 250,000 people each week (“About Church Online,” n.d.). In addition to this, LifeChurch.TV has also developed the largest platform for digital Bible reading, the YouVersion Bible App, with over 394 million downloads to date (“The Bible App,” n.d.).

In his article, *Design and the digital Bible: persuasive technology and religious reading*, Tim Hutchings, demonstrates that throughout the course of religious history the approach to sacred texts has changed with each progressing form or literary technology (Hutchings, 2017b). Digital reading is no exception, and I propose that the American church is undergoing a paradigm shift in how it approaches Bible reading in this increasingly digital age. As such, it is my perspective that these technologies should be viewed through the framework of a paradigm shift and the work of Thomas Kuhn will be used to analyze it as such (Kuhn, 1964). Kuhn’s work has been criticized as being too broad in its use of the word “paradigm” (Von Dietze, 2001). However, in this analysis a paradigm will be viewed as the foundational platform of knowledge and understanding for which a part of the world is being interpreted. For instance, in analyzing how the use of digital Bible applications has influenced the sacred view of this

religious text, the paradigm through which I would argue that we must now operate is one that is driven by our understanding of digital learning.

In a 2011 paper, entitled *iReligion*, Torma and Teusner argue that the presence of a religious digital reading experience, “moving some power of control in reading media text from producers/authors to readers,” as they argue that hypertext creates a more engaging reading experience (Torma & Teusner, 2011). On the other hand, Schugar et al. found, through studying a group of college students, that though overall comprehension of a text was comparable between traditional textbook reading and e-reading, they concluded that students who read from a tradition text have a clear advantage in deep critical analysis of the material (Schugar, Schugar, & Penny, n.d.). In a similar study, Hutchings analyzes how various reading media function for the purpose of studying the Bible. He found that a significant number of the Christian users he surveyed feared a loss of sacredness and acknowledged a disposition towards reading the Bible as a fragmented text rather than as a cohesive story. Hutchings further argues that this is a reflection of the greater educational concerns with e-reading retention (Hutchings, 2015). Other critics of the digitalization of the Bible, such as Rachel Wagner, associate professor of religion and philosophy at Ithaca College, asserts that it perpetuates a perspective of fluidity in place of the supposed rigidity of a truly sacred text (Wagner, 2012).

I would argue not only is it vital to fully visualize the cohesion and unity of the Bible, but also that these deeper levels of understanding are critical to effective engagement with sacred religious texts. However, Bobby Gruenwald, the innovator responsible for the YouVersion Bible App, paints a different picture of what the purpose for which the app is designed. He states in a 2013 interview with the New York Times, “We have a generation of people that can’t fathom

paying 99 cents for a song that they love, and we were asking them to pay \$20 for a book that they don't understand.” (O’Leary, 2013). What Gruenwald attempts to convey is that one of the purposes of the Bible app is to enable access Scripture without having any cost to the user. A 2013 survey of digital Bible app users found that 77% of app users read the Bible more due to the proximity of having it available on their phones (“Now the Bible is an App—Infographic,” 2013), seemingly indicating that this app is serving Gruenwald’s purpose. The debate can be condensed to the question of: is the purpose of a Bible app to replace traditional texts, or to provide a means for people to access the Bible without needing to own a physical text and thereby broadening the reach of the church? This is one of the underlying questions that I plan to analyze and give evidence as to why this is a vital question that must be asked in the modern church.

Research Question

At the core of this project is the need to evaluate the reasoning behind the use of these specific technologies in the church. So, in analyzing the YouVersion Bible App, the question of ‘Is the purpose of a Bible app to replace traditional texts, or to provide a means for people to access the Bible without needing to own a physical text and thereby broadening the reach of the church?’ will be used to analyze the role of the Bible app in churches. On a broader level, this research will revolve around analysis with a primary research question of: how have the shifts in technology usage, created by the Bible app and livestreaming of services, influenced the level of engagement that people exhibit in church?

Methods

The primary method of research will be document-based research. The main reason for this methodology is because the relevant sample for the scope of this project is the American church as a whole – which cannot be accurately measured by my own surveys. All of the sources that have been mentioned previously will be used in this way. In addition, I plan to interview a few local church leaders from churches that have chosen to livestream their service and some that have not, in order to get perspective into how this decision is made in the local church. My hope is to present this data into two sections for each of the two previously mentioned technologies. Within each section, I will showcase the relevant research in such a way that hopefully displays the complexity and tradeoff in adopting these technologies. Finally, these two pieces will be brought together in context of the greater paradigm shift of the digitalization of the American church.

Conclusion

The STS project provides perspectives arguing both for and against the integration of new technologies in the church. I hope to provide work that is educational to the modern church and brings a source of clarity into the decision-making process when new technologies are considering being adopted. I expect that the adaptation of these technologies in the church will prove to not be a clear-cut issue, but rather one that relies heavily on the motivations behind their usage. I expect to find that while a Bible application and an online service will increase the access people have to religious content, the broader cultural implications for the church such as: declining in-person attendance and perceived sacredness of the Bible could outweigh the value added by these technologies.

In terms of the technical project, I expect that our team will find that the sustainable production of these polymers will be economically feasible given the expectation that people

must be willing to pay more for sustainably sourced goods. As a whole, I think that this project is very implementable and could easily be adopted to begin the process of moving towards a more sustainable plastic industry.

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