

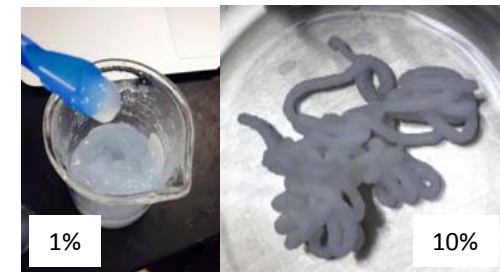
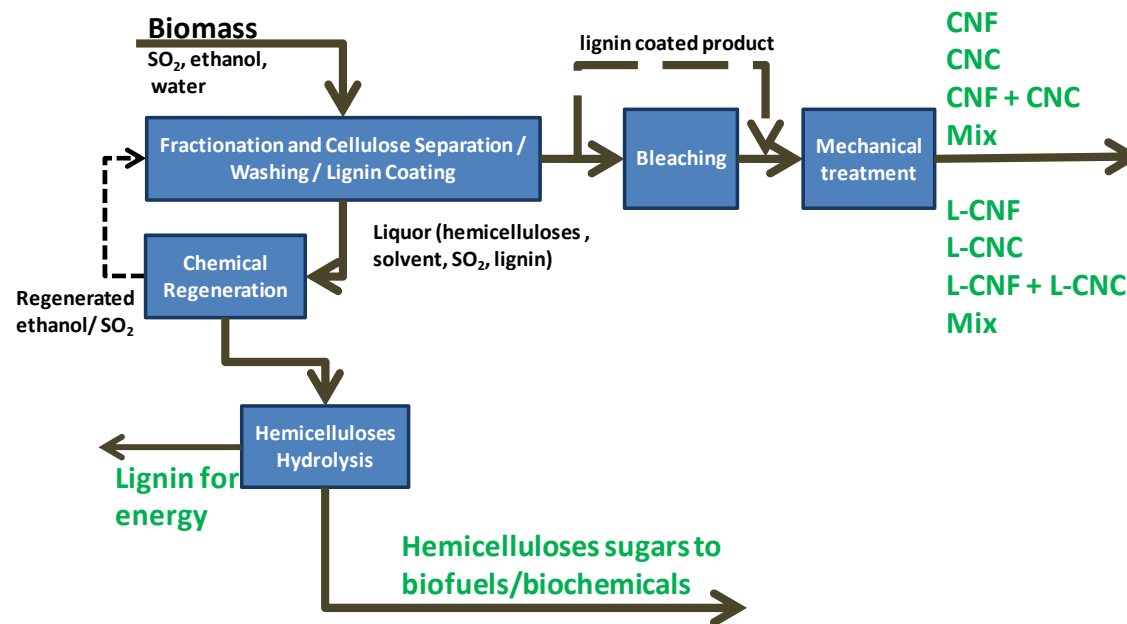
# Challenges and Opportunities in Manufacturing Panel

**Kim Nelson, PhD**  
**American Process Inc.**

*Cellulose Nanomaterials – A Path Towards Commercialization*  
*A Workshop Co-Sponsored by*  
*USDA Forest Service*  
*National Nanotechnology Initiative*

# American Process Inc.

- Currently installing a 1 ton per day (dry basis) nanocellulose pilot line at our existing AVAP Biorefinery in Thomaston, Georgia to produce cellulose nanocrystals (CNC), cellulose nanofibrils (CNF), and hydrophobic, lignin-coated varieties directly from biomass



