



Recycling Research at NCSU

- Flotation Deinking
- Sensors for Automatic Sorting
- Sludge to Ethanol



Natural Surfactants for Flotation Deinking in Paper Recycling

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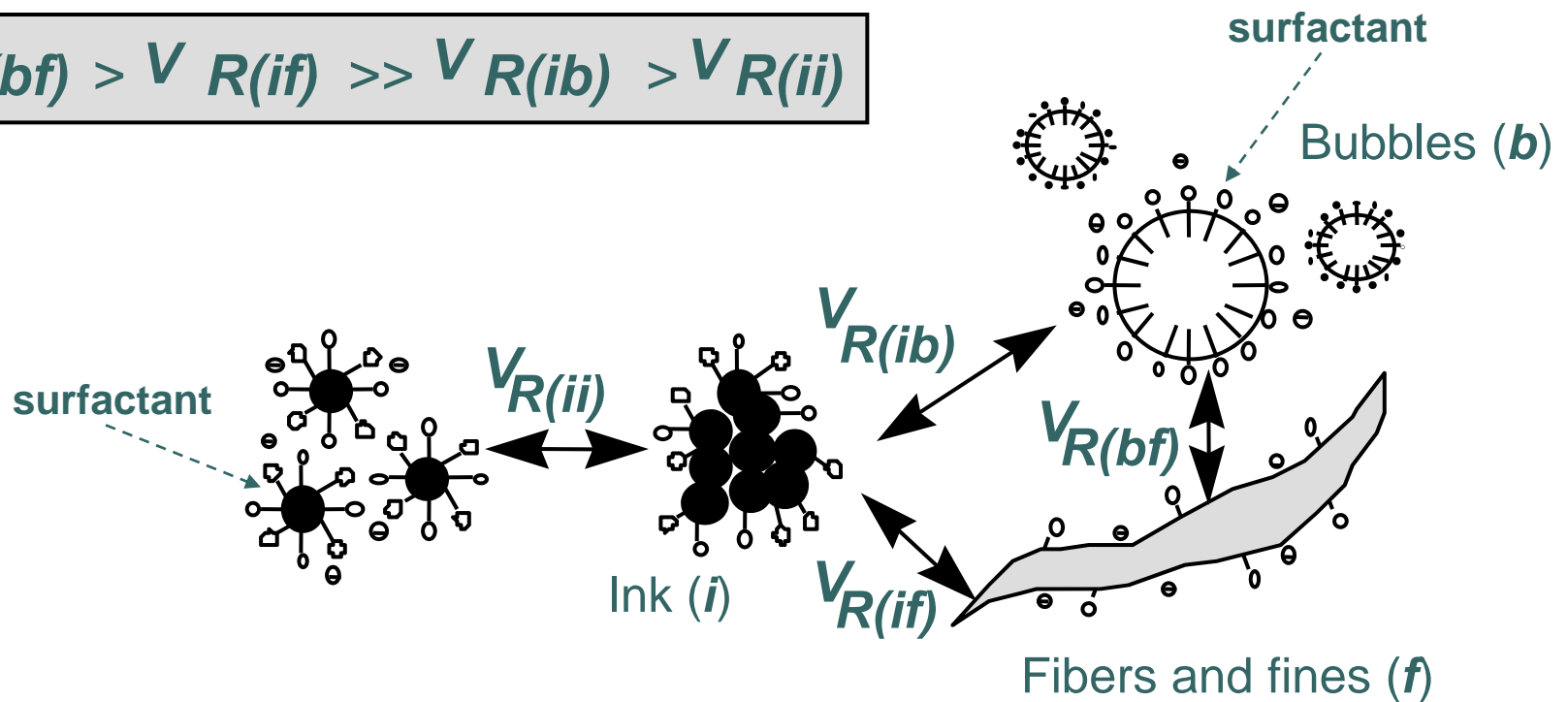
Forest Biomaterials Science and Engineering, North
Carolina State University, Raleigh USA

Balance of Forces

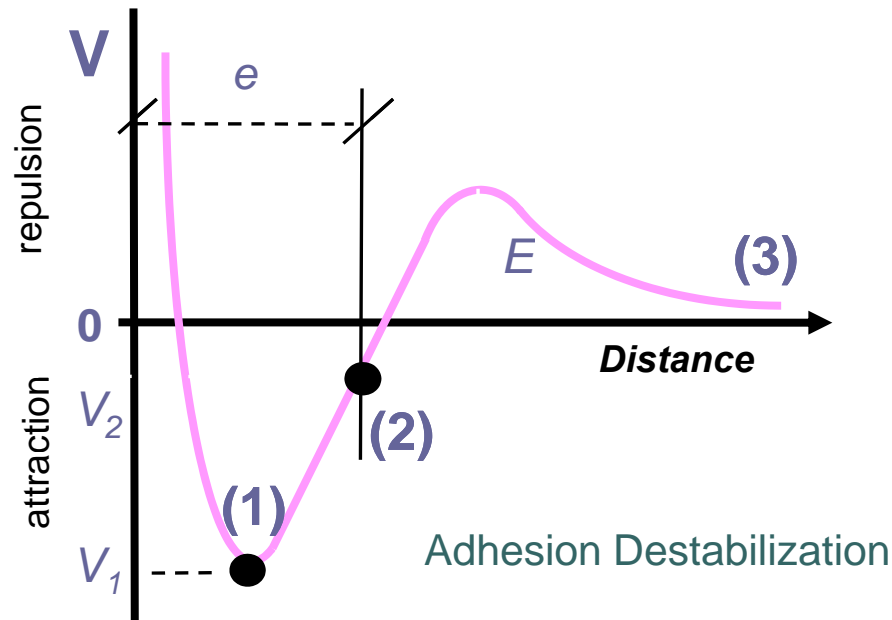
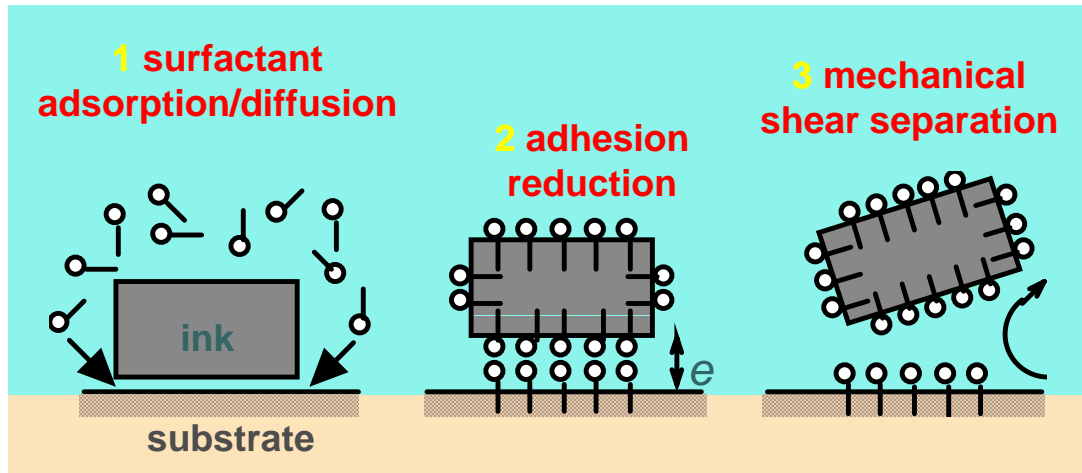
- flocculate free ink particles
- have them adsorbed onto rising bubbles
- prevent ink re-deposition onto the fiber
- prevent adhesion of fibers on froth.

