TEXAS TECH UNIVERSITY

# Valorisation des fibres de coton de basse qualité: Applications non- traditionnelles

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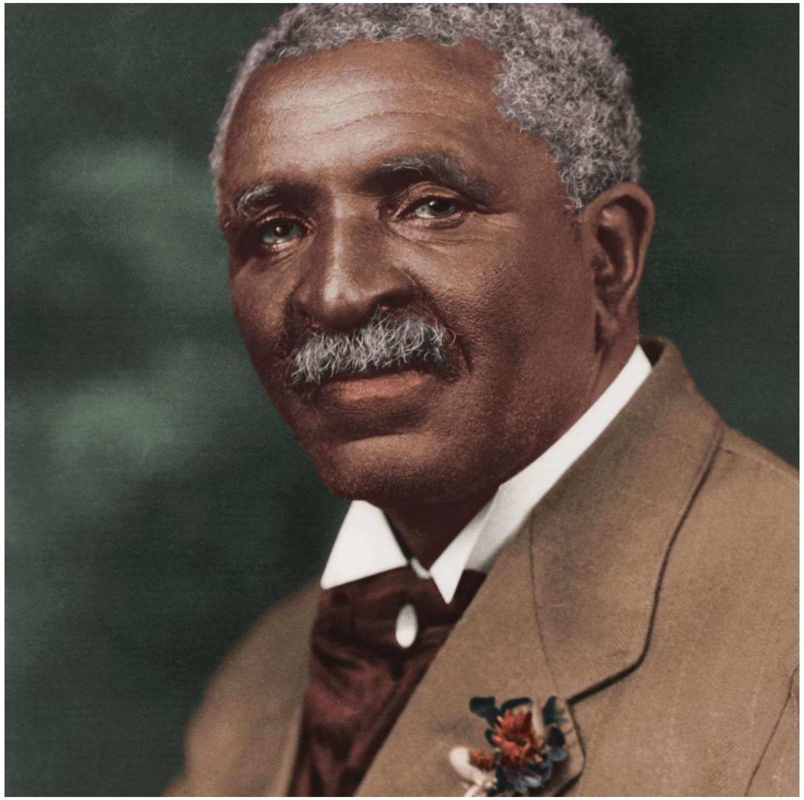
# Wastes

*"Waste is man-made. Nature produces no wastes; whatever is consumed is returned to the whole in a reusable form. Man fails to utilize appropriately the bounty of nature"*



*George Washington Carver, Botanist and Inventor (1864-1943)*

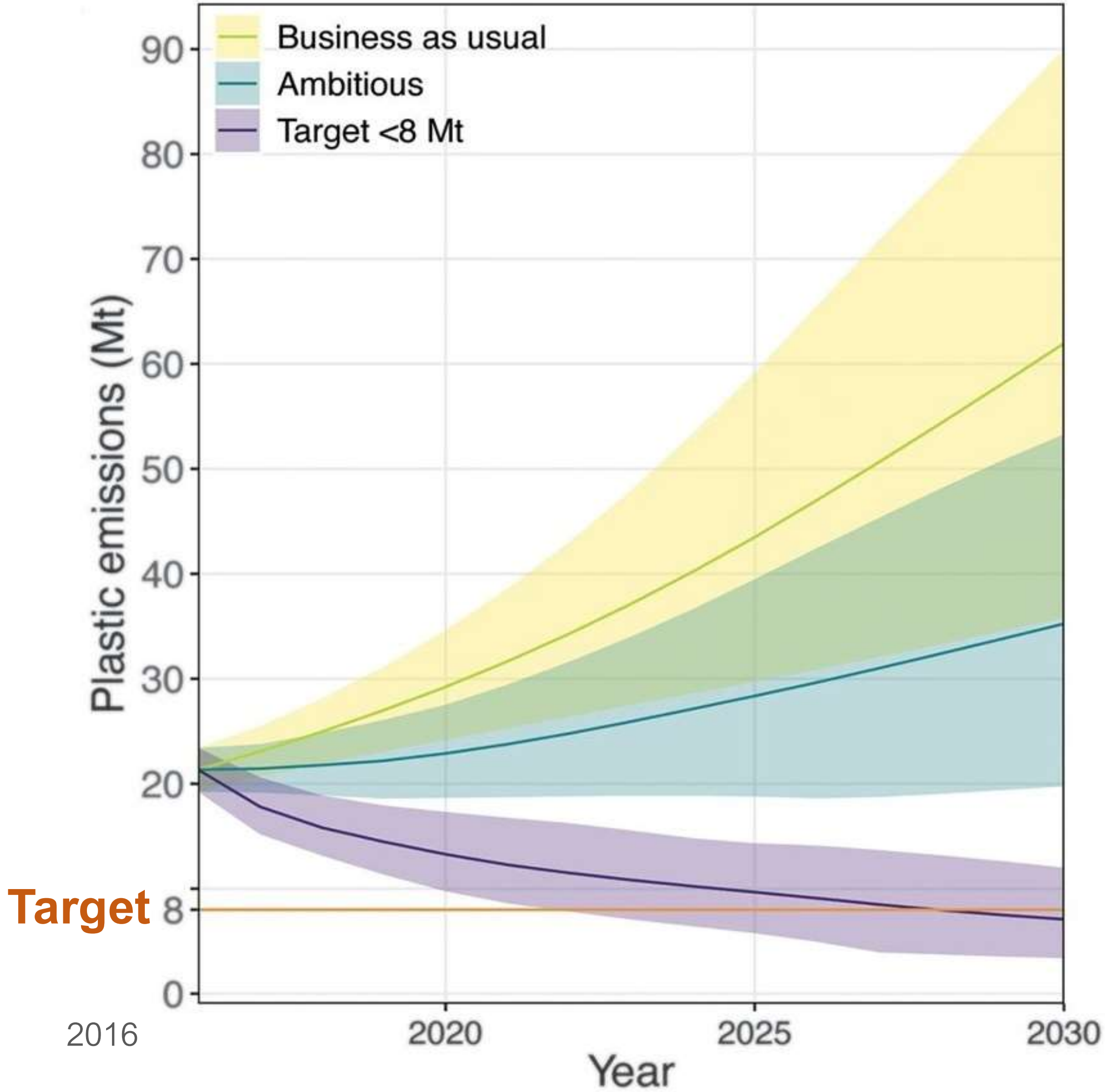
# Plastic pollution

*Near the Caribbean island of Roatan, off the coast of Honduras) Photo: Caroline Power, October 2017*

*The Ocean will soon have more plastic than fish*

# Plastic pollution

Science
AAAS




*Mt: Million metric tons*



Borrelle, S. B., *et al*. *Science* **2020**, *369*, 1515–1518.

# Single use plastics

***Single use plastics a necessary Evil during the Pandemic***

*GFP: Insight Drives Innovation, https://www.gep.com/company*

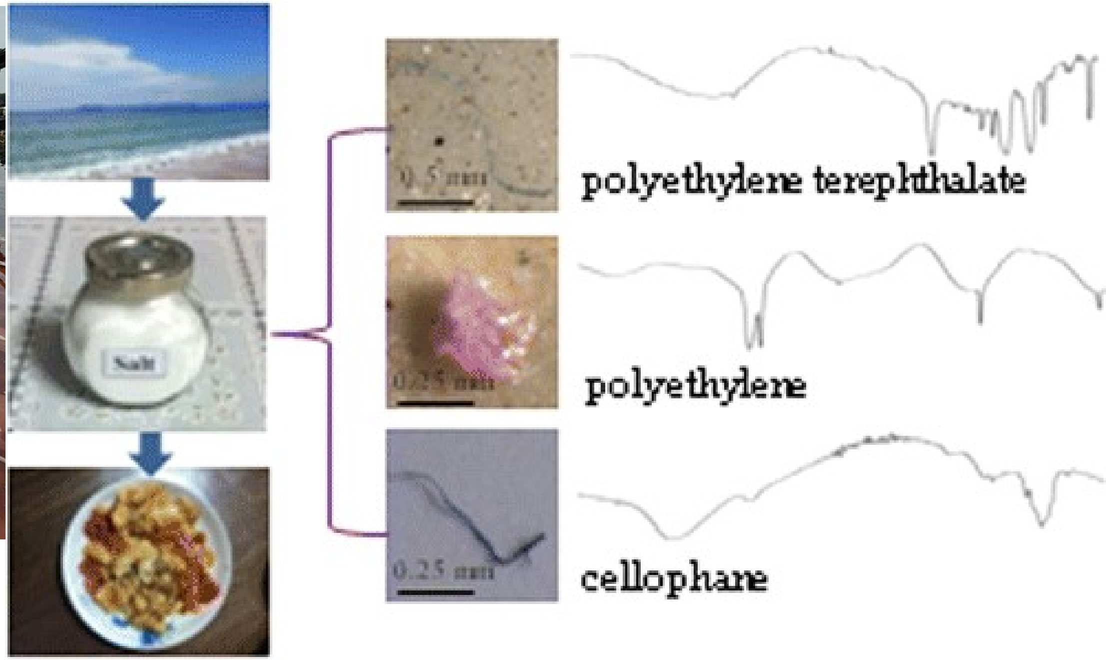
# It takes up to 450 years for a plastic bottle to decompose in landfills

*https://www.savemoneycutcarbon.com/*

**6.3 billon tons of plastic** since mass production began in the 1950s but only [600 million tones have been recycled]. The remaining 4.9 billion tons have been sent to landfills or left in the natural environment

**Plastic is broken down by means of photodegradation: UV radiation from the sun breaks down the plastic into smaller pieces overtime.**

# From plastics to microplastics



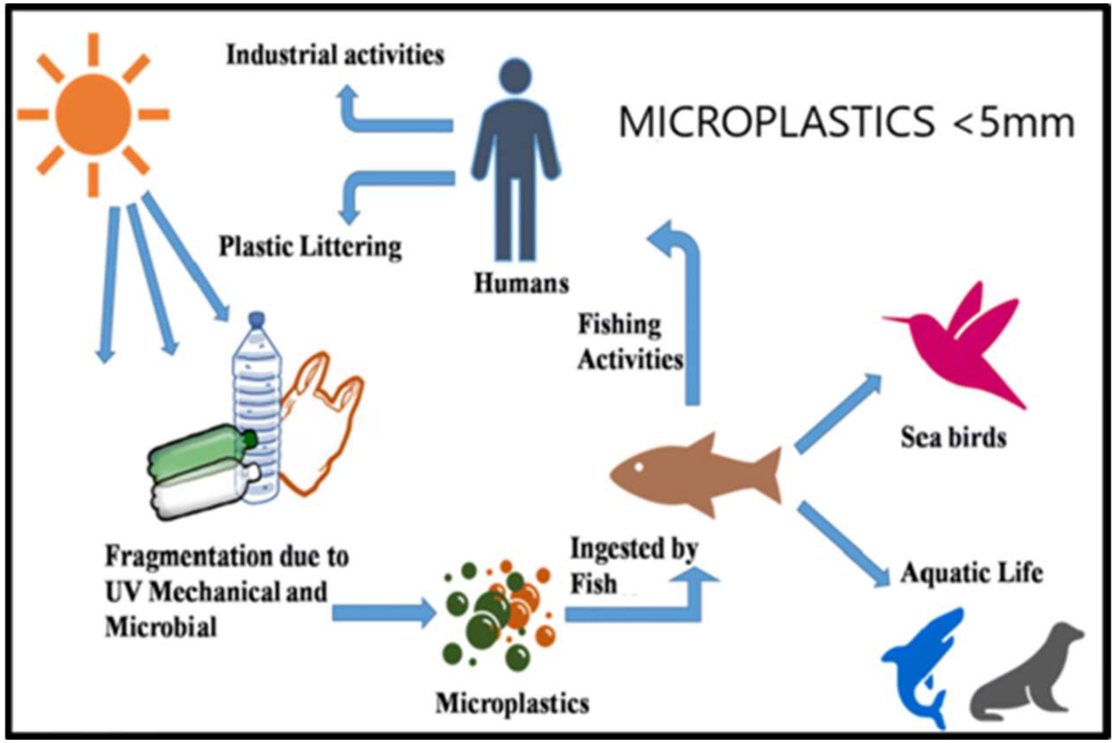

***90% of table salt is contaminated with microplastics***

*EcoWatch, 2018. https://www.ecowatch.com/table-salt-microplastics-2613395969.html*

***Commercial sea salt samples purchased in China contaminated with tiny microplastics***

*Phys Org, 2015. https://phys.org/news/2015-11-commercial-sea-salt-samples-china.html*

# From plastics to microplastics



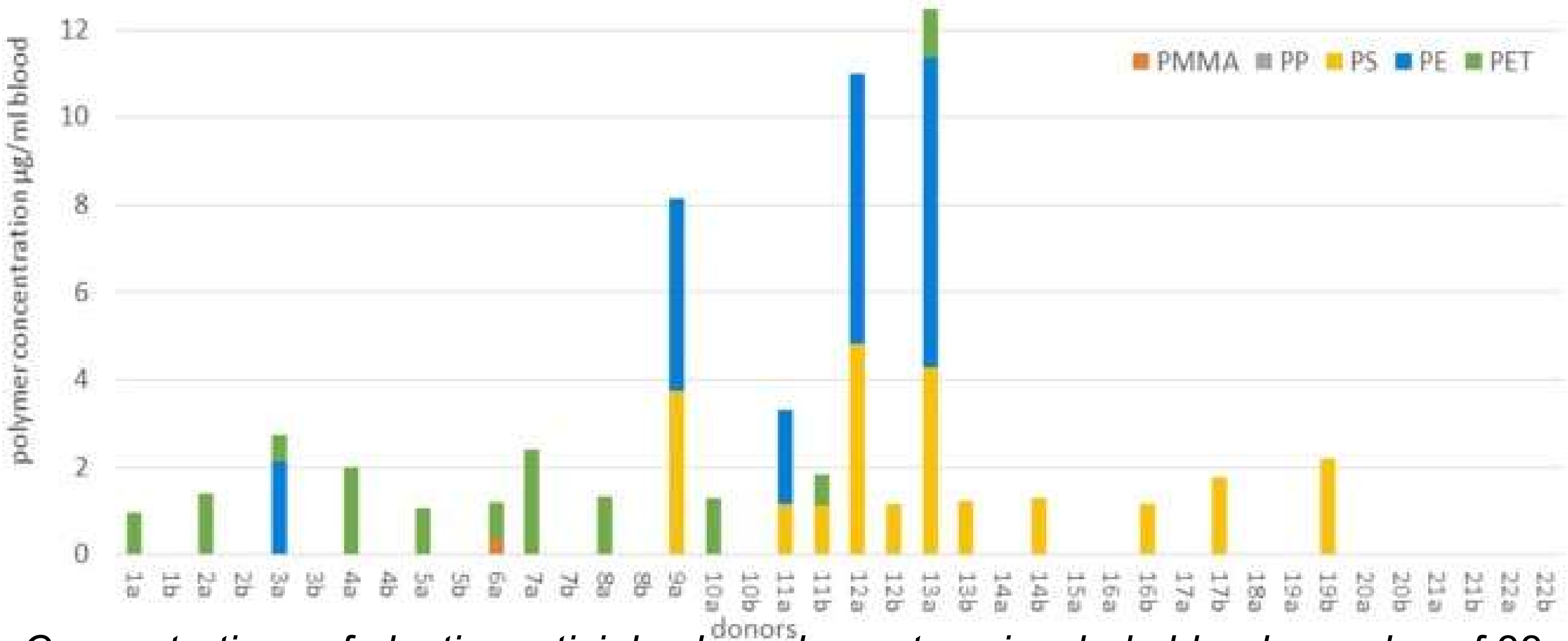

*Environ Sci Pollut Res. 28 (2021)19544.*

***Researchers have found microplastics deep in lungs and in the bloodstream.***

*https://www.nbcnews.com/*

# From plastics to microplastics

Four high production volume polymers applied in plastic were identified and quantified for the first time in blood. **Polyethylene terephthalate**, **polyethylene** and **polymers of styrene** were the most widely encountered, followed by **poly (methyl methacrylate)**.
*Leslie et al. Environ. Int. 163(2022) 107199*



