

Nanocellulose Reinforced Polyurethane Hydrogels

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Soybeans are Ohio's #1 cash crop and #1 export crop
Soybeans generate over \$2.5 billion in annual revenue in Ohio, and over \$5.3 billion in economic impact
Ohio soybean industry creates about 30,000 Ohio jobs
Ohio is the 6th largest soybean producing state
There are about 25,000 soybean farmers in Ohio



	SEED COMPOSITION
	19% oil
MEAL -	34% PROTEIN
	21% INSOLUBLE CARBOHYDRATES (FIBER)
	9% soluble carbohydrates
	4% ash (minerals)
	13% MOISTURE
ta as of October 2015	Contract Con







•Soybeans are produced on about 5 million acres in Ohio

- •Total annual production is usually about 250 million bushels (6.8 million metric tons)
- •More than half of Ohio soybeans are exported
- •Ohio is known as a reliable supplier of commodity and specialty (food grade, organic, non-GMO, etc.) soybeans







#### commercial product portfolio





- Cellulose (and CNF) are renewable ٠ resources and biodegradable materials
- Interest in extracting cellulose (and CNF) • from waste plant materials, such as soybean straw (approximately 35 % cellulose)











# Potential nanocellulose applications

Lightweight but stiffer than Kevlar® and with eight times the tensile strength of steel

- electrically conductive
- highly absorbent
- thermostable



NANOCELLULOSE



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# **Polyurethane hydrogels**

Deaths from DFU or DFU related Amputation . Equal or exceed deaths from Prostate cancer, Breast cancer and Hodgkin lymphoma combined



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### **Cellulose nanofibers (CNF) from straw mulch**





TEMPO-mediated oxidation of cellulose

- mixture of TEMPO, NaClO, NaBr, maintained at pH = 10
- converts primary hydroxyl groups of cellulose to carboxylic acids (as carboxylate salt).





NMP = *N*-Methyl-2-pyrrolidone





∩-H

HO

ÒН

OH

HO<sup>1</sup>

OH



 $\cap$ 

ΗO

HO

HO

`OH

°OH

HO

.OΗ







## **CNF hydrogels**

- Hydrogels can be easily made from the 0.5 wt% CNF in TEA/NMP solution
  - Simply add a small amount of diisocyanate with catalyst, cure for 24 h at room temperature



(a)









## **CNF** in polyurethanes – water uptake

- Soaked in isopropanol for 48 h
- Soaked in Milli-Q water for 48 h, then weighed. Freeze dried, and reweighed





- IMTE PID/CN (이 IMT/) [1





- Isolated CNF from soybean straw
- Dispersed high loadings of CNF (0.5 wt%) in NMP using triethylamine
- Simple fabrication of CNF hydrogels by addition of diisocyanate with catalyst to CNF in NMP
- Depending on diisocyanate used;
  - CNF hydrogel can be made transparent or opaque
  - CNF hydrogel can have variable water uptake (28,200-37,300% or 4,690-7,080%)



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