V_R (repulsive energies):

$$V_{R(bf)} > V_{R(if)} \gg V_{R(ib)} > V_{R(ii)}$$



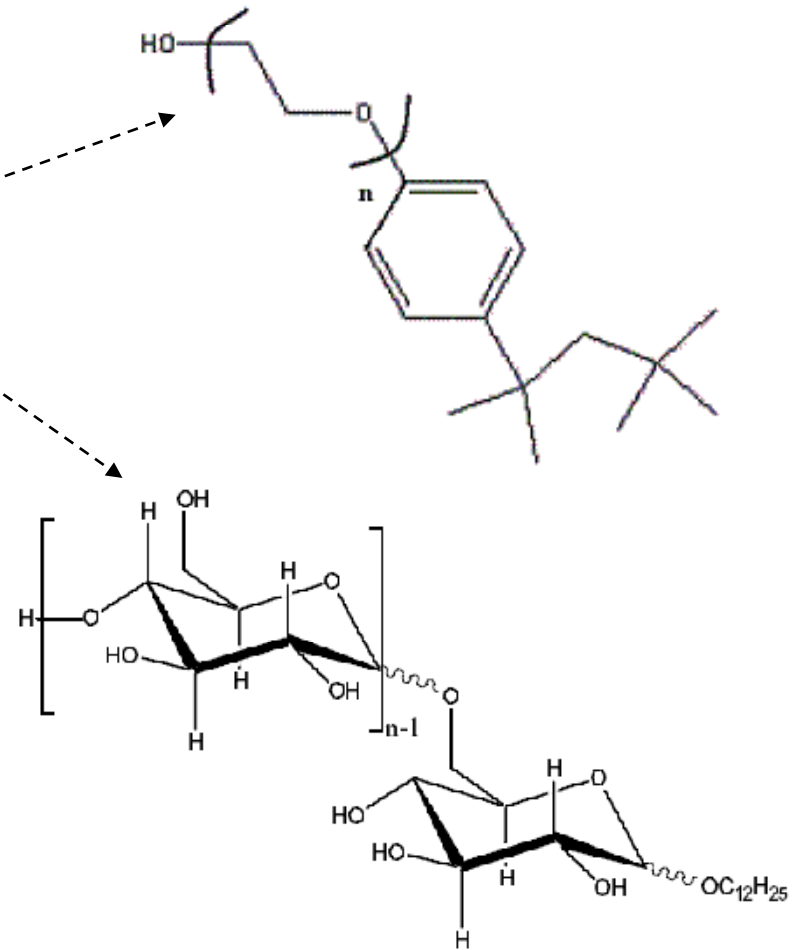
Detergency (assists detachment, may interfere with bubble attachment)



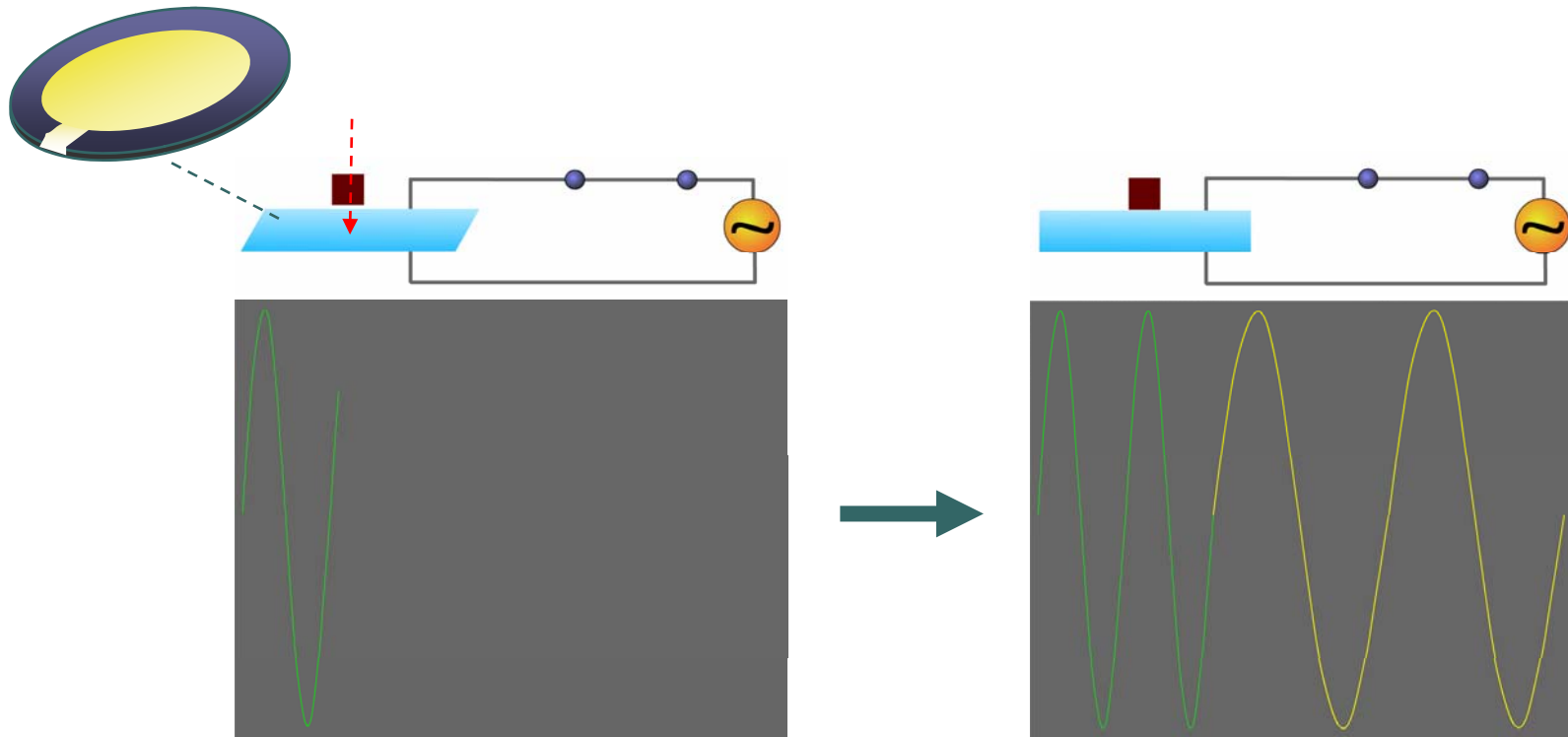
- (1) adhered particle
- (2) particle separation
- (3) particle removal