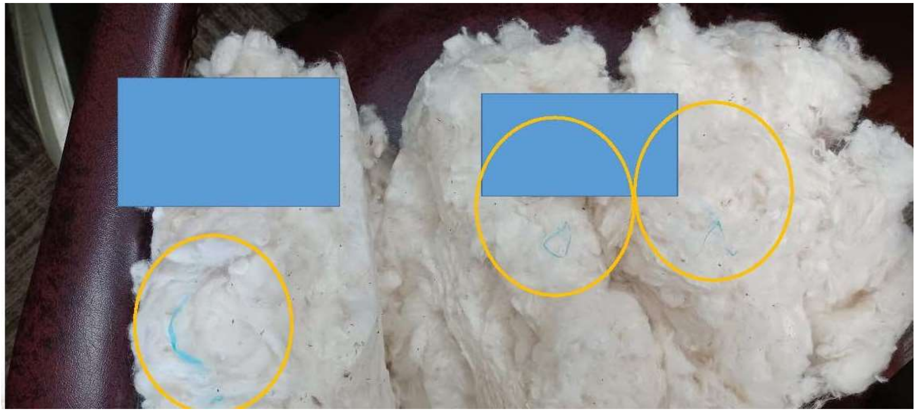

*Concentrations of plastic participles by polymer type in whole blood samples of 22 donors. Leslie et al. Environ. Int. 163(2022) 107199*

# Cotton contamination with plastics



*Credit: Dr. John Wanjura, USDA-ARS Lubbock*

# Cotton contamination with plastics

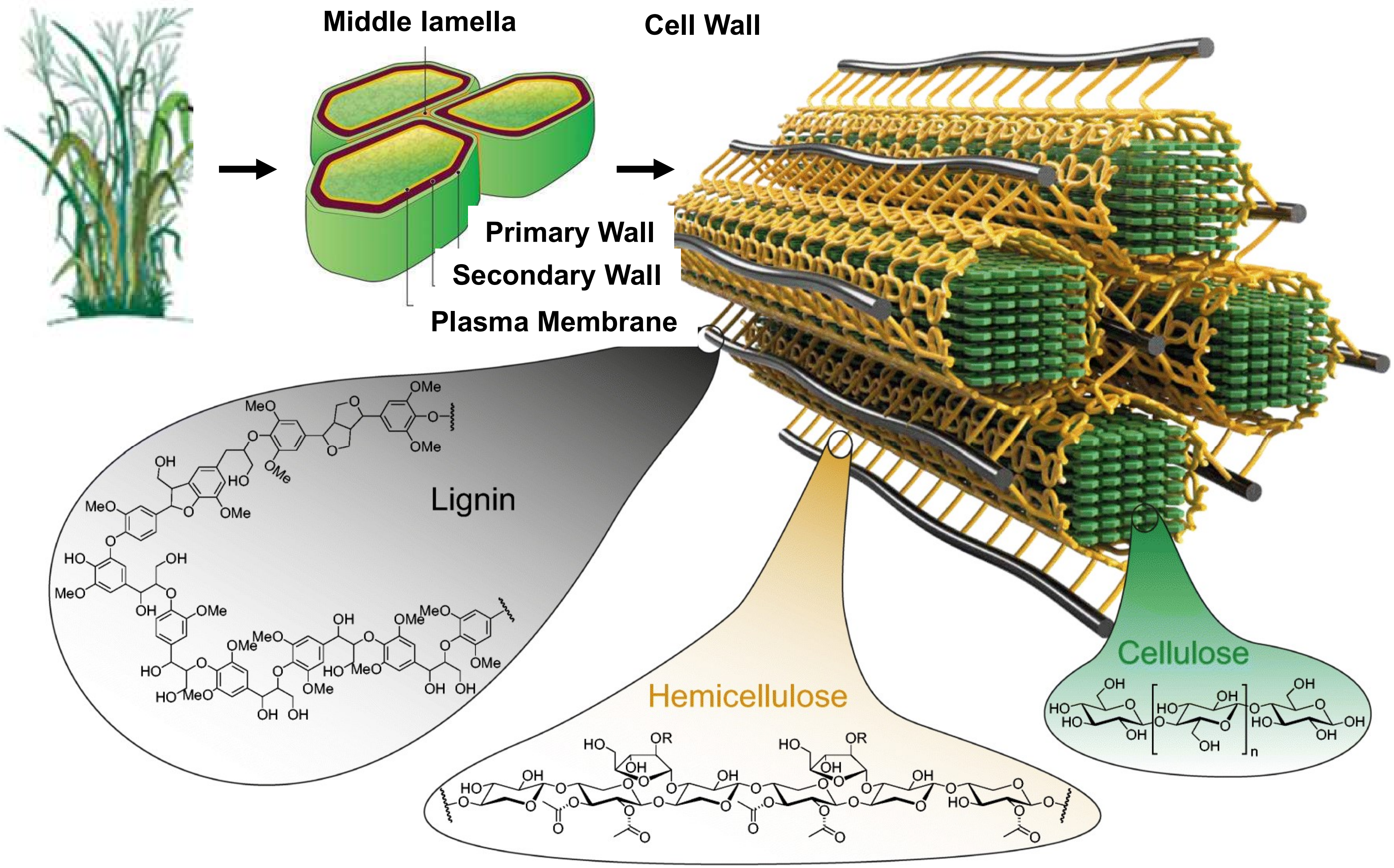


*Credit: National Cotton Council*

# Could we use discounted cotton and cotton linter cellulose to produce bioplastic films?

# From Cellulose Biopolymer to Bioproducts

# Composition of lignocellulosic biomass



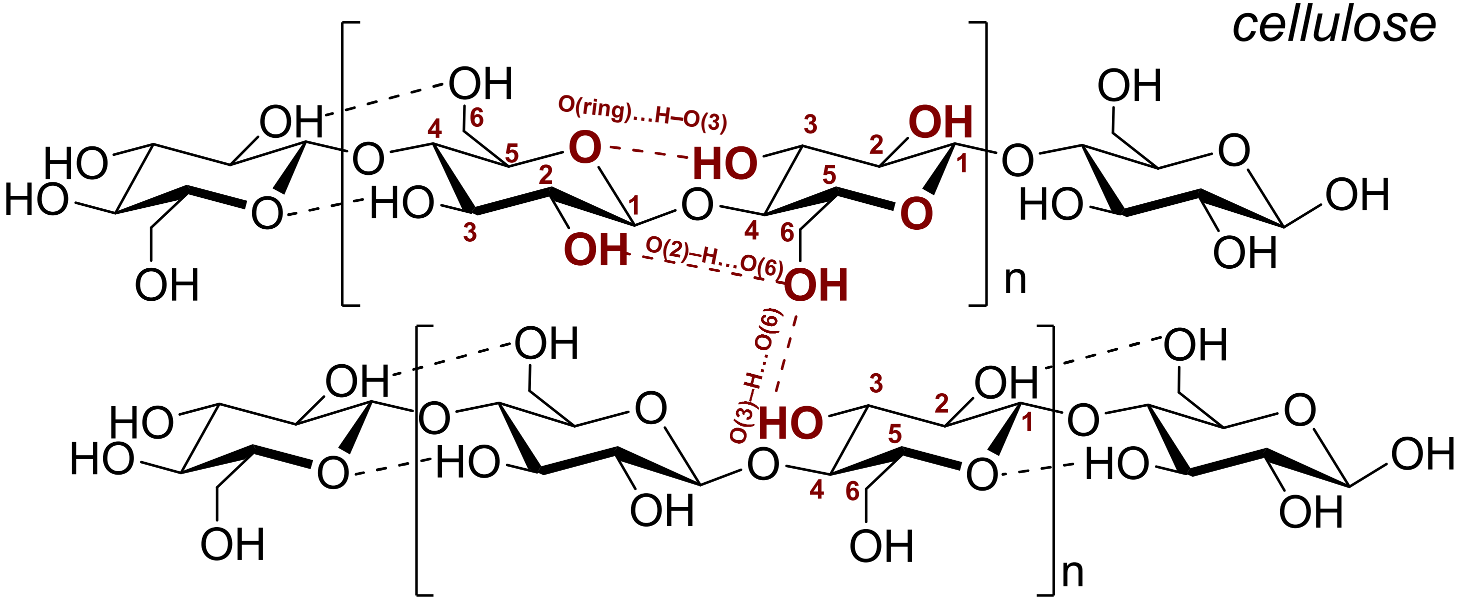

Brethauer, S., Shahab, R. L.; Studer, M. H. Impacts of biofilms on the conversion of cellulose. Appl. Microbiol. Biotechnol. **2020**, *104*, 5201–5212. https://doi.org/10.1007/s00253-020-10595-y

# Structural complexity of cellulose

Potential application of cellulose is hindered by:

- ❖ high molecular weight
- ❖ high crystallinity
- ❖ rigidity of the polymeric chain due to extensive hydrogen bonding

*Cotton, purest form of plant cellulose*



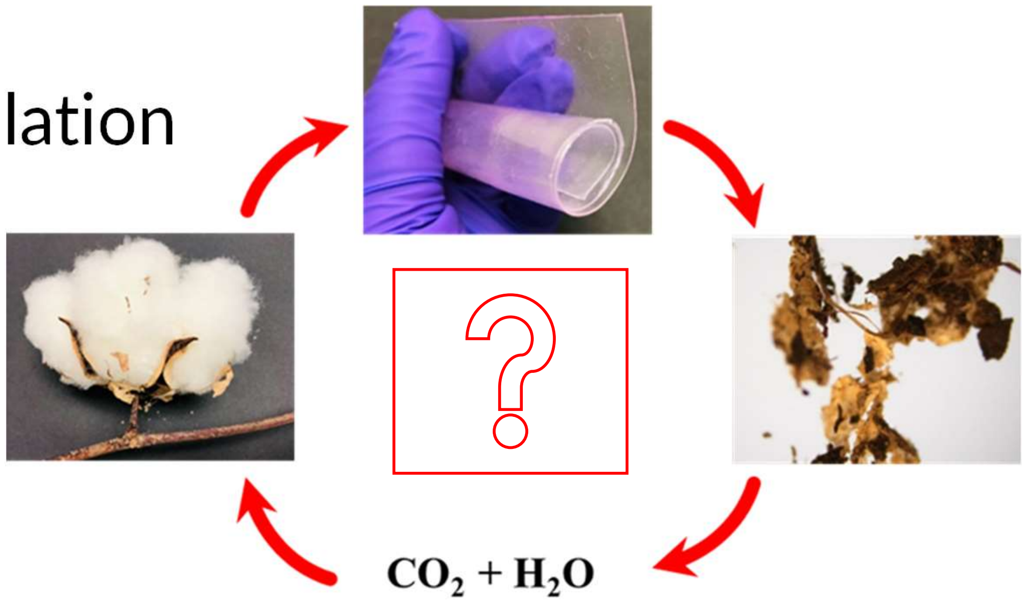
# Bioplastic, an ecofriendly alternative