AVAP CNC



AVAP L-CNC

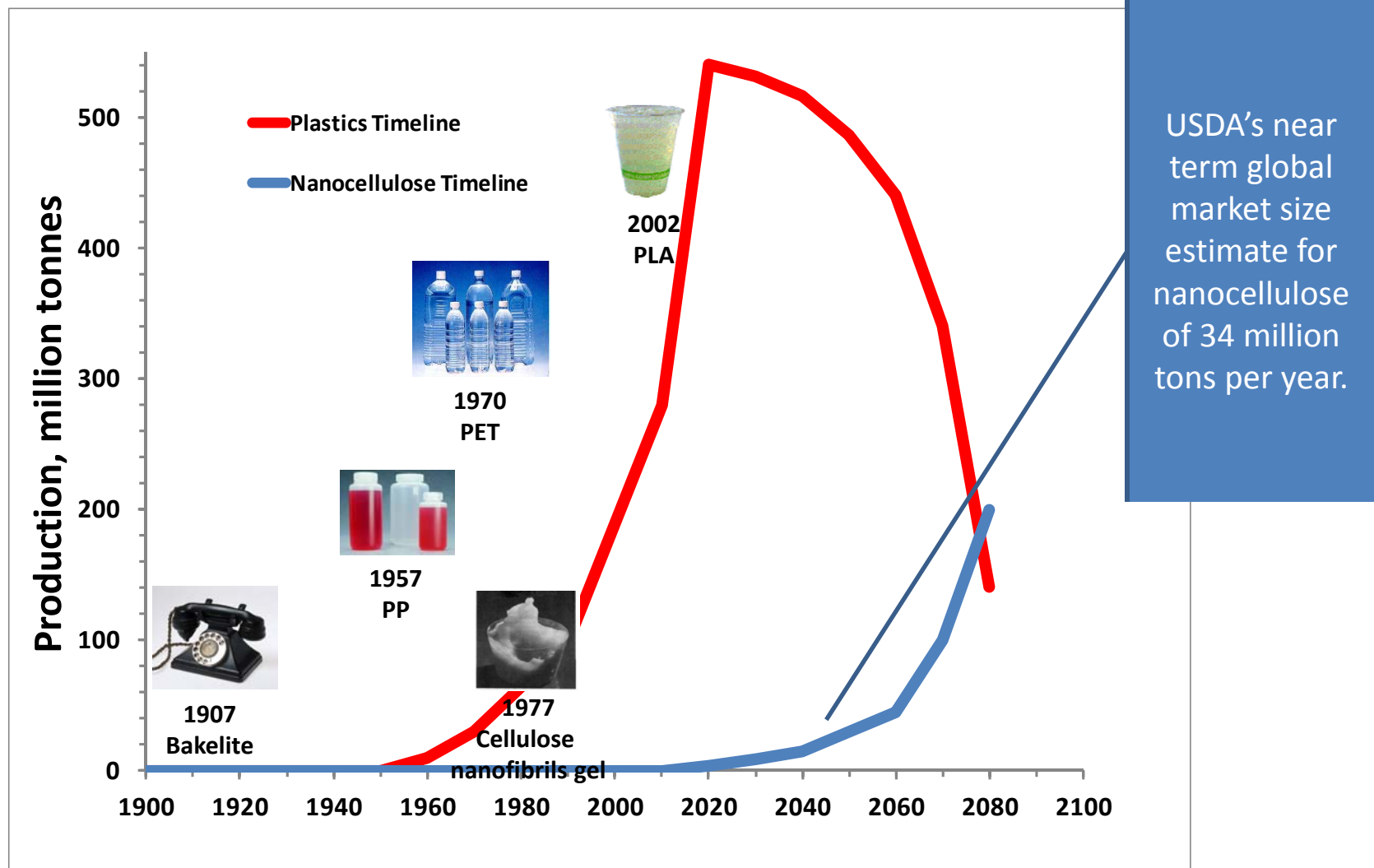
# Manufacturing Opportunities

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- **Low Production Cost for CNC and CNF** with estimates of <\$1 lb (wet basis).
- **Low cost feedstock utilization** with omnivorous processes.
- **Low tonnage “side line” production** in existing pulp mills for coproduction with pulp, lignin, and biofuels or biochemicals
- **High tonnage “stand alone” production** in repurposed pulp mills using existing infrastructure including wood delivery and handling, utilities, waste water treatment, bleach lines etc.
- **Large demand potential** with a near term global market size estimate for nanocellulose of 34 million tons per year (recent USDA funded study)<sup>1</sup>.