Surfactants Studied

- Alkyl phenol ethoxylate (APE)
- Alkyl (C10-C16) mono and oligomeric D- glucopyranose
- Protein-based surfactant from soybean
- Commercially formulated surfactant blend



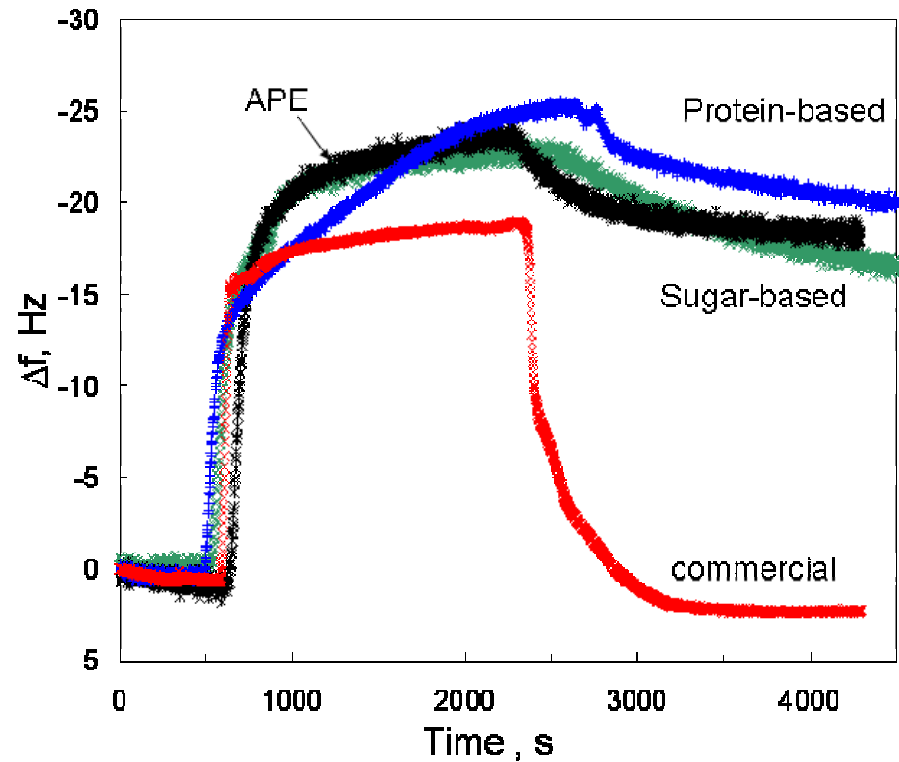
Quartz Crystal Microbalance



Frequency change (Δf): related to the mass of the attached film

● ● ● QCM Results

- Surfactant solution injected around 500 s
- Rinsing with water at about 2500 s
- Commercial surfactant had lowest affinity to model ink film



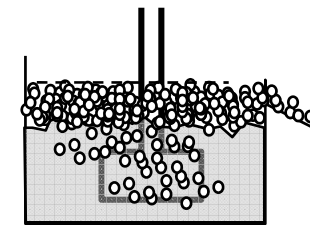
Type	Amount adsorbed (ng)	Surfactant released (ng)
Commercial	10.1	11.3
Synthetic	12.8	3.0
Protein-based	13.6	3.1
Sugar-based	12.4	3.7

● ● ● Flotation Deinking Experiments

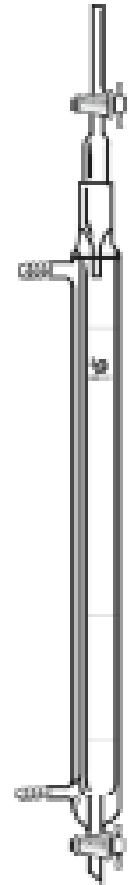
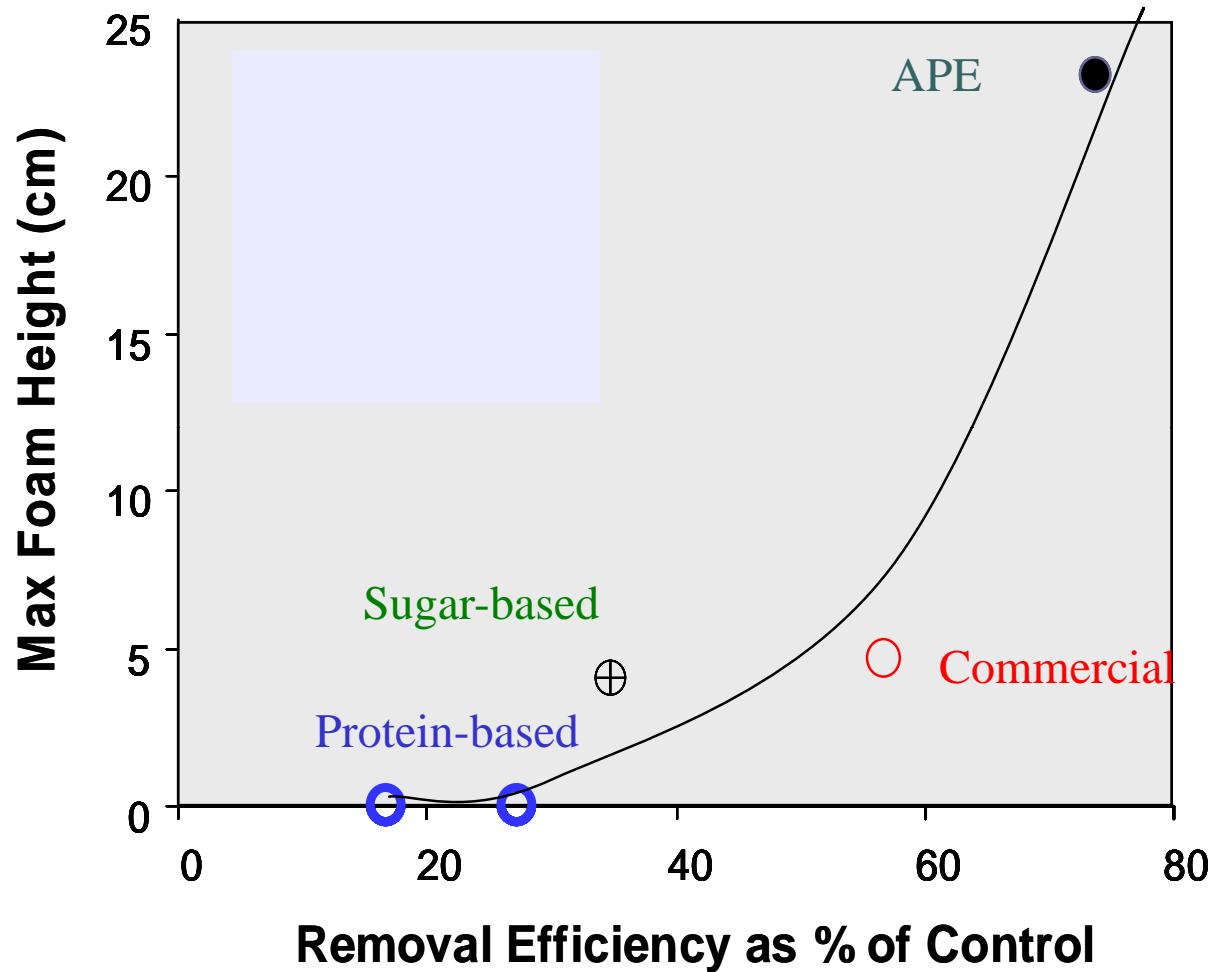
- Pulping 3% K, 10 min, 50 C, Tappi Disintegrator
- Flotation Wemco Lab Cell, 1% K, RT, stopped when foam production ceased, ranged from 60-210 s
- Image Analysis, Scanner system, 0.007 mm² smallest particle size considered