**Bioplastics are biobased, and/or biodegradable.**

- biomass, biocompatible
- limit plastic waste accumulation

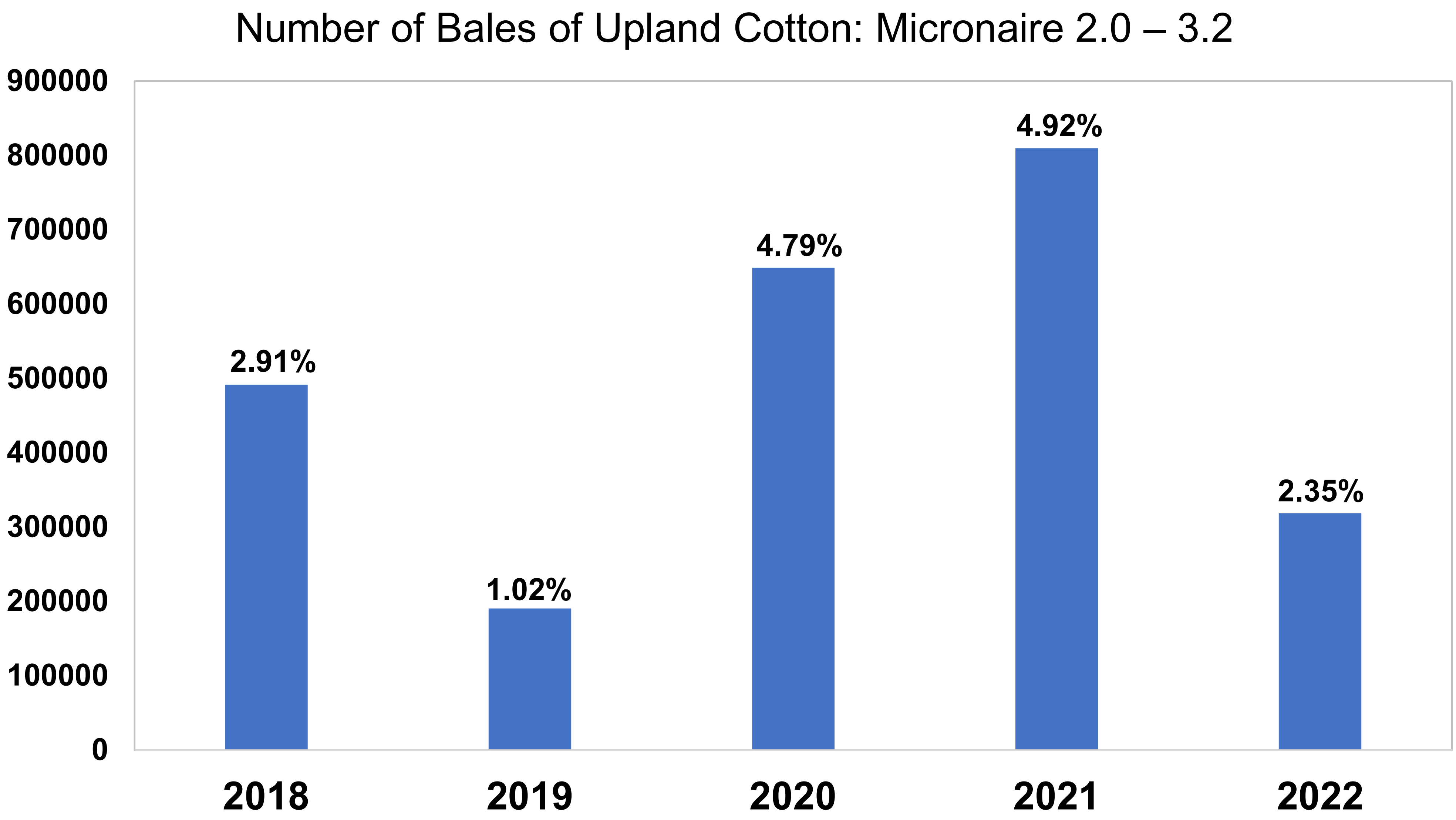
**Types of bioplastics:**

- starch-based plastics
- protein-based plastics
- some aliphatic polyesters

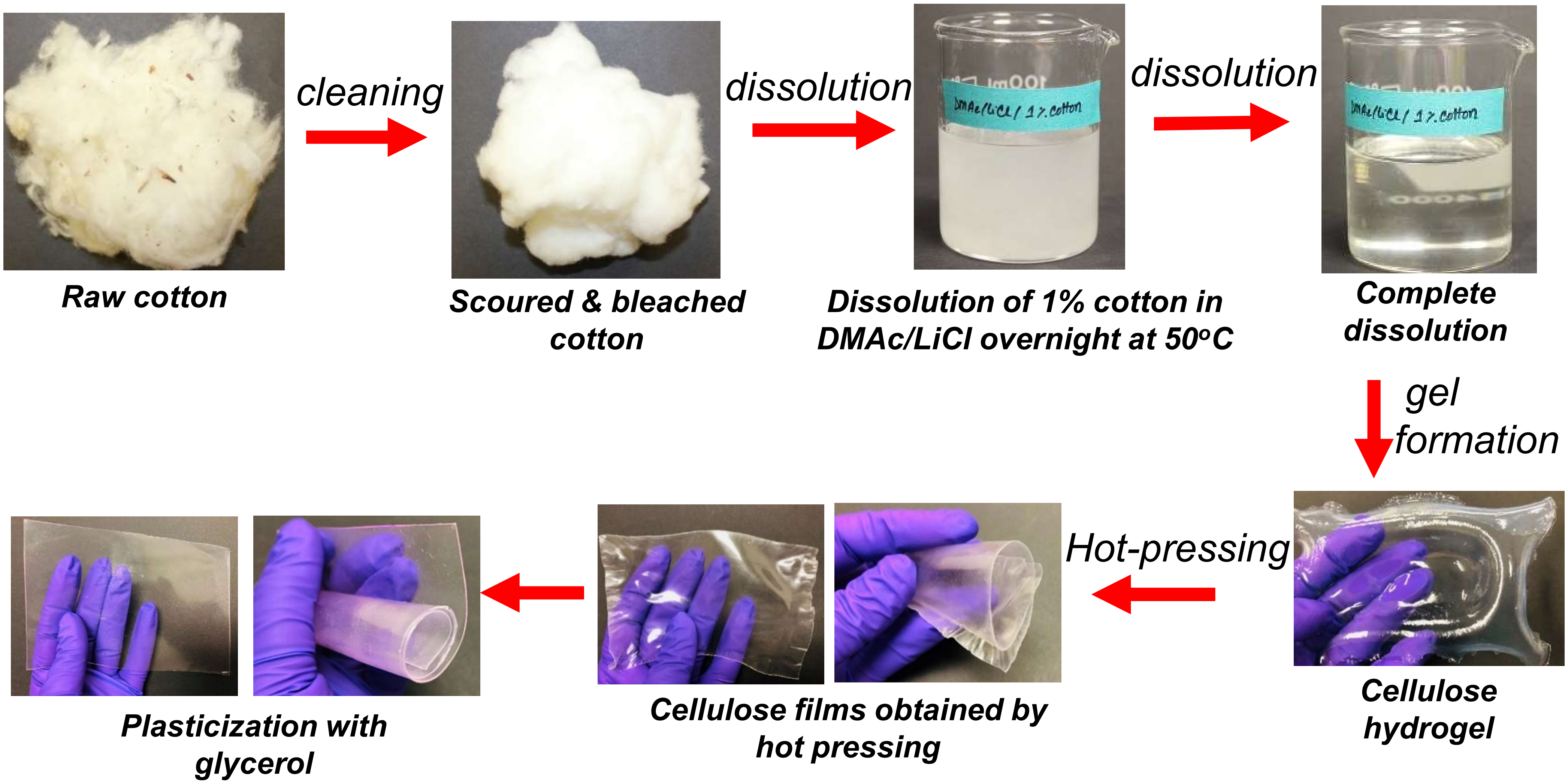



**Cellulose is the most abundant biopolymer on earth and could be the source for plastics production**

# Micronaire 2.0 – 3.2



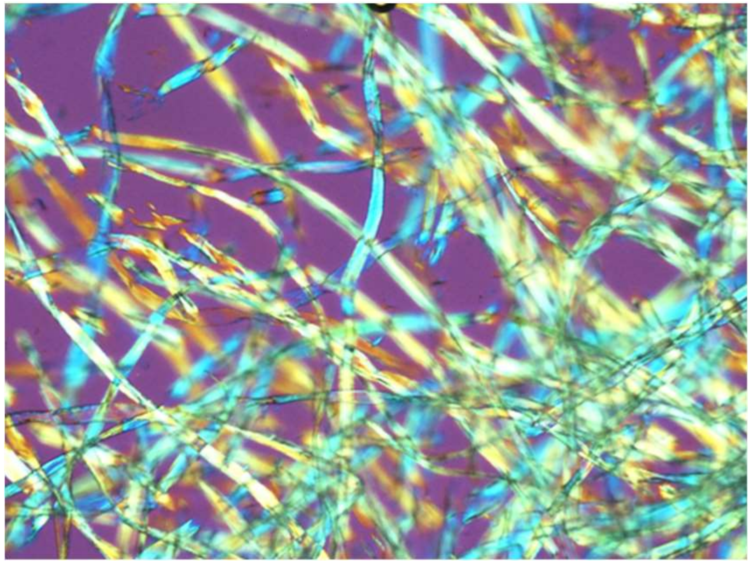
# Dissolution of cellulose*



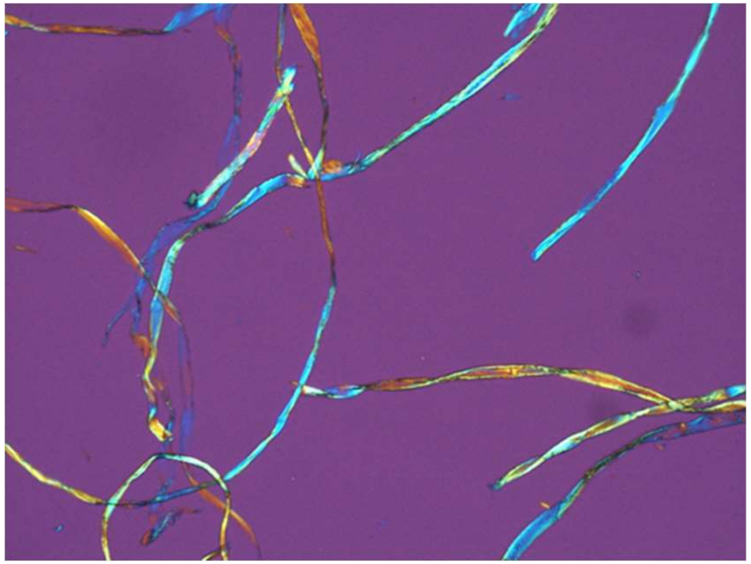

* Abidi, *Patent Pending*

S. Rumi et al. Cellulose (2021) 28:2021-2038

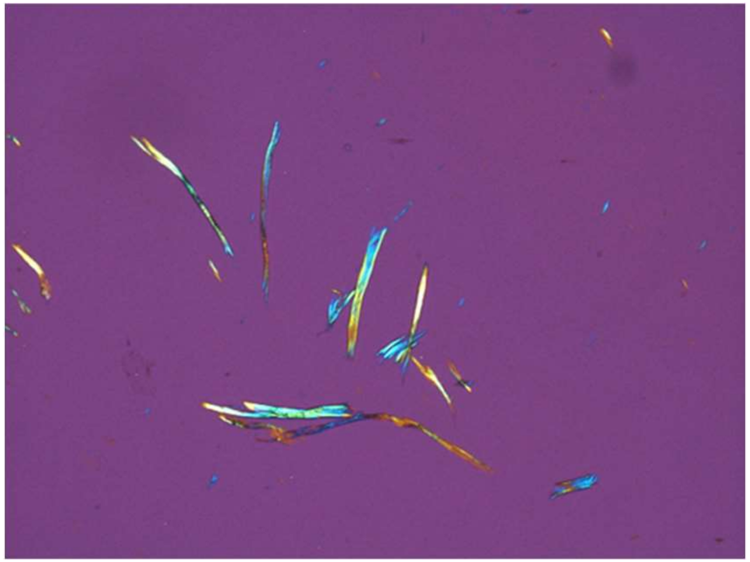
# Dissolution of cellulose in DMAc/LiCl



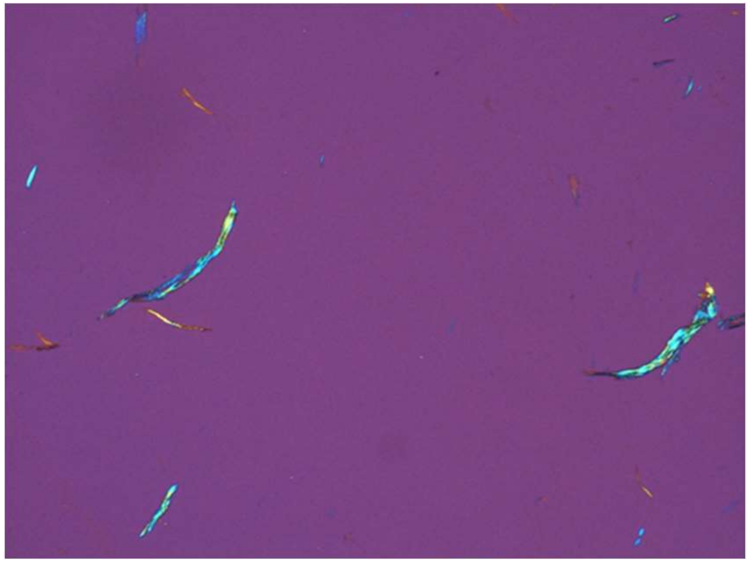
*Cotton in DMAC/LiCl at t=0*



*After 6h at 105$^oC$*



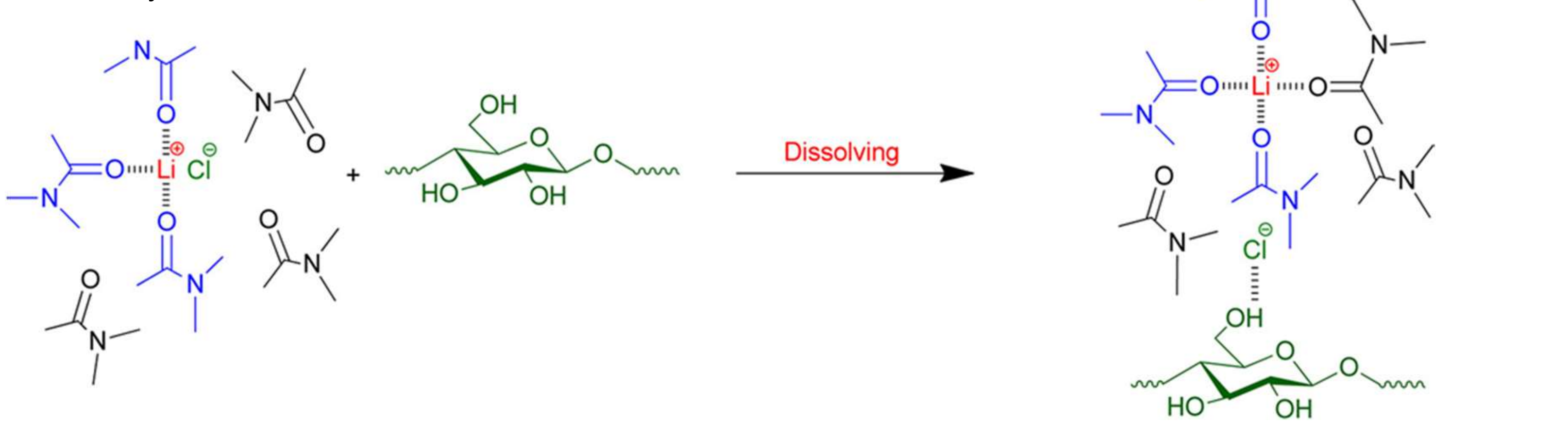
