Thesis Project Portfolio

Investigation into Polyhydroxybutyrate and Bacterial Nanocellulose Composites for Single-Use Paper Packaging

(Technical Report)

The Role of Synthetic and Bio-Based Plastics and in the Transition to a Circular Economy

(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, 2021

Department of Biomedical Engineering

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Prospectus

Paper and plastic have become two of the most common materials humans interact with daily. Each material class offers a unique variety of properties in isolation and complement each other nicely when used in conjunction; however, the manufacturing, and in many instances the disposal, of both materials is heavily flawed. Reliance on unsustainable energy sources, harsh chemicals and immense water usage are the more noteworthy flaws upstream, whereas downstream the frequent single-use nature of these products creates an immense amount of waste, clogging-up every waste management system in which they are disposed (i.e. landfill, sewer, recycling plant, etc.) and heavily polluting the environment.

My technical work was based in the investigation of emerging biopolymers, polyhydroxybutyate (PHB) and bacterial nanocellulose (BNC) as an attempt to design and test a more sustainable, fully biodegradable secondary packaging composite. BNC acts as an additive that increases the structural integrity of paper fiber blends, contributing to improved performance in-use and recyclability at the end of life. BNC was shown to cause a significant improvement in paper strength under TAPPI-like conditions as the overall recycled (shortened) old corrugated cardboard fiber concentration was increased. PHB provided a hydrophobic barrier, which is often the intention of a plastic coat/adhesion but allows biodegradation unlike traditional coatings. The speed of biodegradability of our composite could not be accurately tested, however, both materials are accepted frequently as some of the most readily biodegradable materials and will be a certain next step in my personal exploration.

My thesis observed the uncertain future of biodegradable materials in light of historical trends in plastic use, disposal and regulation. Despite obvious flaws in the existing recycling system, petroplastic companies continue to heavily endorse it as the primary solution to the immense volumes of waste created around the world day in and day out. As bio-based and biodegradable have become more popular marketing points, petroplastic-focused companies have managed to stay relevant by engineering materials/techniques that allow macro-level degradation in the environment; however, widespread adoption of these polymers pose an even larger threat to global and human health than their inert counterparts. Catalyst-degradable polymers are often petroleum-based but are treated to break down from their macro form into smaller chains and constituent molecules. My analysis explores the forces that affect the mass commercialization and circularization of plastic goods and packaging.

Circular economies have been theorized as the saving grace to prevent and restore human inflicted environmental damage. Except in a few niche cases, attempts at achieving such a model have failed across various industries; however, emphasis on circularity continues to grow in response to the (ever-more) observable effects of air, ocean, and land pollution. Sustainable solutions are needed across every industry and must be thoroughly vetted before mass implementation.

I would like to extend my sincerest thanks to Sean Ferguson, James Groves, Alex Zorychta, Richard Fine, my teammates at Transfoam and Kombucha Biomaterials, and all those I have had the opportunity to connect with as I've immersed myself in this space in the last two years.