$$RE\% = \frac{(PPM_{Control} - PPM_{Sample})}{PPM_{Control}} * 100$$



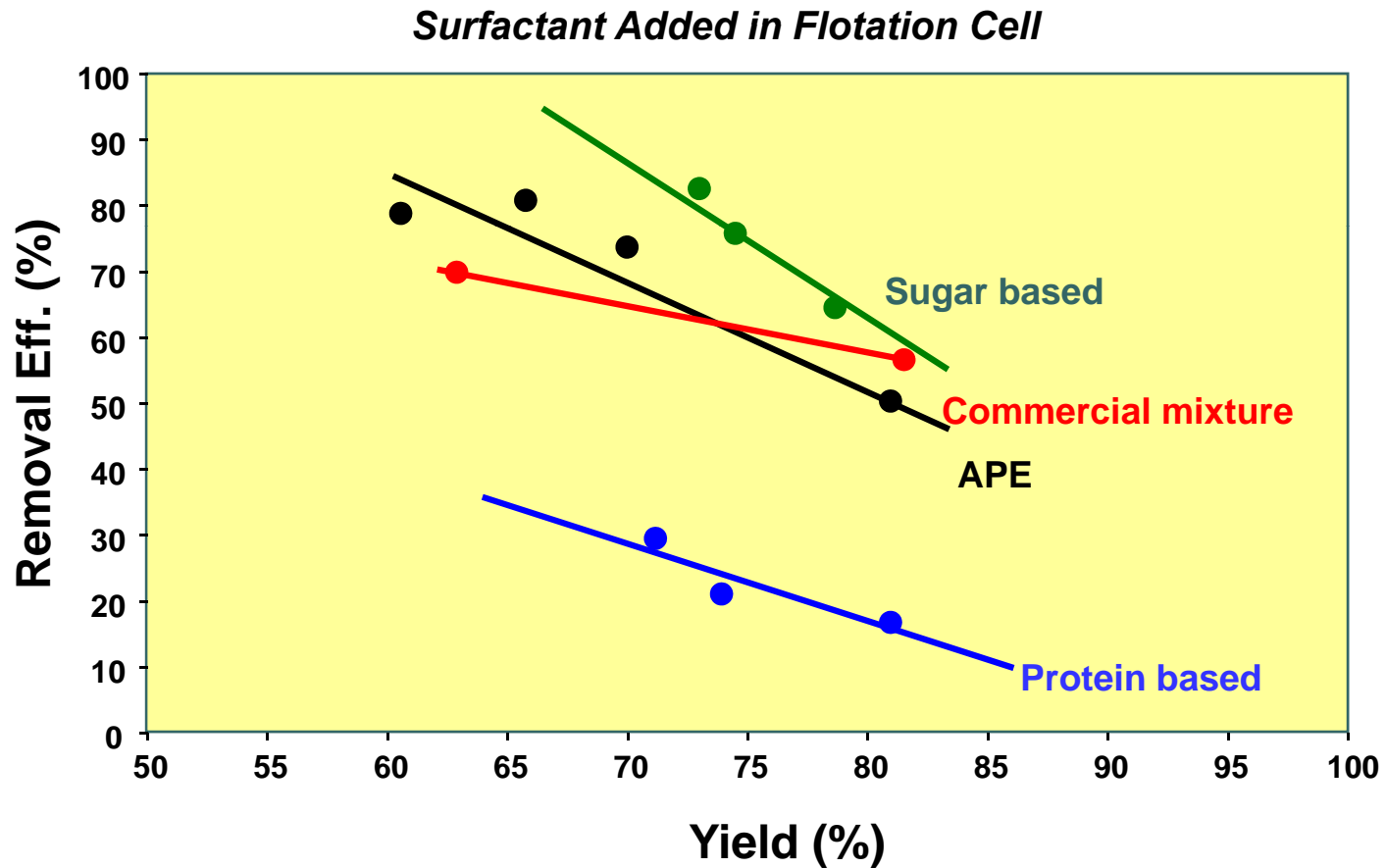
Flotation Deinking: Results



- Foamability has a strong correlation with removal efficiency, independent of yield considerations



Flotation Results: Selectivity



● ● ● Flotation Results: Selectivity

- Methods to distinguish differences in adsorption, desorption and detergency of surfactants demonstrated
- Foamability correlated with removal efficiency
- Sugar containing surfactant had high selectivity and the protein based surfactant had low selectivity

Development of Fast Sensors for Automatic Recovered Paper Sorting



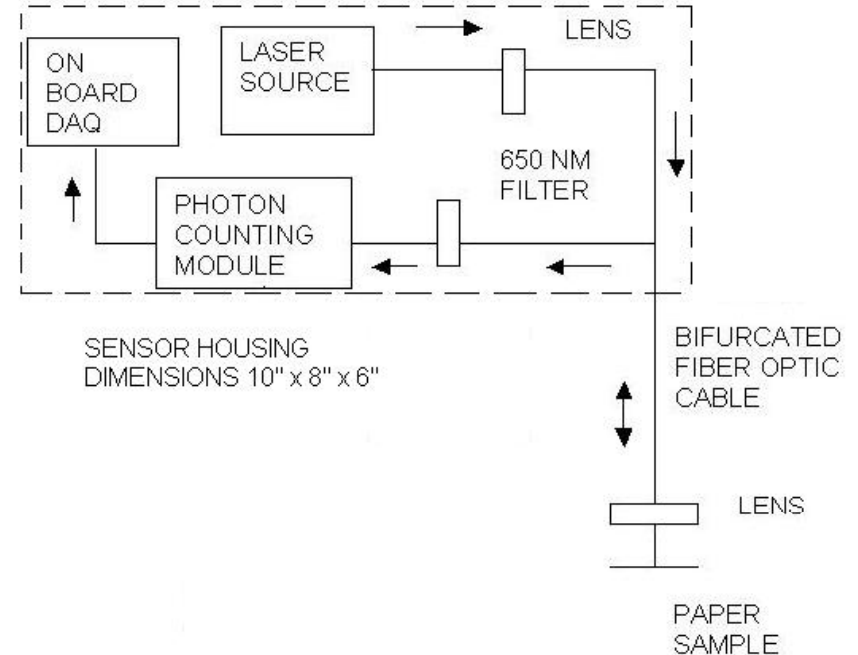
PI: Richard A. Venditti and M. K. (Ram) Ramasubramanian