*After 9h at 105$^oC$*

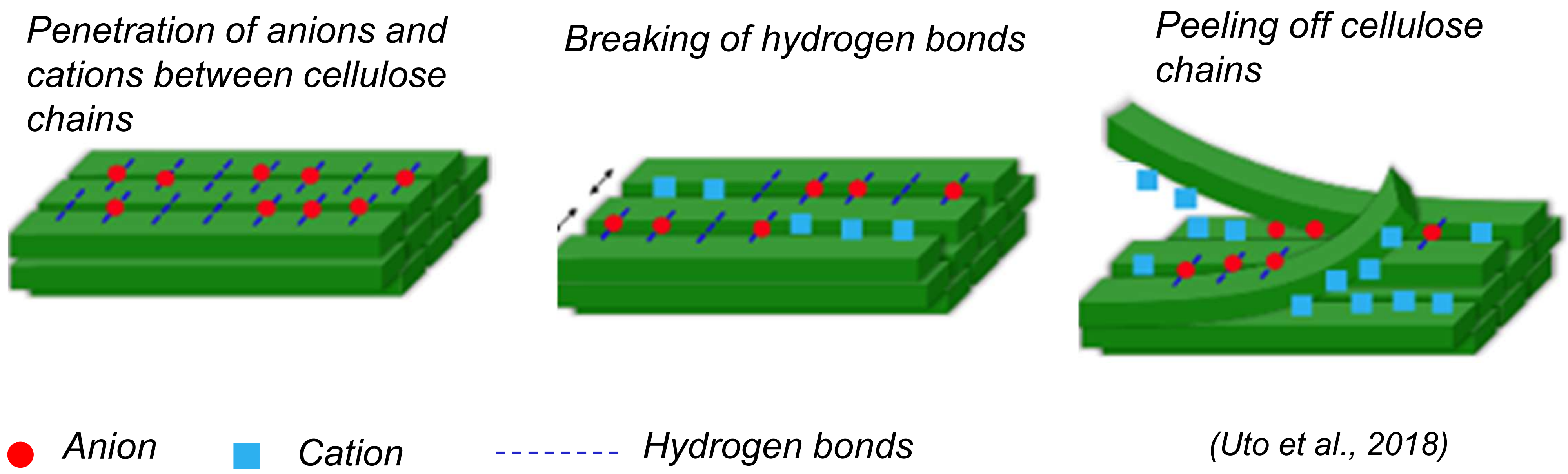


*After 12h at 105$^oC$*

# Dissolution of cellulose in DMAc/LiCl

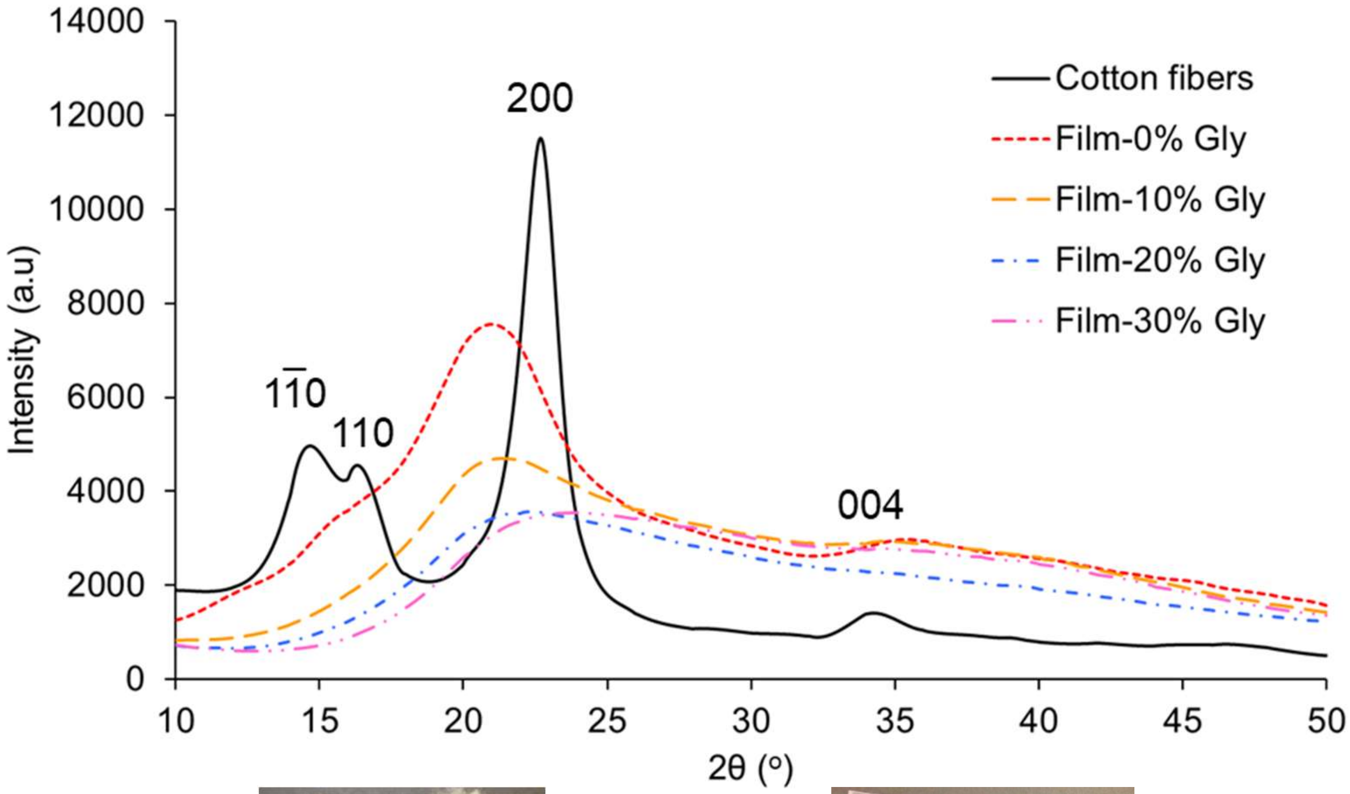
Schematic of the interaction among Li+ cation, Cl– anion, and DMAc when cellulose dissolves into the DMAc/LiCl system.
Zhang et al. J. Phys. Chem. B. 2014, 118, 31, 6507

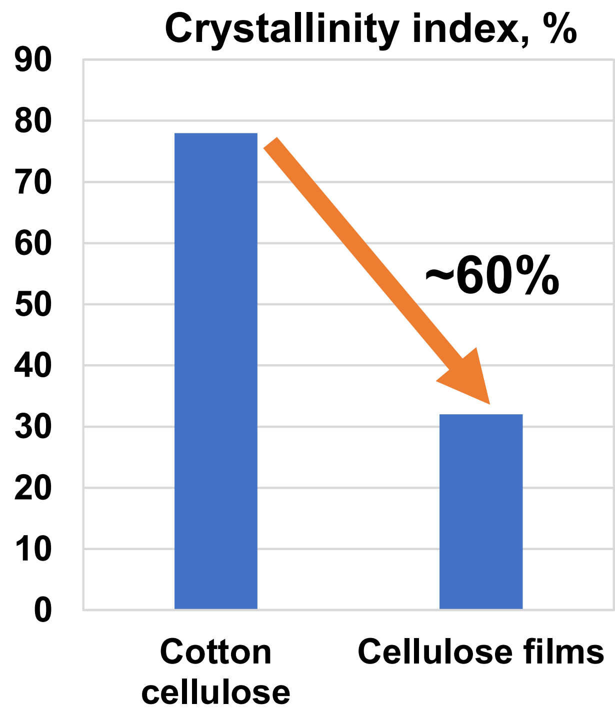


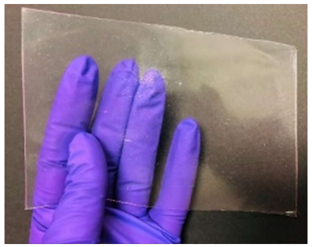




(Uto et al., 2018)

# Dissolution of cellulose in DMAc/LiCl

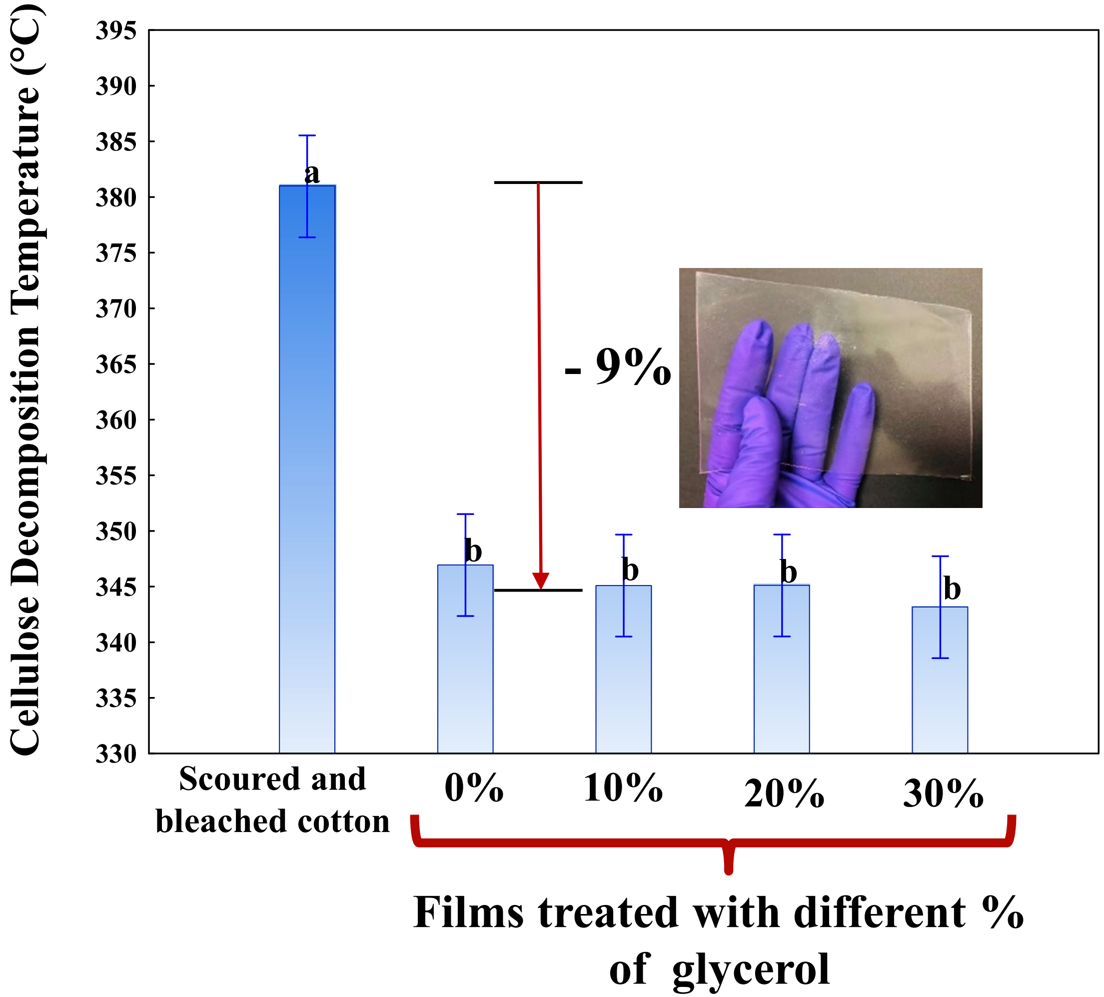


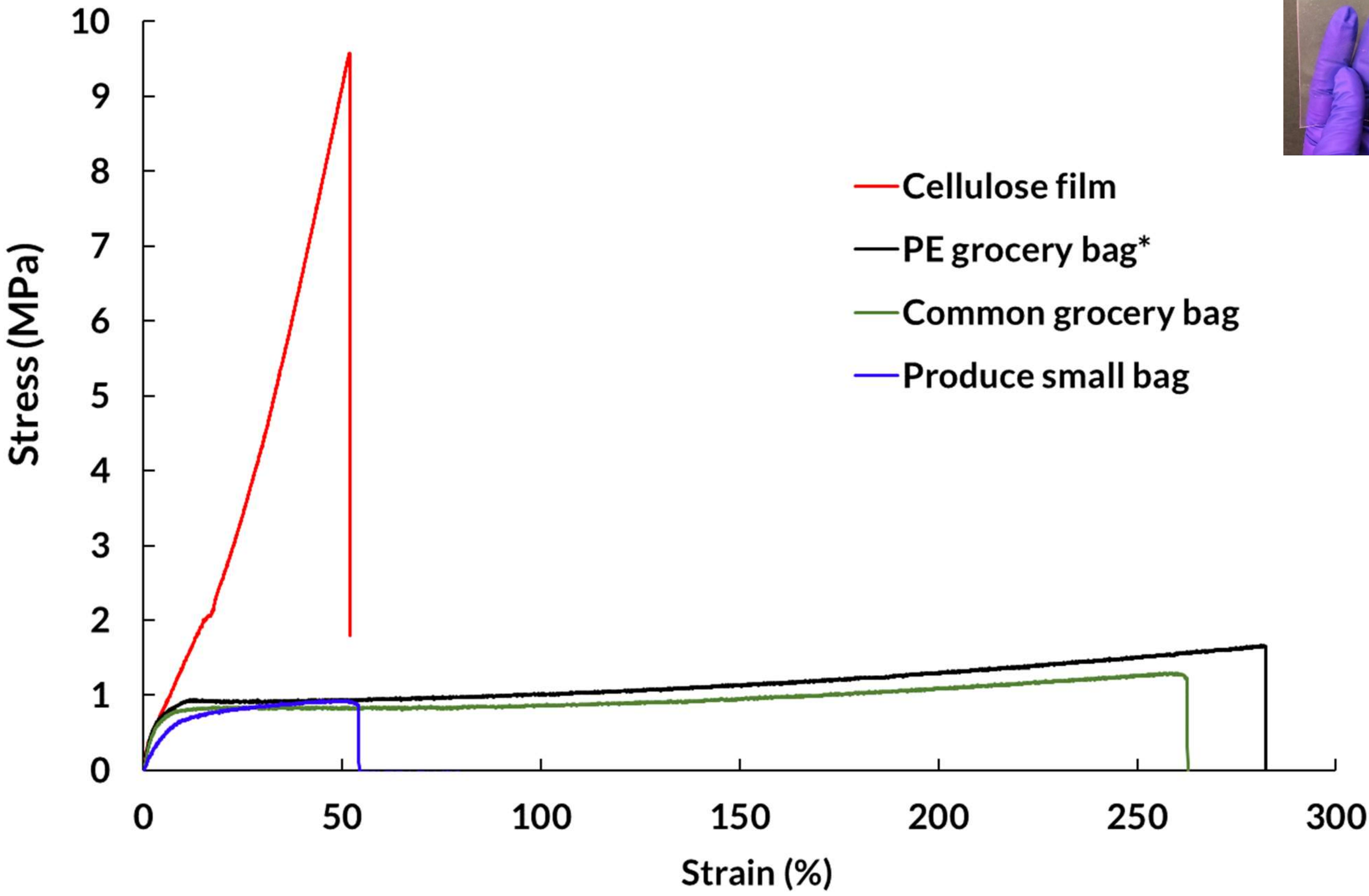



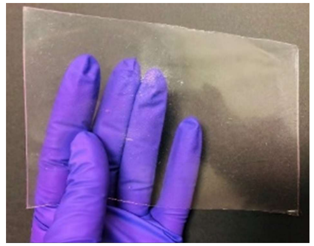
# Thermal stability of cellulose films

| | |
|---|---|
| Polyvinyl Chloride: 200-300°C | Polypropylene: 328-410°C |
| Polyethylene terephthalate: 283-306°C | Polystyrene: 300-400°C |
| Polyethylene: 335-450°C | Cellulose films: 340-355°C |




