



DNFI Innovation in Natural Fibres Awards 2020

The deadline for award submissions is
11 September 2020

Application form

Innovative research and science

A maximum of two extra pages (for a total of three pages) of information and two photographs may be included with this submission.

This Form should be sent to DNFI, e-mail: Secretariat@DNFI.org

Title of the Submission

Production of bioplastic films from low micronaire cotton fibers

Description of the research and the associated science

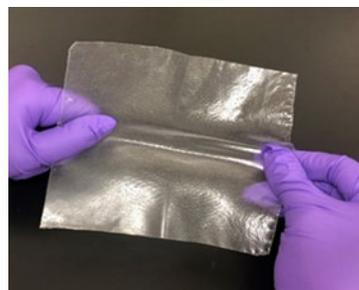
Cotton fiber is one of the most important source of cellulose. Most of cotton fibers produced go to the textile industry. However, due to the increase of the world cotton production and increased competition from synthetic fibers (especially polyester), the market share and price of cotton has been declining. Furthermore, because cotton fiber quality is affected by environmental conditions during growing and maturation, portion of the cotton harvested every year may not fit the spinning requirements. Indeed, the global textile mills are interested in sourcing cotton with fiber profiles adapted to high quality textile products. This means that cotton fibers should be long, uniform, mature, fine, and strong. To keep cotton competitive and prices high, there is a need to create new applications for low-grade cotton (low micronaire cotton). After scouring and bleaching, cotton fibers are composed of almost 99% cellulose. In contrast, wood is composed of about 40% cellulose and the remaining is composed of lignin and hemicellulose.

The growing environmental concerns regarding the accumulation of microplastics generated from synthetic fibers and plastic materials led to an urgent need to find alternatives to petroleum-based products (fibers, films, disposable materials, etc.). Petroleum-based products are notorious for their persistence because they are not biodegradable when disposed of in landfills. They tend to accumulate rather than decompose and their kinetic of degradation or decomposition, either by means of mechanical degradation or photo-oxidation, is very long. For example, it has been reported that the biodegradation rate of cellulosic fibers (cotton and rayon) is high compared to the degradation of petroleum-based materials (e.g. polyester), which are not biodegradable. Therefore, from environmental perspectives it is very important to develop materials based on cellulose (cotton in our case) which may replace petroleum-based materials. This can create a new niche-market for low-grade cotton fibers (low micronaire fibers).

In this research, we seek to develop bioproducts from low micronaire cotton fibers. Because cotton fibers do not melt, any transformation of cotton fibers requires dissolution to form a gel followed by transformation to bioproducts. Our research demonstrates that we can successfully dissolve cotton fibers (micronaire = 2.4), prepare cellulose gel, and then convert it to a bioplastic film (Photos below). Tensile testing shows that the bioplastic films prepared from cotton fibers could have an elongation that can reach 70-80%.



Transparent film prepared from cotton fibers



High elongation transparent films prepared from cotton fibers

Degree to which the innovation may lead to implementation of products or services using natural fibres

Our research at the laboratory scale has demonstrated that low-grade cotton fibers (mic. ~ 2.4) is successfully transformed to bioplastic films. Further research and development are needed to optimize the process and produce bioplastics and other bioproducts from low grade cotton fibers. This can create a niche-market for low-quality cotton fibers and help increase cotton market share.

Level of innovation

We performed the proof of concept to dissolve cotton cellulose and transform it to bioproducts. One patent has been awarded, which focuses on 3D printing from cellulose gel (US 10,311,993 B2). Two provisional patents are pending which focus on the dissolution of cotton cellulose in ionic liquids and conversion to bioplastic films and other bioproducts.

Potential for developing new markets or uses for natural fibres

Cellulose-derived bioplastics are inherently biocompatible and capable of efficiently biodegrade in landfills and composting facilities. Our initial testing showed that when our cotton cellulose bioplastic films are buried in the soil, they start to decompose in about 3 weeks. Microscopic visualization showed the presence of soil micro-organisms on the surface of the films, which initiate and promote cellulose biodegradation. However, when these bioplastic films are kept in normal laboratory conditions, they remain stable with no sign of degradation. Several commercial applications could be envisioned (shopping bags, soil cover for growing fruits and vegetables, bioplastic packaging, regenerated cellulose fiber, single use items, etc.). We believe that this technology can be further developed as a cheaper alternative to petroleum-based plastics currently available on the market. Moreover, these products could be easily tunable to have similar properties to currently used plastics. It could enable the production of cotton-based bioplastics as an alternative solution to plastic accumulation and overcome associated environmental and health problems. Unlike starch-bioplastics, cotton cellulose has no food value and could create a new niche-market for low-grade cotton fibers.

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