Industry Partners: Weyerhaeuser (Tom Friberg)
MSS (Michael Grubbs)

Industrial Technologies Program Forest Products,
DOE Award No. DE-FC36-00ID13880

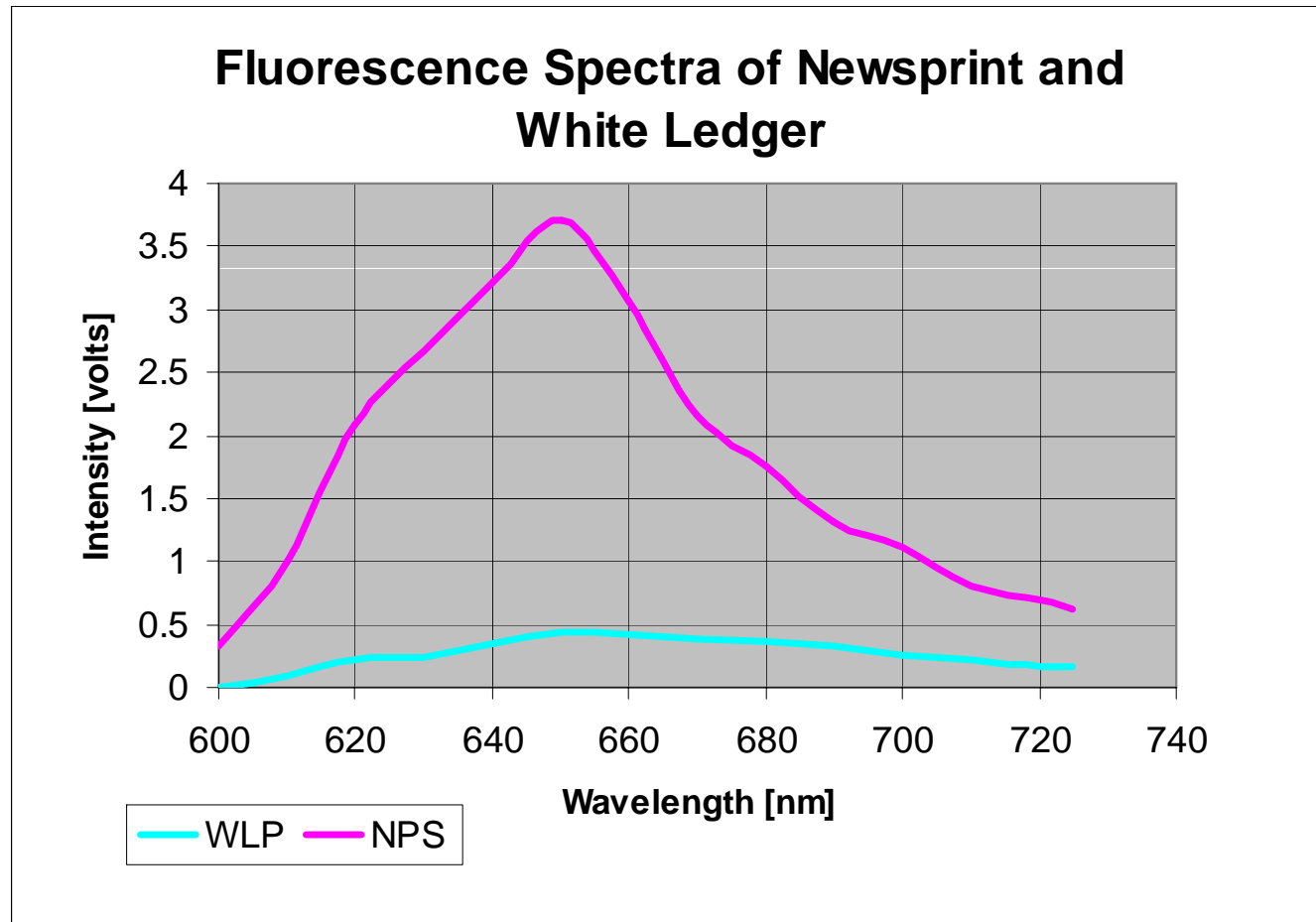
● ● ● Lignin Sensor

- The sensor measures lignin fluorescence at 630 nanometers when excited in the visible region, 532 nanometers, green.
- Newsprint samples with high lignin, produce high intensity.
- Ledger printing and writing grades with low lignin content produce low-fluorescence intensity.