# Tensile properties of cellulose films



# Biodegradation of cellulose films

*Preconditioned soil beds*
*(12 ± 2% moisture)*

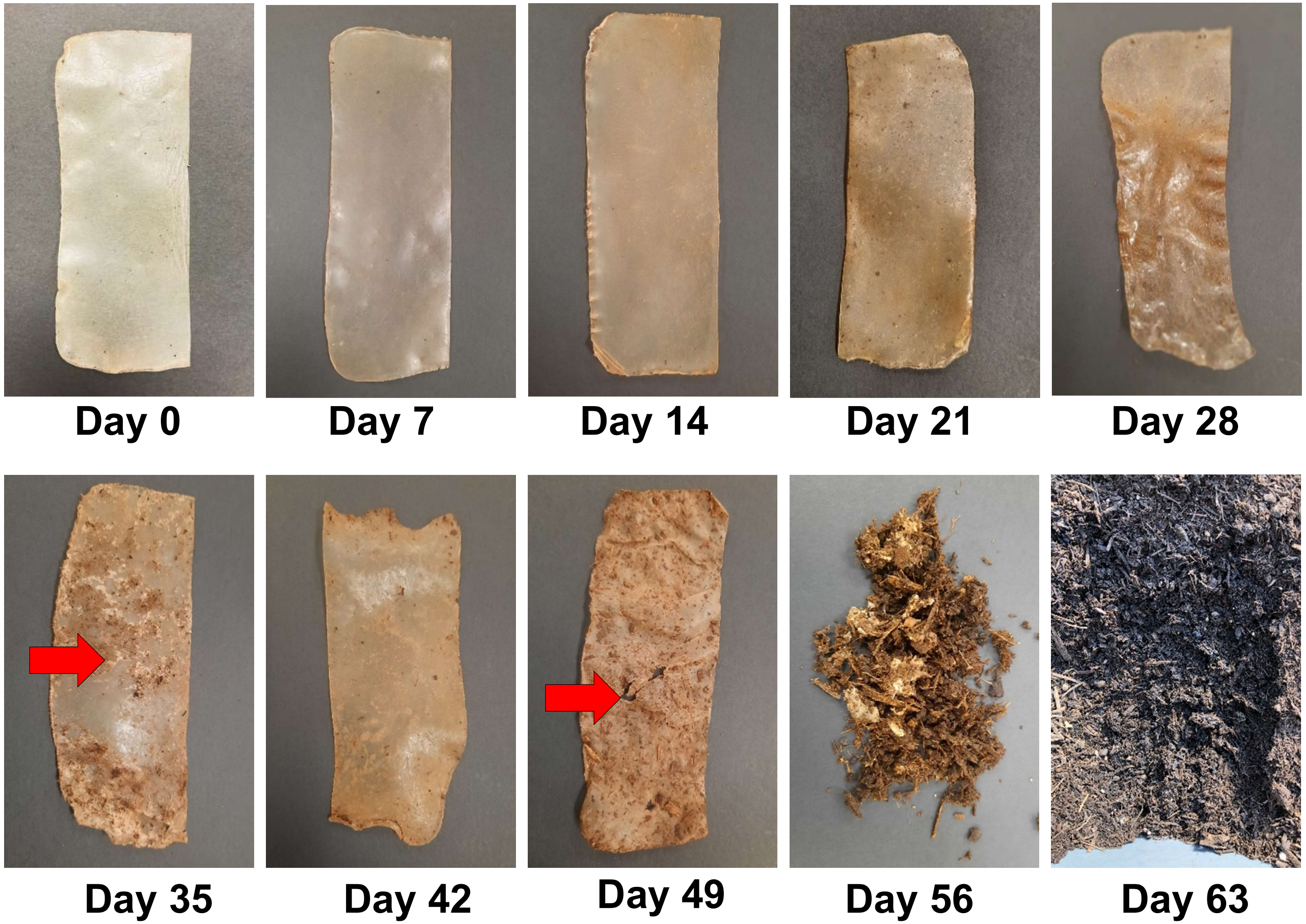
*Soil burial of cellulose films*

*High tunnel and sample trays placed inside a high tunnel*

*Soil moisture measurement using digital soil moisture meter*

# Biodegradation of cellulose films

**Start: 11 Aug. 2021**



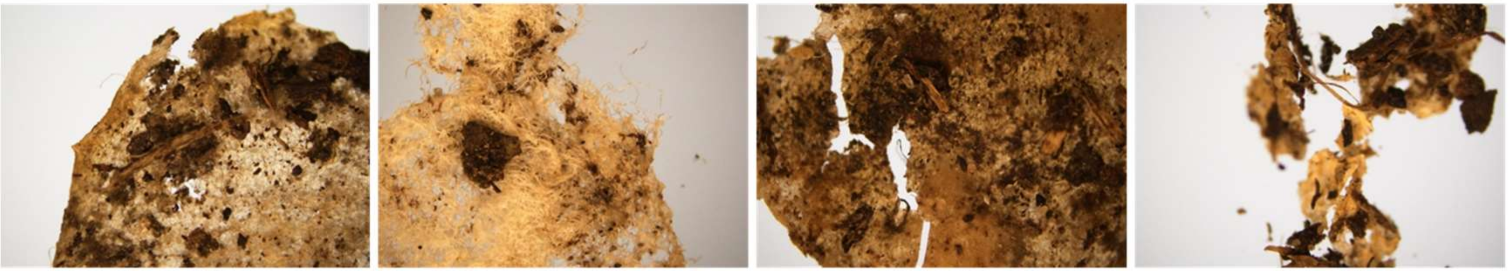

**End: 13 Oct. 2021**

**(Samples were degraded)**

Major changes: discoloration, shrinkage, adhesion of soil particles, appearances of whitish substance, holes, cracks, and fragmentation.

# Biodegradation of cellulose films

Day 0 | Day 7 | Day 14 | Day 21 | Day 28

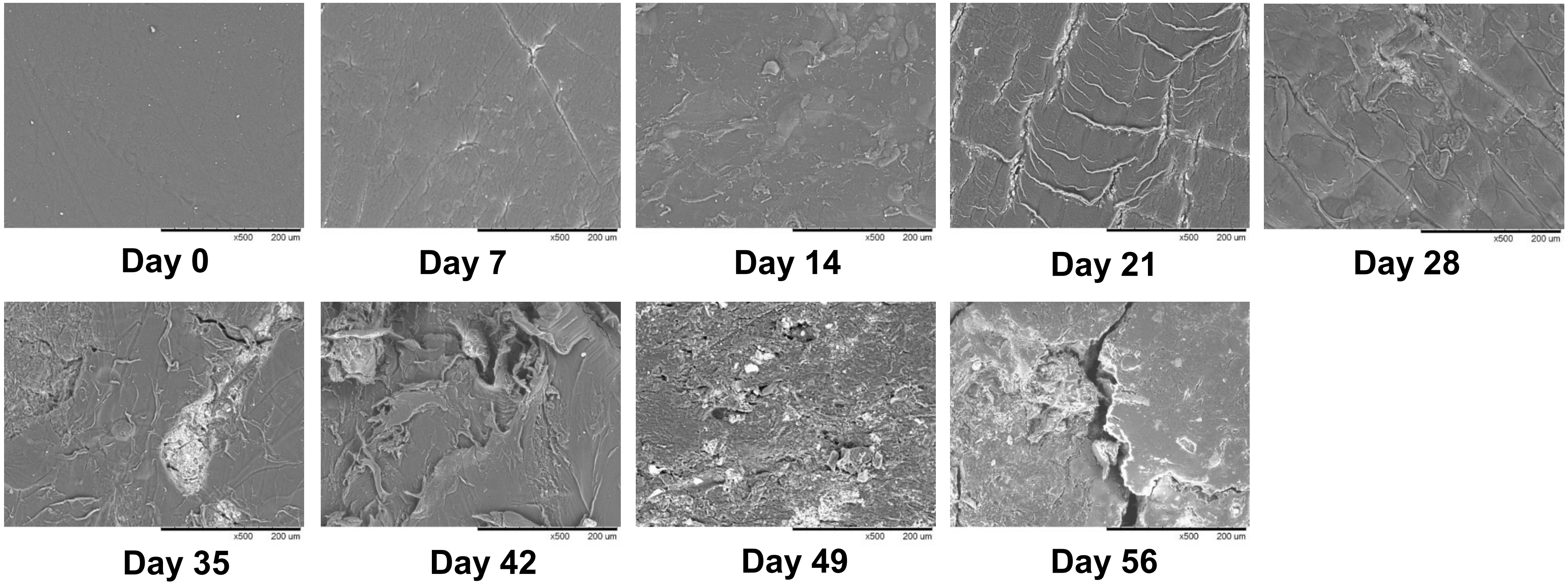


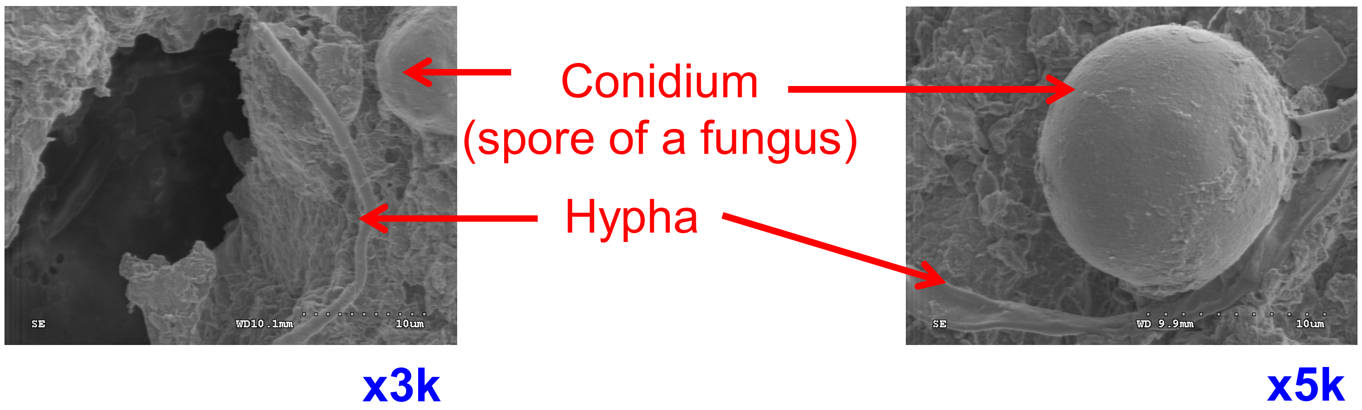
Sample degraded

Day 35 | Day 42 | Day 49 | Day 56 | Day 63


Major changes: discoloration, adhesion of soil particles, and appearances of holes, cracks, and fungi mycelium.

# Biodegradation of cellulose films



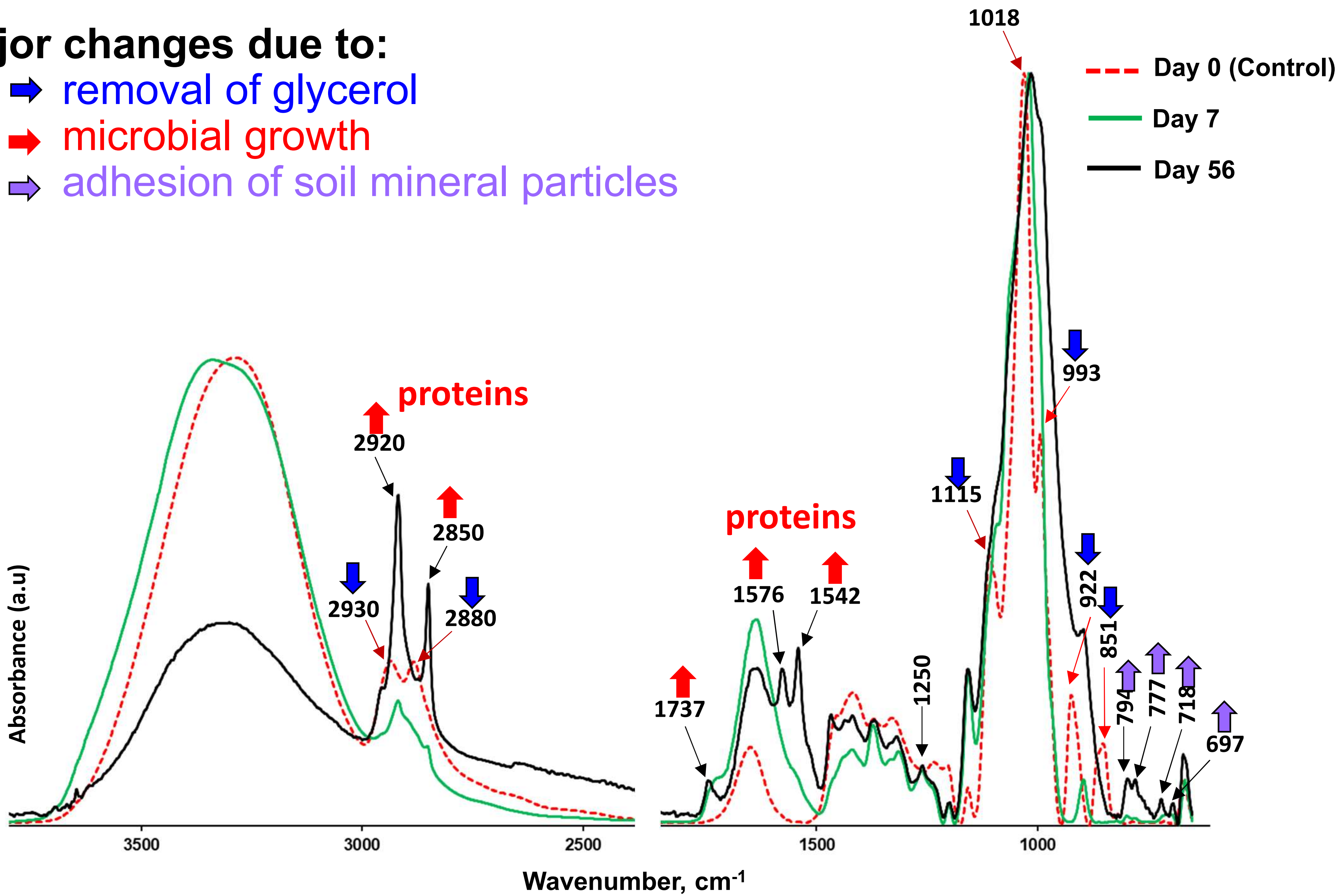




Conidium, a type of asexual reproductive spore of fungi usually produced at the tip or side of hyphae (filaments that make up the body of a typical fungus) or on special spore-producing structures called conidiophores. The spores detach when mature.

# FTIR of cellulose films

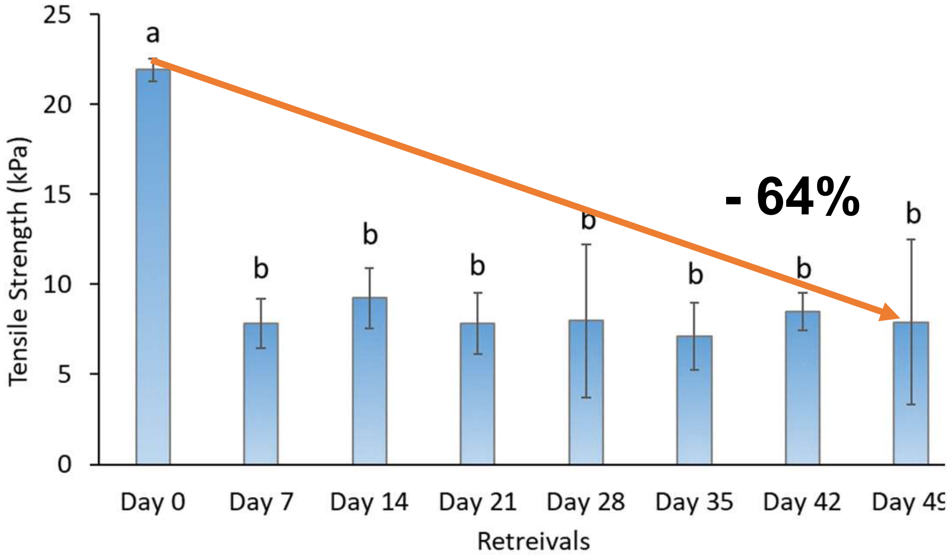
**Major changes due to:**

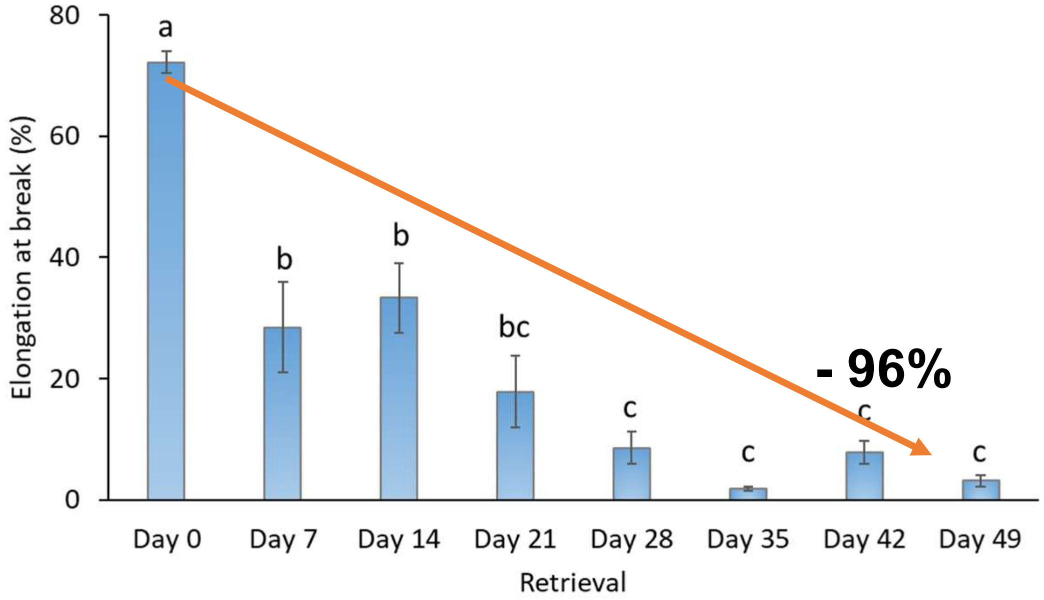
- removal of glycerol
- microbial growth
- adhesion of soil mineral particles