1. Cowie, J., Bilek, E.M., Wegner, T.H., et al.(2014)

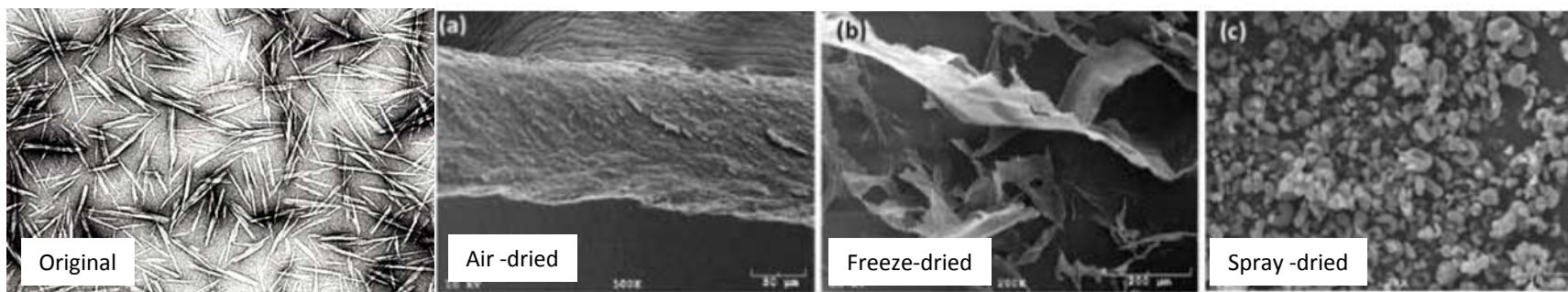
# Possible Global Production Curve



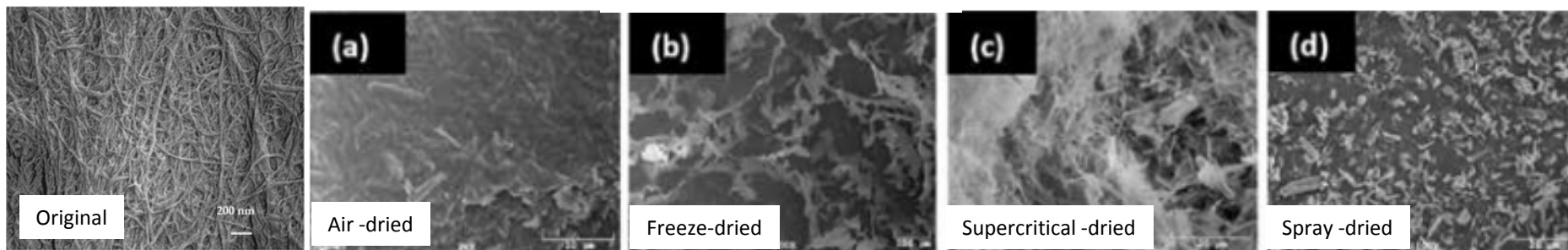
# Manufacturing Challenge: Drying

- Economical preservation of discrete nanocellulose particle morphology during drying for effective re-dispersion in hydrophobic plastic resins

## Cellulose Nanocrystals<sup>1</sup>



## Cellulose Nanofibrils<sup>2</sup>



1. Drying Cellulose Nanocrystal Suspensions, Peng et al. Production and Applications of Cellulose Nanomaterials, TAPPI Press.

2. Drying Cellulose Nanofibril Suspensions, Peng et al. Production and Applications of Cellulose Nanomaterials, TAPPI Press.

# Manufacturing Challenge: Drying

- **Lesson learned from similar experience:** Coating CNC with lignin appears to prevent hydrogen bonding during freeze-drying. Resulting powder can be uniformly re-dispersed in silicone for a semi-transparent, stronger composite.
- **Research Question:** Is there a low cost, hydrogen bonding “blocker” for freeze-drying of conventional CNC that maintains color/transparency and is compatible with hydrophobic plastics?



# Manufacturing Challenge: Rapid Particle Size Characterization

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- Develop rapid size characterization of CNC and CNF for process and product quality control

## TODAY



- Cost: \$\$\$\$
- Sample prep time: ~30 min per sample
- Characterization time: ~15-25 min per sample + manual image analysis
- Staff requirements: highly technical experts
- Location: Specially designed individual room- sensitivity to ambient conditions

## TOMORROW



- Cost: \$
- Sample prep time: <5 minutes per sample
- Characterization time: <5 min per test
- Staff requirements: process operators
- Location: Operating floor or process quality test lab

# EHS Priorities

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## Safety

- Occupational Safety
  - Detection in environmental media
  - Airborne exposure methods
- Product Safety
  - Demonstrating safety of functionalized nanocellulosic materials
  - Human health testing
  - Environmental releases
- International Safety Standards

## Regulatory

- Lack of clarity on regulatory requirements for nanomaterials
- Variability of requirements by geography and application
- Lack of standards for nanomaterials
- Lack of validated methods for assessing safety



# Thank You



PRESENTED BY

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