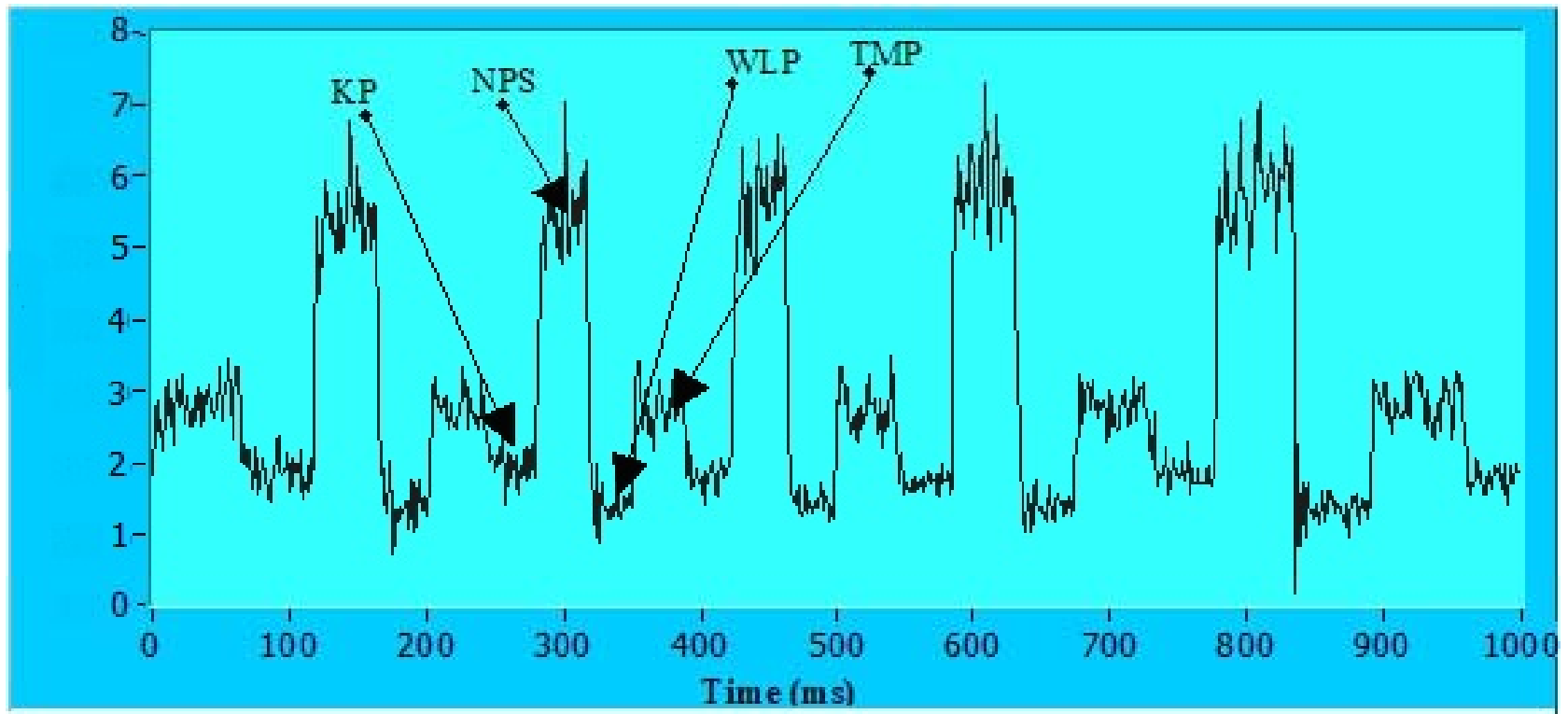




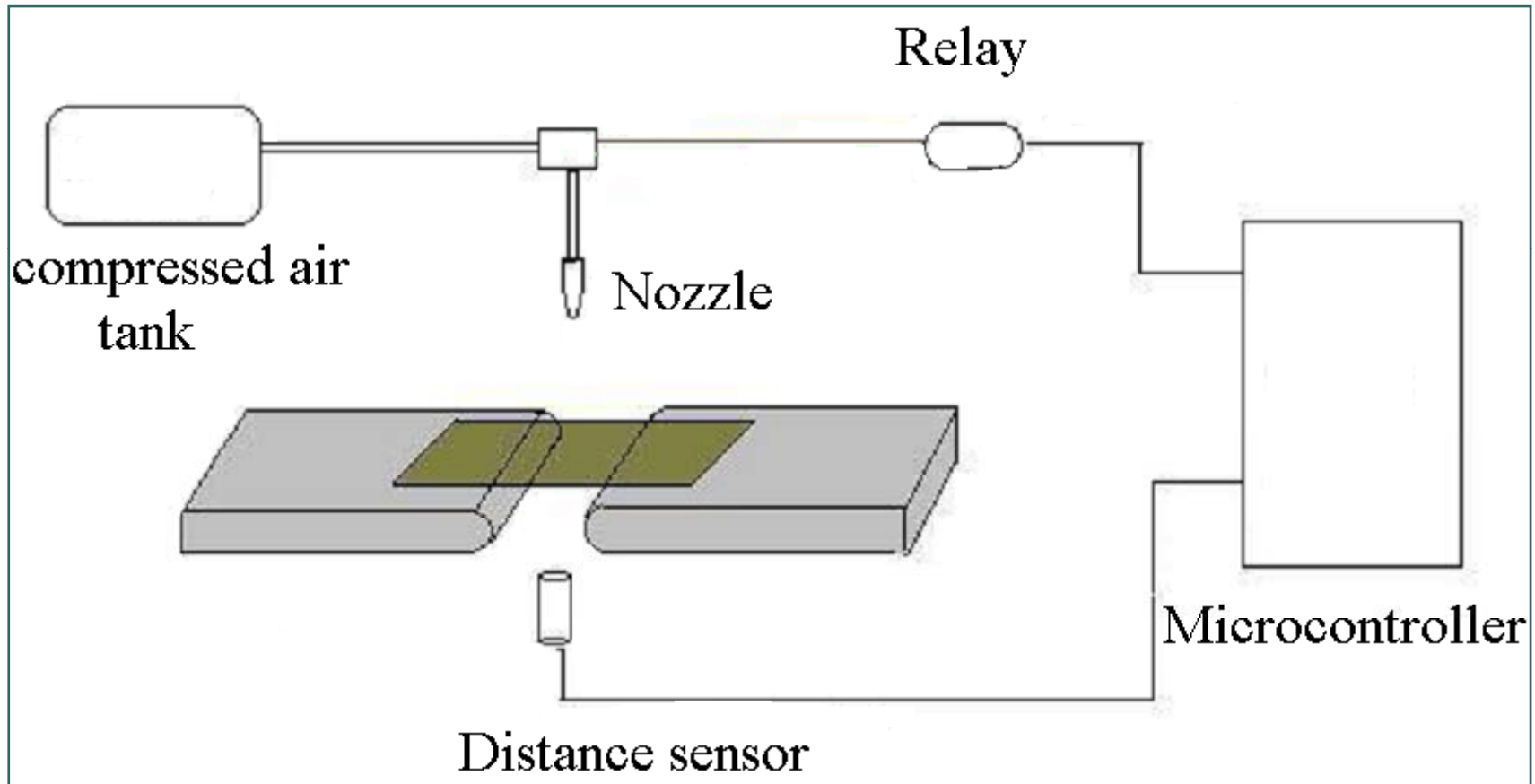
Lignin Fluorescence from Newsprint



Sensor performance with moving samples (495 fpm)