# Tensile properties of films as a function of time

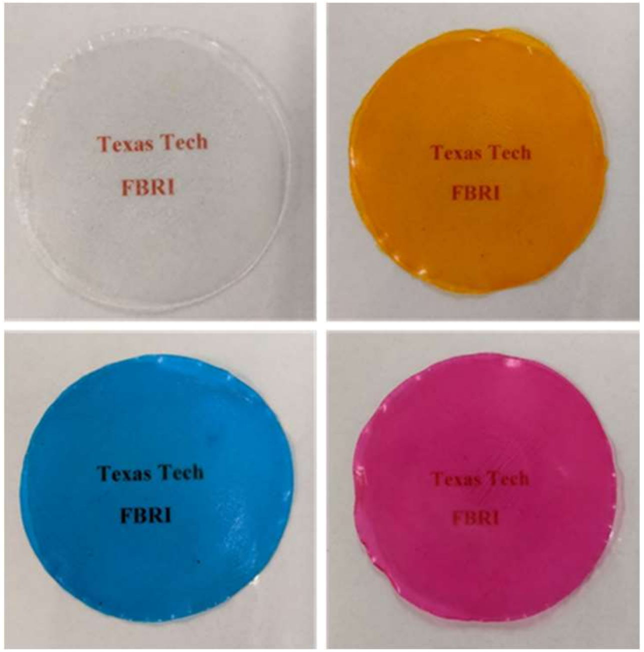
*Cellulose films buried in the soil*



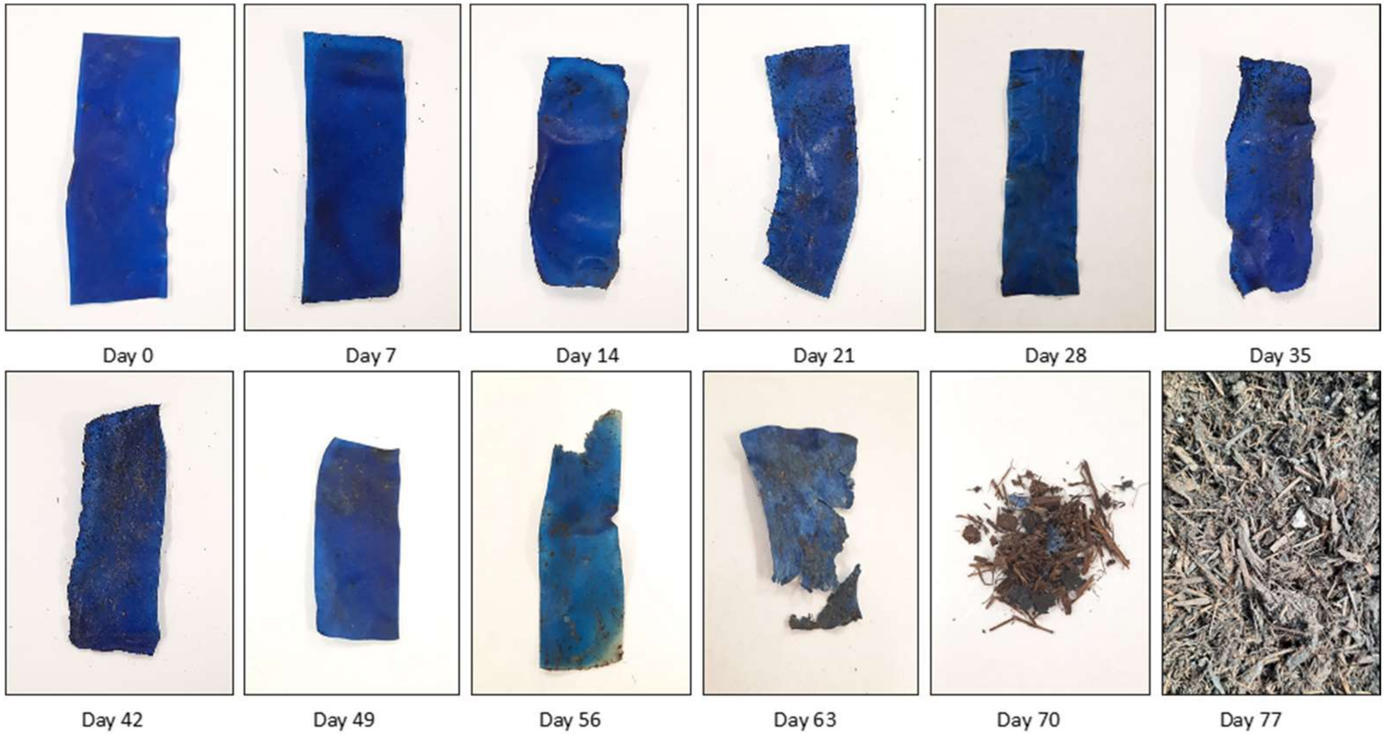



# Dyed cotton cellulose-based films

*Cellulose-based films can be dyed using cotton dyes*

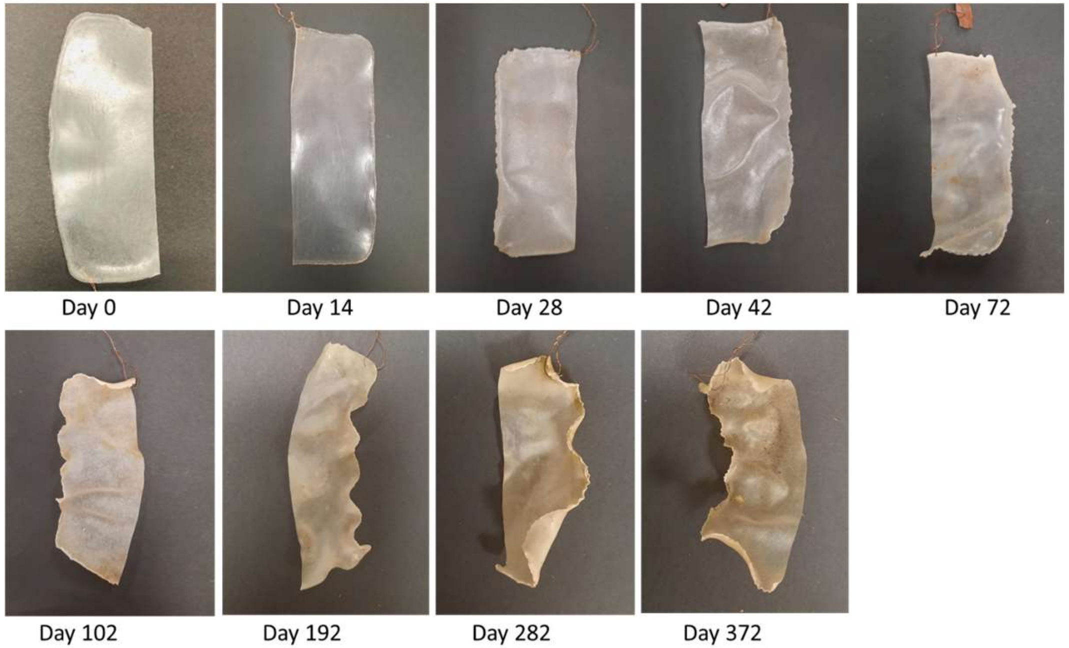


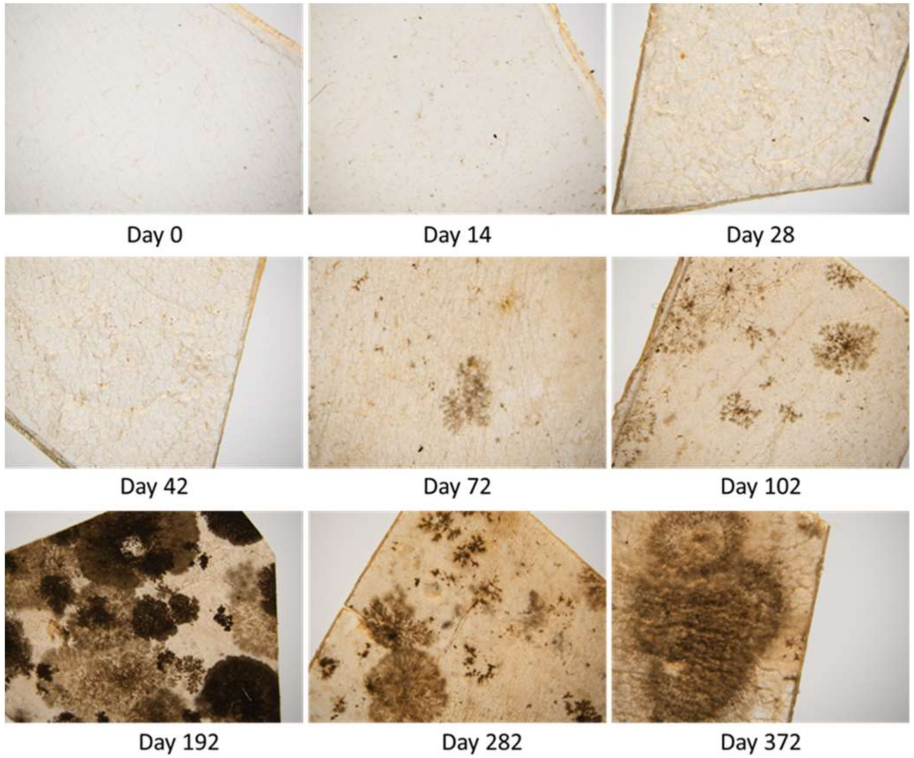

*Dye molecules do not inhibit the biodegradability of films*



# Degradation of cellulose-based films

*Cellulose films as foil cover*



# Degradation of petroleum-based films

*Regular plastic buried in the soil*

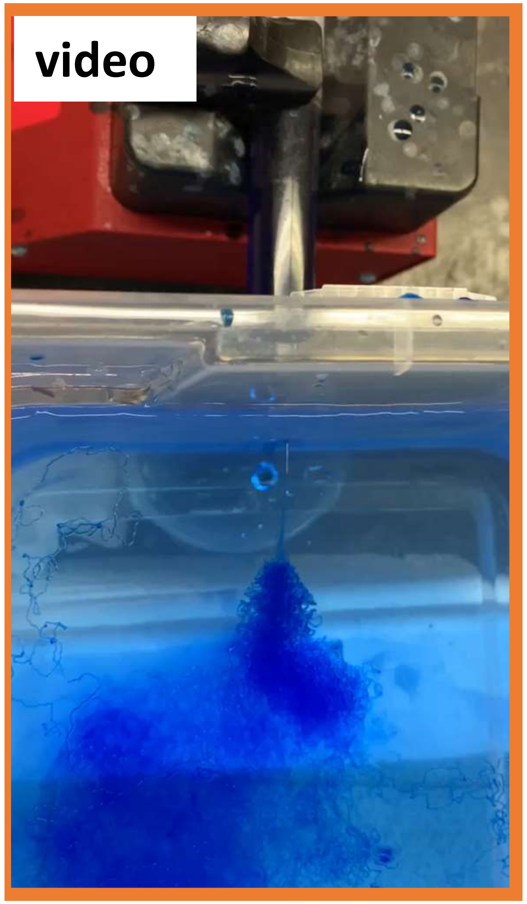
**Day 0**

**After 2 years**

*Regular plastic shopping bag under the action of sunlight*

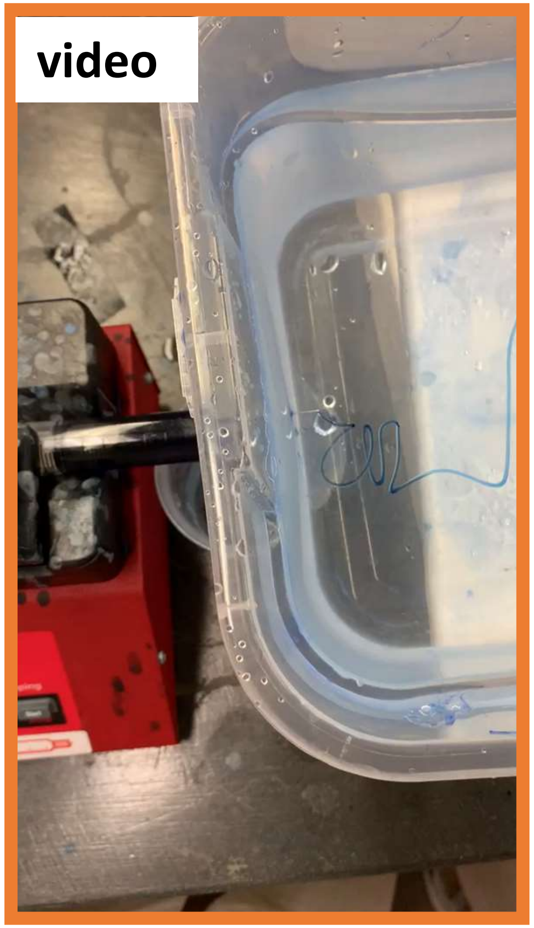
**After 2 years**

# Wet spinning from cotton cellulose solution

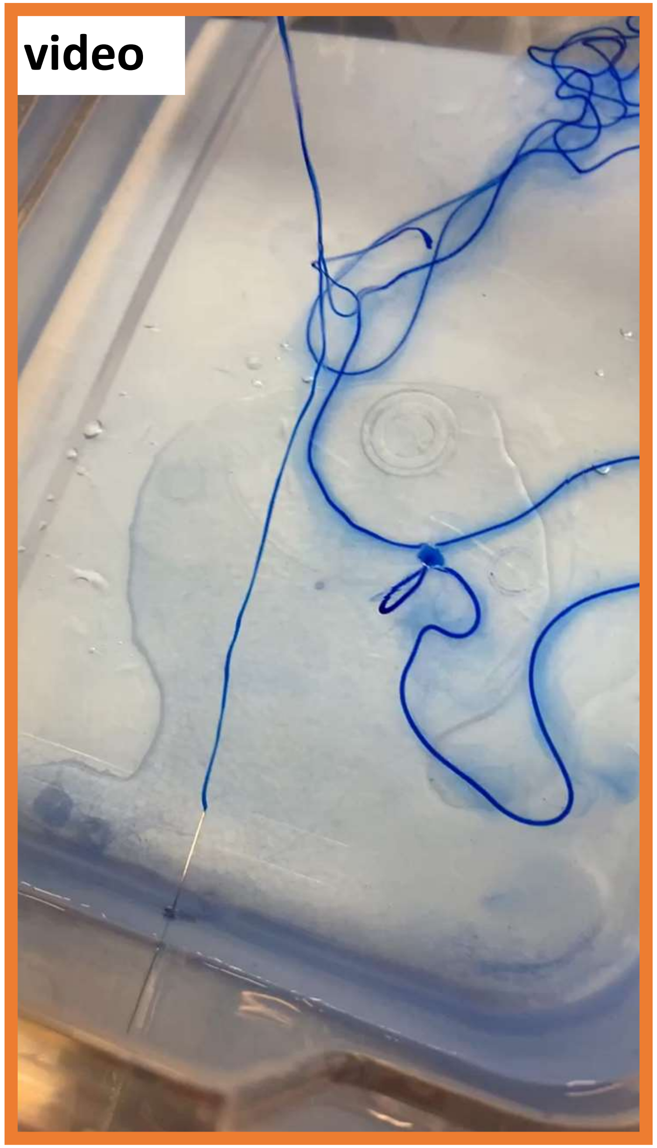



**Wet fibers**


Dried fibers



# Wet spinning from cotton cellulose solution

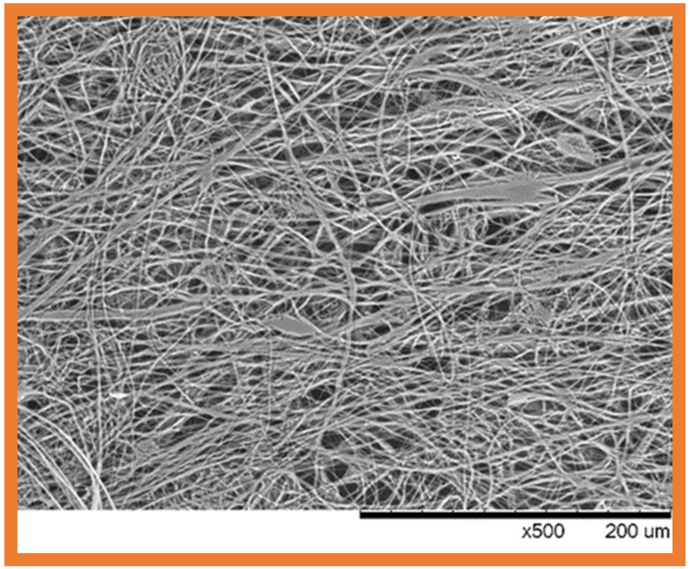


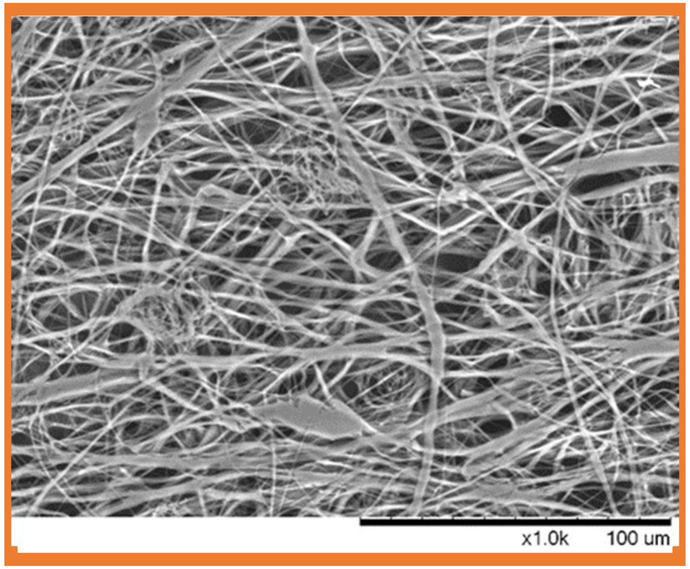

Wet fibers