- ● ● **Stiffness sensor:**



Pilot plant trials of stiffness

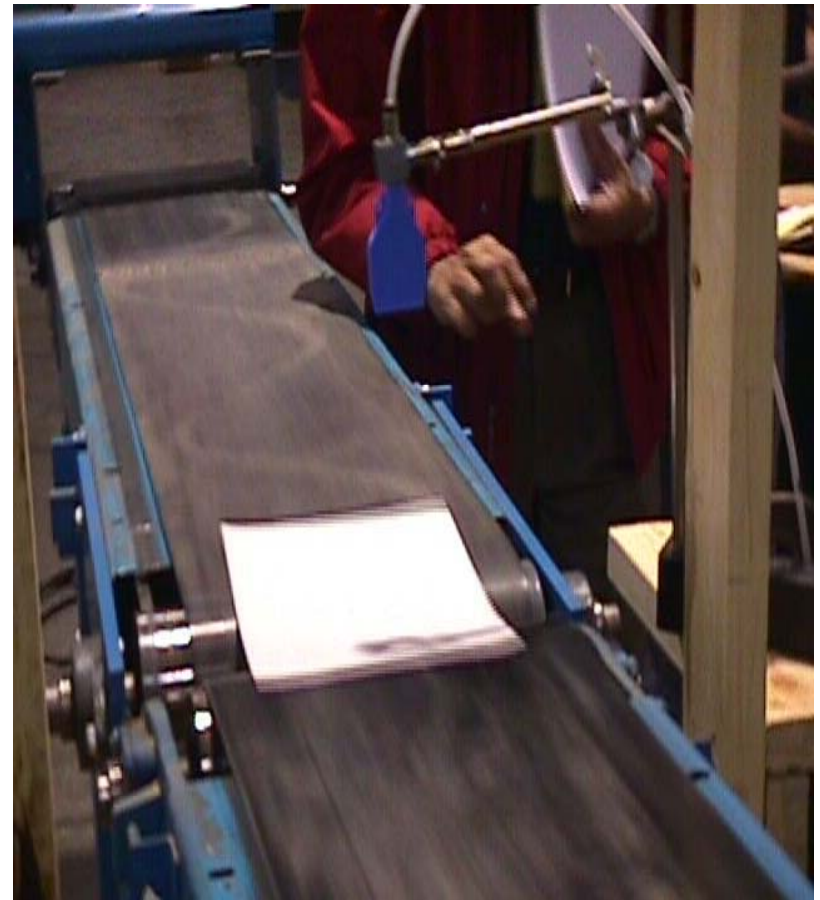
- ● ● sensor

Static Test



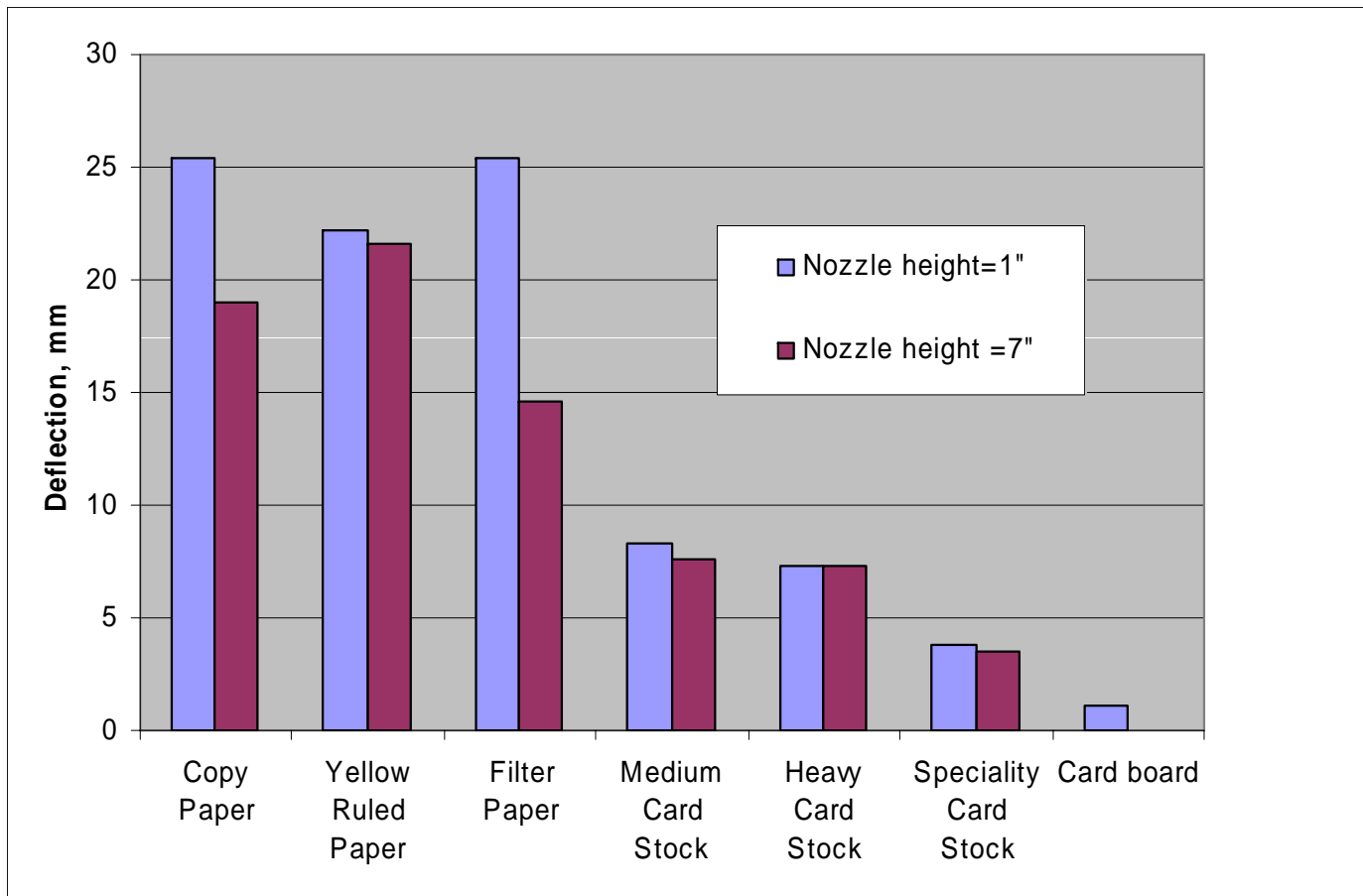
Dynamic Test

Conveyor speed = 280 ft/min





Dynamic test results



Nozzle inlet pressure = 10 psi, Samples were loaded in MD

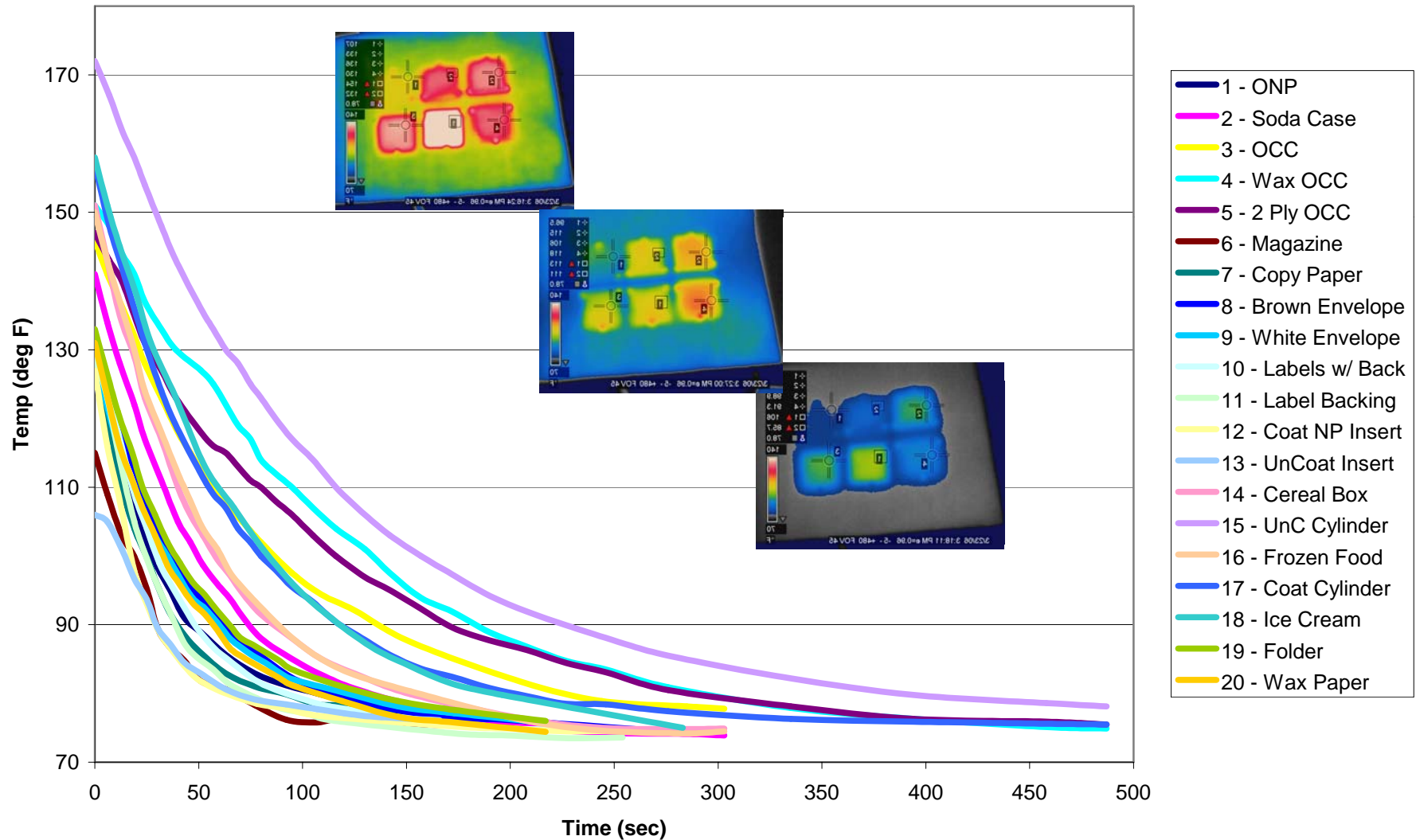
● ● ● IR Thermography sorting:

- Heating paper samples to 100 C
- Positioning under ThermoVision ® A20M Infrared Camera
- The camera records temperature over time

•(Complete information can be found at
•http://www.flirthermography.com/cameras/infrared_camera_complete/1032/)

Thermography characteristics:

Cooling Profiles



Implementation

- A sensor-based sorting system by MSS has been commercialized
- 15 tons per hour
- Sorts white, colored, newsprint
- Conveyor, sensors and pneumatic actuators for sorting
- Color, gloss, NIR, and lignin sensor

MSS

MultiWave™

The New MSS Sensor Generation - Faster, Wider, Better!

The MSS MultiWave™ sensor is the world's first automated NIR, color, gloss and lignin sorting system able to sort paper and plastics at speeds of 6 meters/sec (1,200 ft/min).

Sensor Technology

The MultiWave™ sensor provides proprietary full spectrum color and near infra-red spectroscopy at scanning speeds that are more than double compared to other NIR sensors.

And another world's first - the MultiWave™ provides gloss and lignin identification.

System Description

The MultiWave™ provides MRF's as well as paper and plastics processors with a solution for automated optical separation at levels not possible before.

At up to 15 tons/hr the incoming stream is uniformly fed in a single layer on high-speed conveyors at velocities of 1,200 ft/min (6 meters/sec) and higher.

Besides increased speed, the MultiWave™ sensor can be furnished in machine widths of up to 96" (2440mm).

This allows it to process significantly higher throughput rates than any other sorting modules available on the market - it scans more than 160 ft² per second (15 m²/sec).

The MultiWave™ analyzes all items and classifies them according to their specific "signatures".



The master computer processes the signals and fires compressed air jets. Depending on the setup the materials can be ejected

together into one chute (upward) or separately into two chutes (one up, one down).

The integral auto-calibration feature insures consistently high sorting accuracy.

The MSS MultiWave™ features a user-friendly color touchscreen with advanced diagnostics and complete setup flexibility.

Software upgrades and remote access are available through the included modem.

CP System Integration

A division of CP Manufacturing, MSS designs products that integrate at the most optimum level with the world's most advanced mechanical screens.

The V-Screen™, NEWScreen™ and CPScreen™ are the perfect choice for pre-processing any incoming feedstock material.

MSS Warranty

As with all MSS products, the MSS MultiWave™ system is covered with a full one-year warranty on parts, workmanship and performance.

Upgrades
Dual-Ejection
Split Configuration
Metal Detector

Features
Color Touchscreen
Modem Access
Count Statistics

intelligent automated . sorting



MSS Inc. - A Division of CP Manufacturing - 3738 Keystone Avenue - Nashville, TN 37211, USA
Phone +1-615-781-2669 - Fax +1-615-781-2923 - info@magsep.com - www.magsep.com

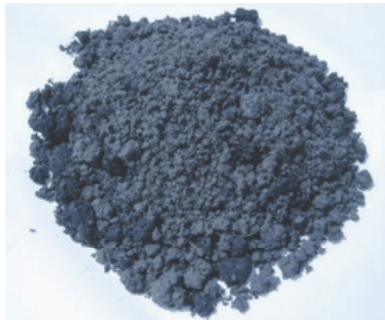


Conclusions

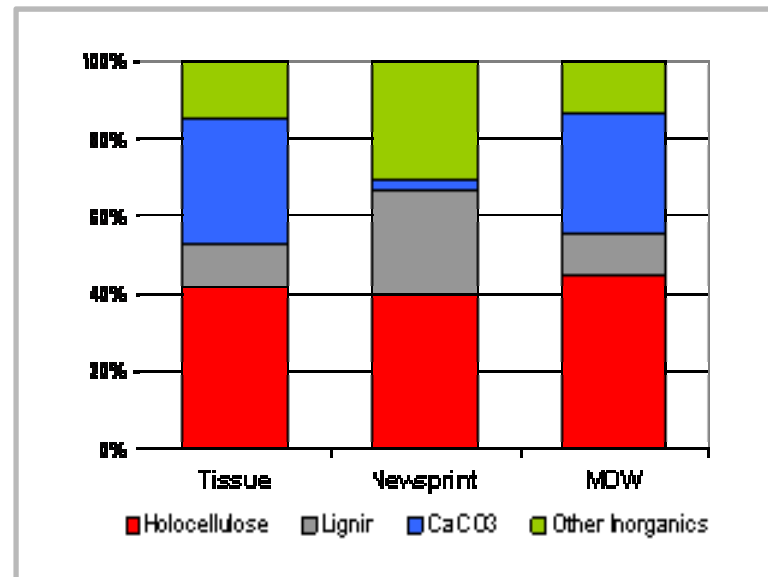
- Lignin content based sorting has been incorporated into a commercial operation
- Stiffness and Thermography can also be used as an input for paper characterization

Low Cost Conversion of Industrial Sludges to Ethanol

- Biofuels Center of North Carolina
- Demonstrate an effective technology to convert industrial papermaking sludge as a cost effective feedstock for the efficient biochemical biomass conversion to ethanol
- Need to develop separation processes to remove inorganics from fibers/fines



Papermaking Sludges



CaCO₃ useful for soil amendment. But fiber is detrimental.

Carbohydrate useful for ethanol feedstock. CaCO₃ is detrimental.