Dried fibers

# Electrospinning from cotton cellulose solution

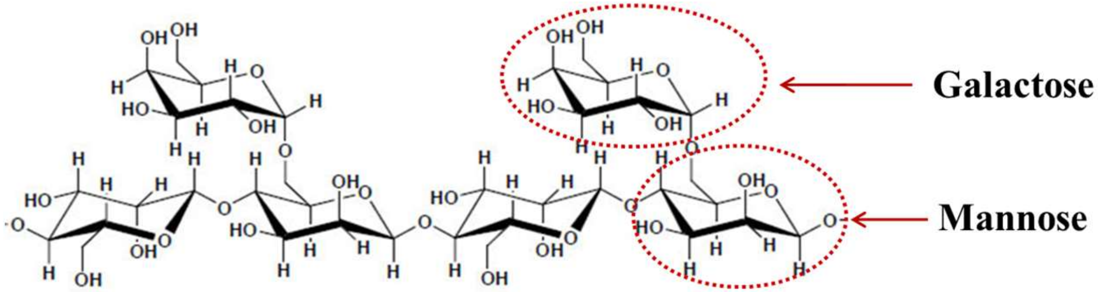

Electrospun fibers



# What is guar gum?

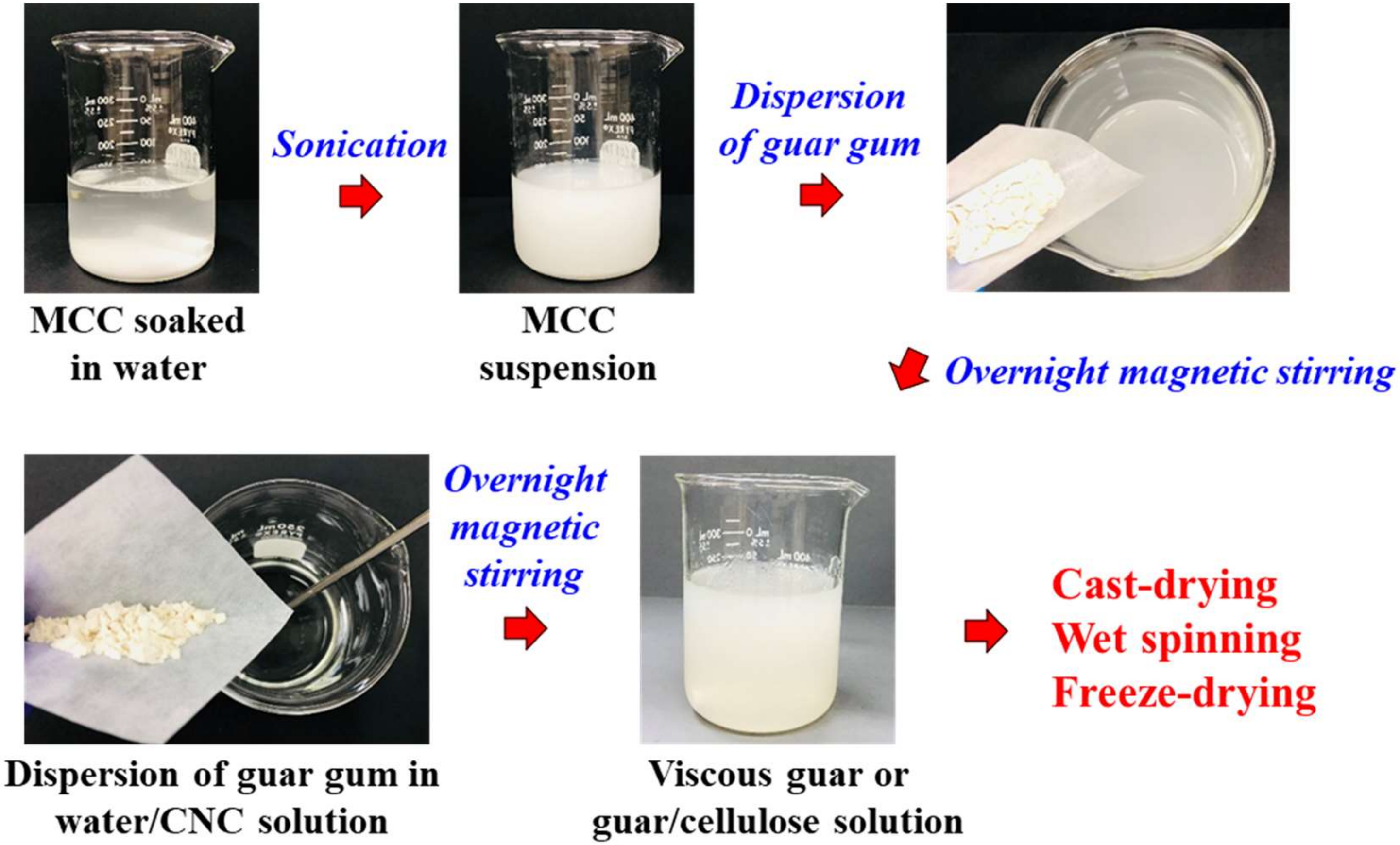
- A galactomannan extracted from guar or cluster bean (*Cyamopsis tetragonolobus L.).*
- Emerging as one of the most versatile and low-cost water-soluble biopolymers with unique fascinating properties.




Uses of guar gum

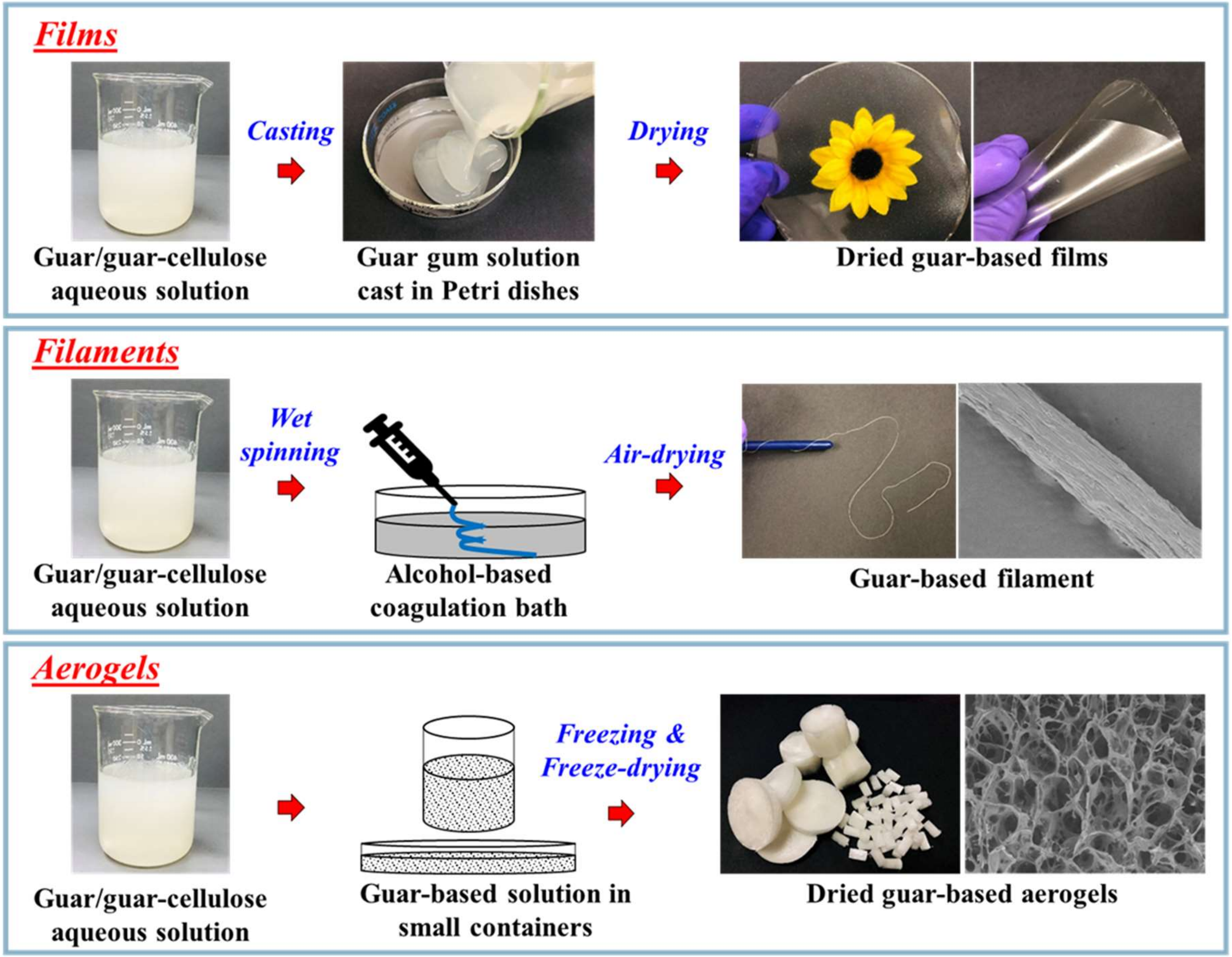
- Additive to pharmaceuticals, food, cosmetics, and several consumer products
- Hydraulic fracturing in oil well drilling to harvest shale gas and oil

# Cellulose-guar composite solution



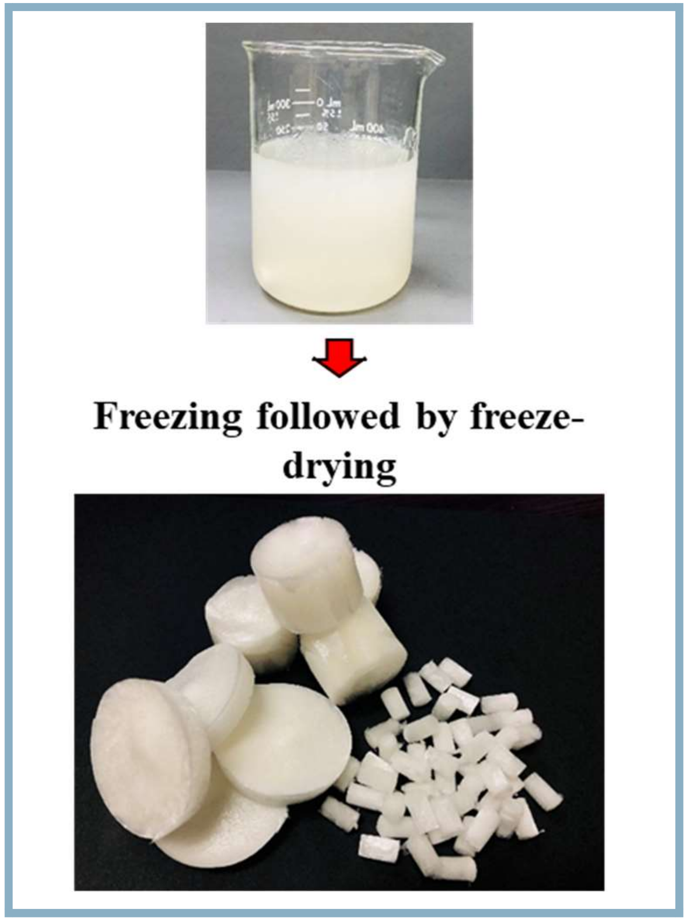

*Provisional US patent: 63/478,273*

# Cellulose-guar composite materials



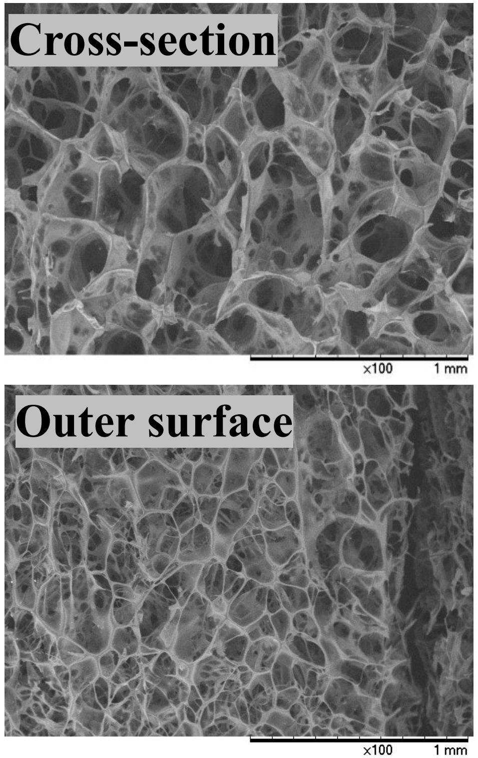

*Provisional US patent: 63/478,273*

# Cellulose-guar composite materials

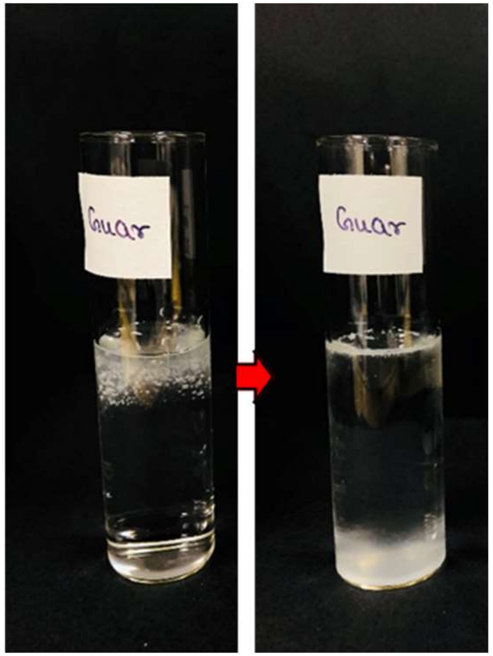



- Shape and size can be changed using different molds
- Can be used as a carrier for active ingredients

*Porous structure*



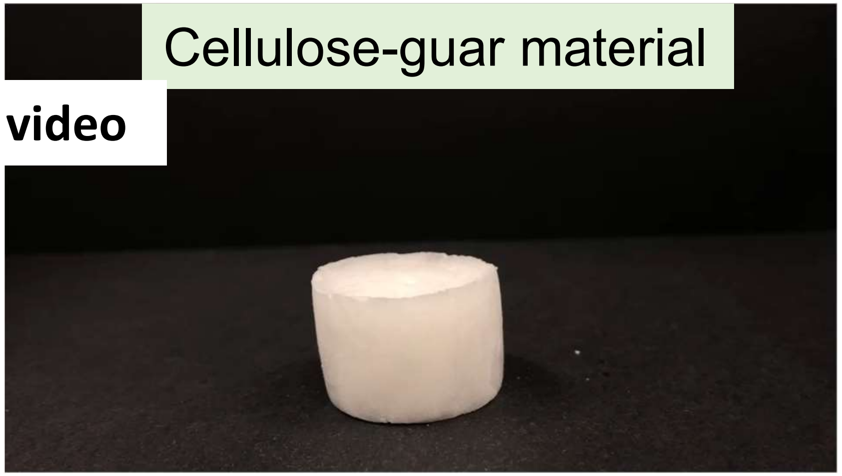

*Water soluble (~2-3 min with stirring)*



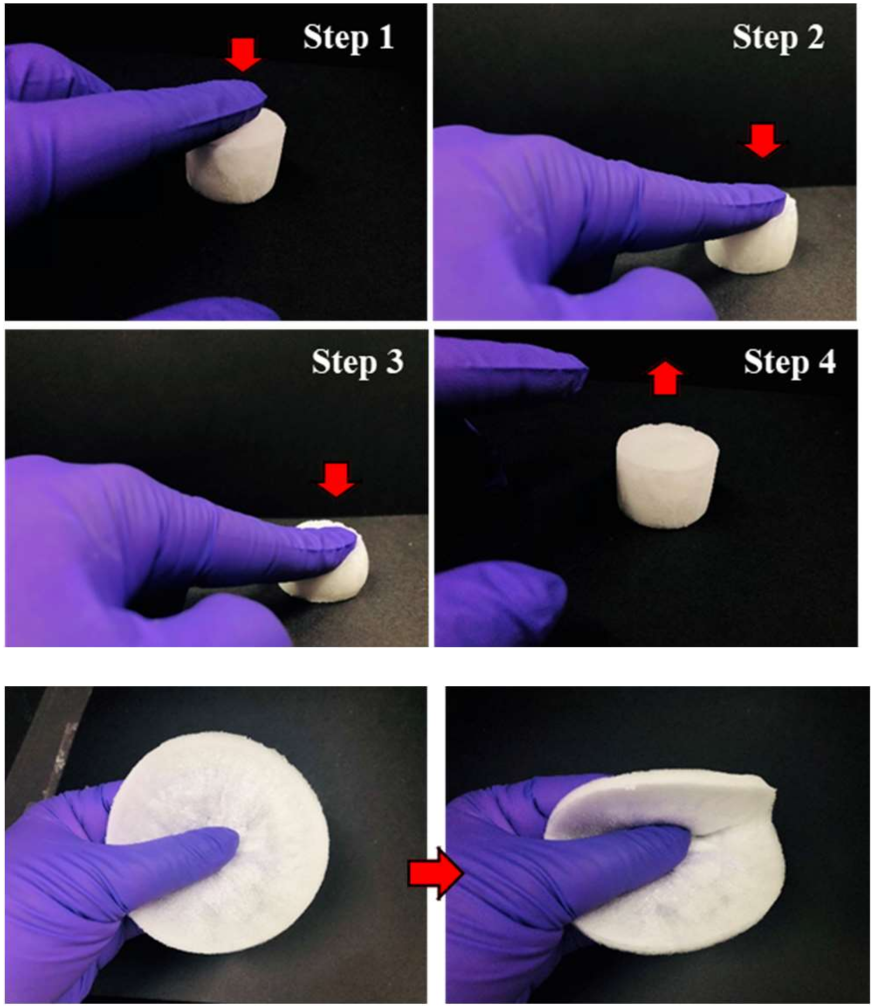

*Provisional US patent: 63/478,273*

# Cellulose-guar composite materials

- Easily compressible or foldable

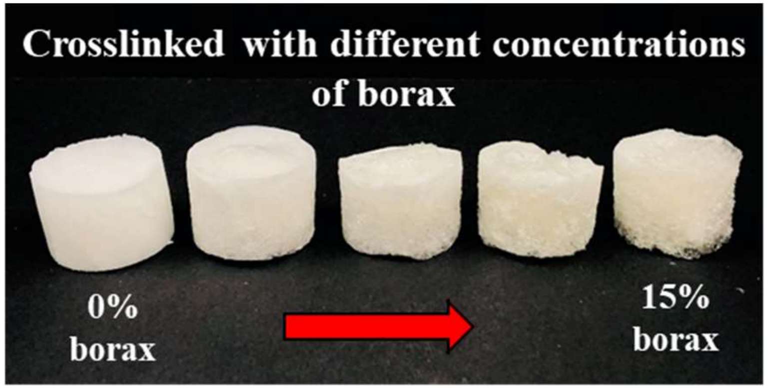


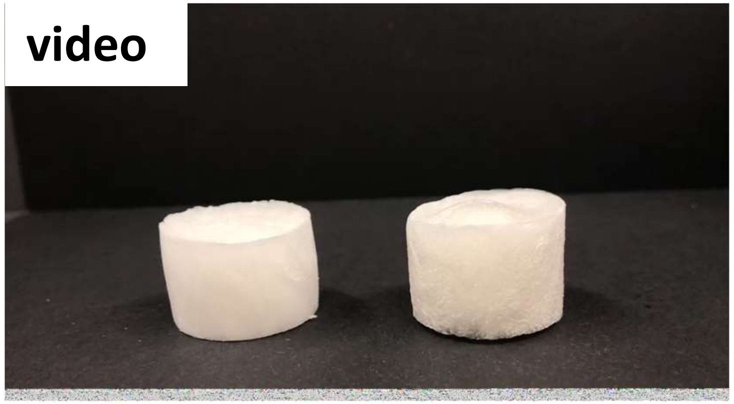


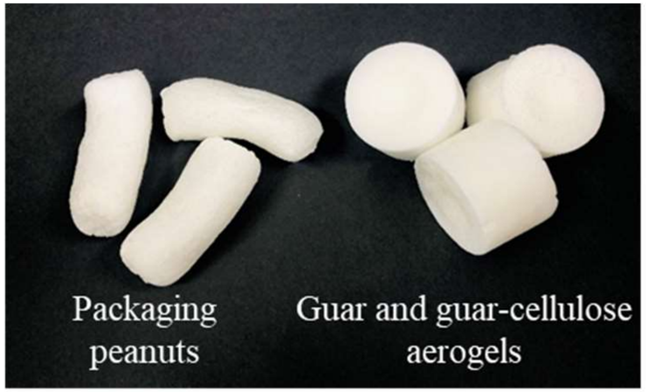



*Provisional US patent: 63/478,273*

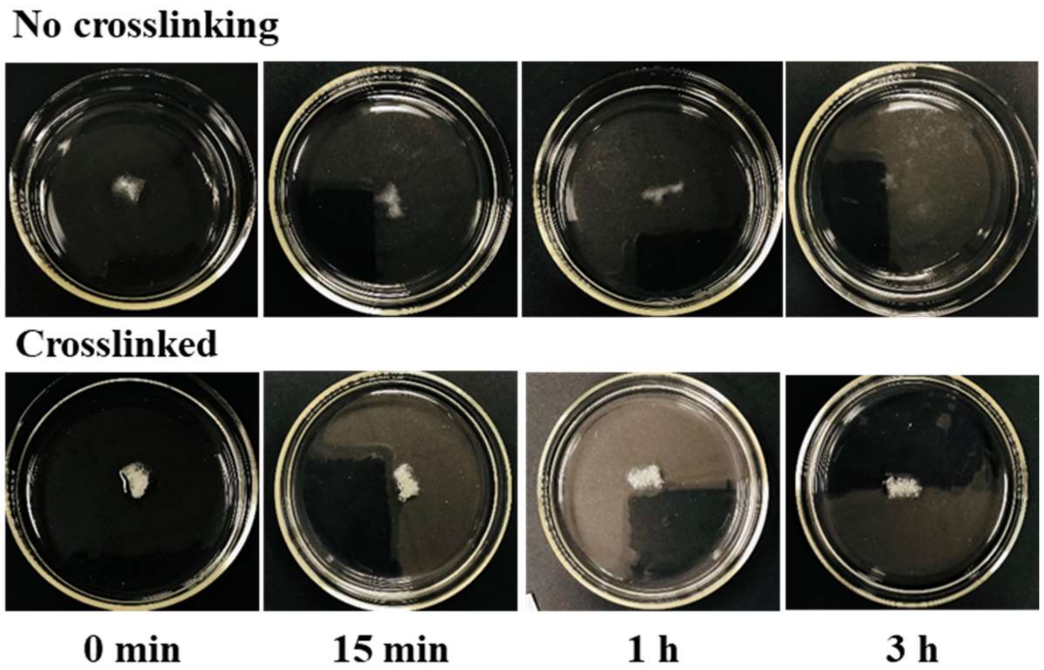
# Cellulose-guar composite materials



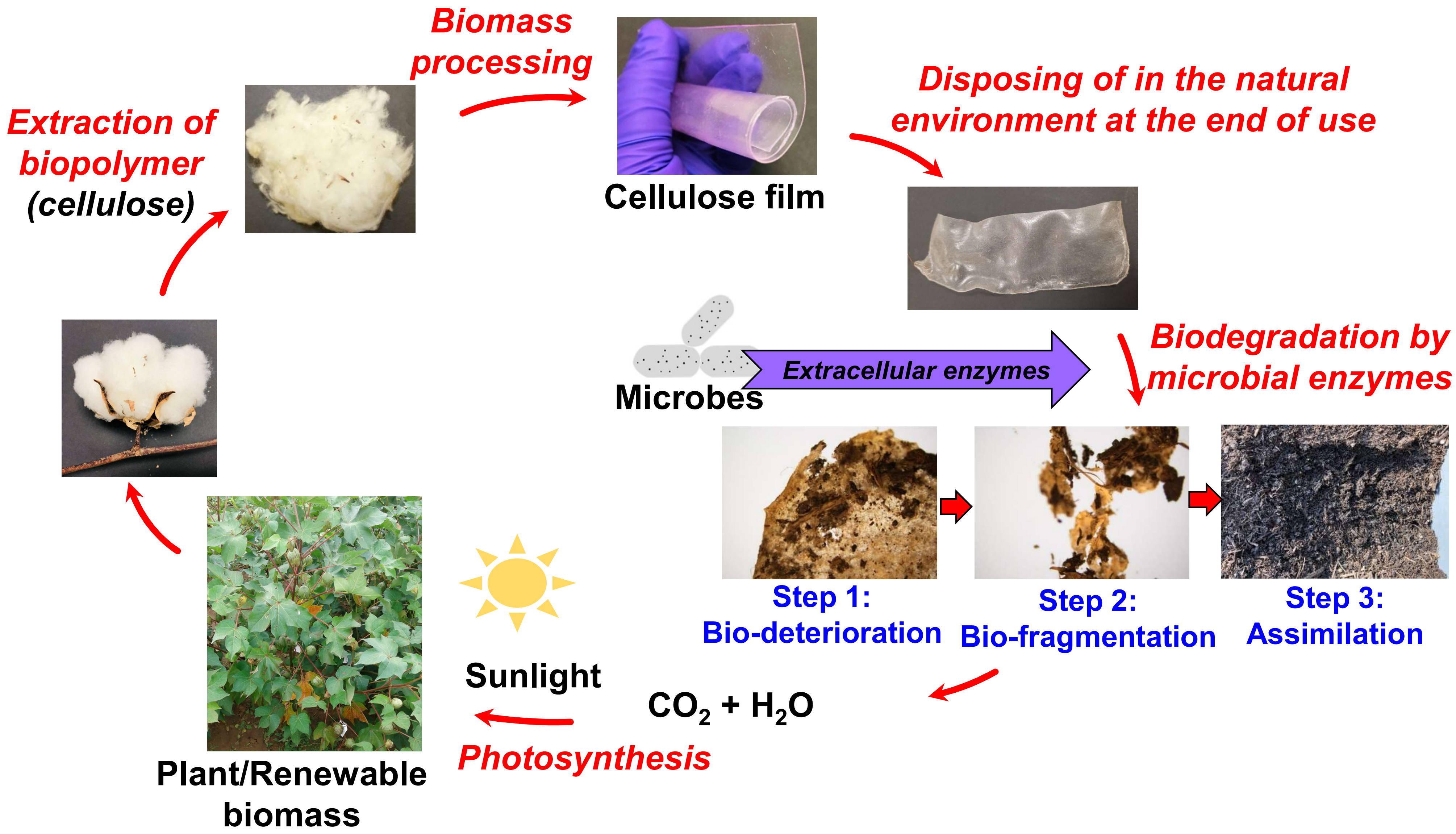

- Water solubility can be customized by crosslinking




- Guar-based aerogels resemble packaging peanuts

*Provisional US patent: 63/478,273*

# Carbon cycle of cellulose films



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# Thank you