Paper Industry Challenges and Opportunities

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C. P. Klass Background

- Western Michigan University – BS in Pulp and Paper Technology
- Pace University – MBA in Marketing Management
- 50 years in paper industry and TAPPI
  - Process engineer and production management
  - Paper chemicals and equipment marketing
  - 22 years as a consultant
- Adjunct Professor at Western Michigan

Summary of Presentation

- Overall trends in printing, writing and packaging papers
- Digital printing an impact on paper industry
- Trends in packaging
  - RFID tags
  - Recyclable barrier coatings
- New materials and technologies
  - Nanoparticle biopolymer latex
  - Zeolite pigments

Overall Trends

- Becoming a global market
- Increased brightness in both uncoated and coated papers
- Neutral/alkaline papermaking
- Calcium carbonate replacing kaolin clay
- Blurring distinction between coated and uncoated

Uncoated Free Sheet Papers

- Higher brightness and whiteness
  - Increased OBA use
- Neutral/alkaline sized
- Must be multifunctional
  - Offset
  - Laser toner bond and xerography
  - Ink jet printability
  - Opacity
- Internal bond and surface strength critical

Uncoated Free Sheet Process & Quality Trends

- High filler levels - ≥18% PCC
- Surface sizing
  - Starch with good strength and film forming
  - Synthetic surface size
  - Cationic additive for ink jet
- Pigment addition to surface size
  - Porosity control
  - Ink receptivity

Free Sheet Alternative

- Uses a combination of bleached kraft and mechanical pulp
- Light metered size press coating and soft nip calendering
- Multipurpose equivalent to uncoated free sheet office papers
- Brightness equivalent or higher
- Lower priced but better profit margin

Film Coated Offset

- Made by metered size press coating and soft nip calendering on a high-groundwood content sheet
- Better quality and runnability than SCA in heatset offset
- Displacing both SCA and No. 5 LWC
- Growing market in inserts and cost conscious magazines

Summary of Coated Paper Quality Trends

- *Market Paper Brightness Higher Than Standard*
- *Changes In Paper Properties*
  - FINE PAPERS
    - ↑ Brightness
    - ↓ Opacity
  - GROUNDWOOD
    - ↑ Brightness
    - ↓ Opacity
    - ↓ Sheet Gloss
- *Imported Papers Have Higher Brightness*

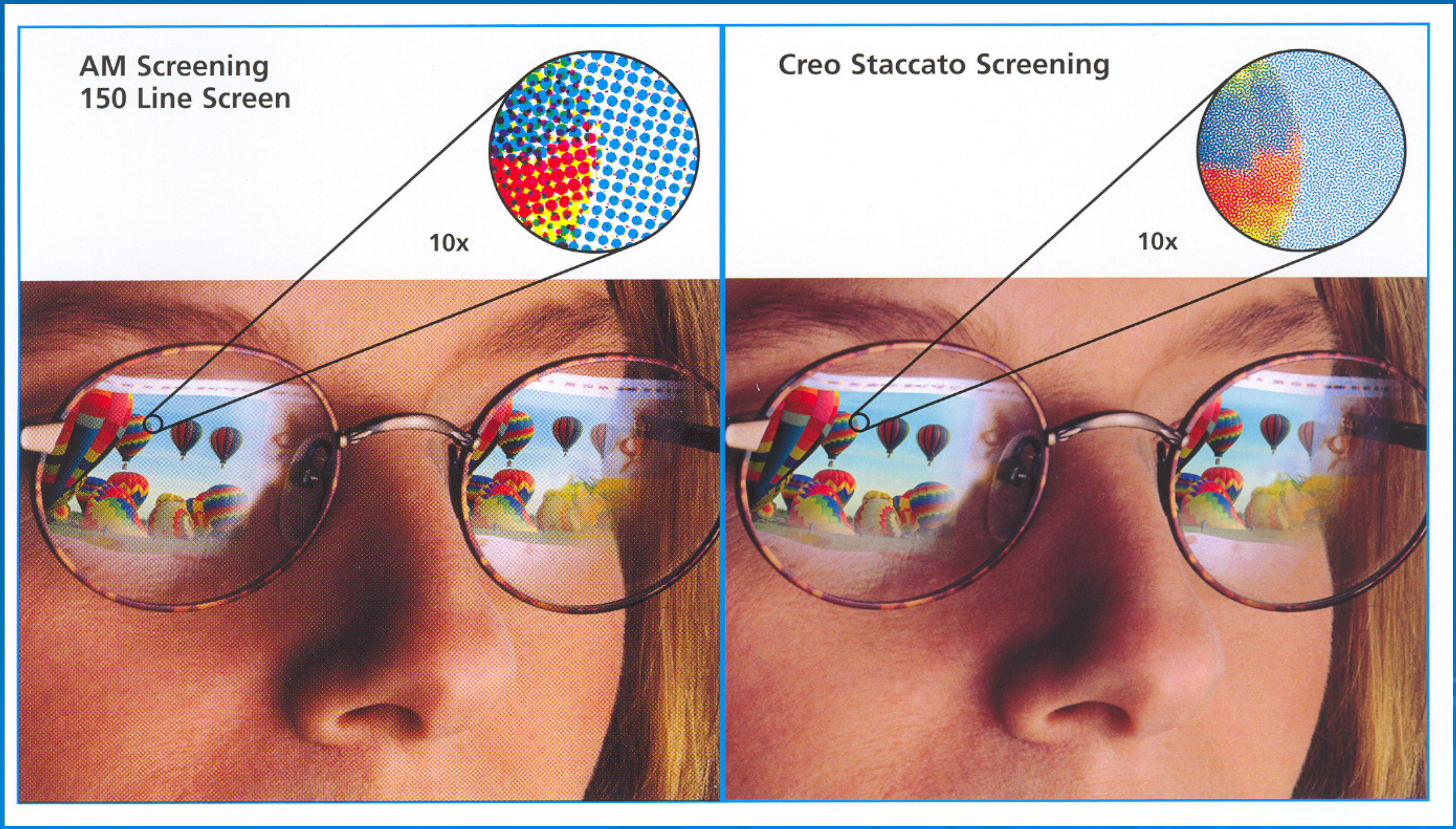
Coated Board Quality Trends

- Increased brightness
- Increased smoothness
- Low pps_{10}
- Increased gloss
- Move toward a blue shade
- Need to develop digital printability
  - Ink jet
  - LEP

Coated Offset Printing Papers

- Growth of heat set web offset
  - Lighter weights - ULWC
  - Blister and print-through concerns
- More colors
- More ink coverage and trapped areas
  - Increased mottle potential
- Finer line screens

Offset Printing Papers Emerging Trend Stochastic Screening



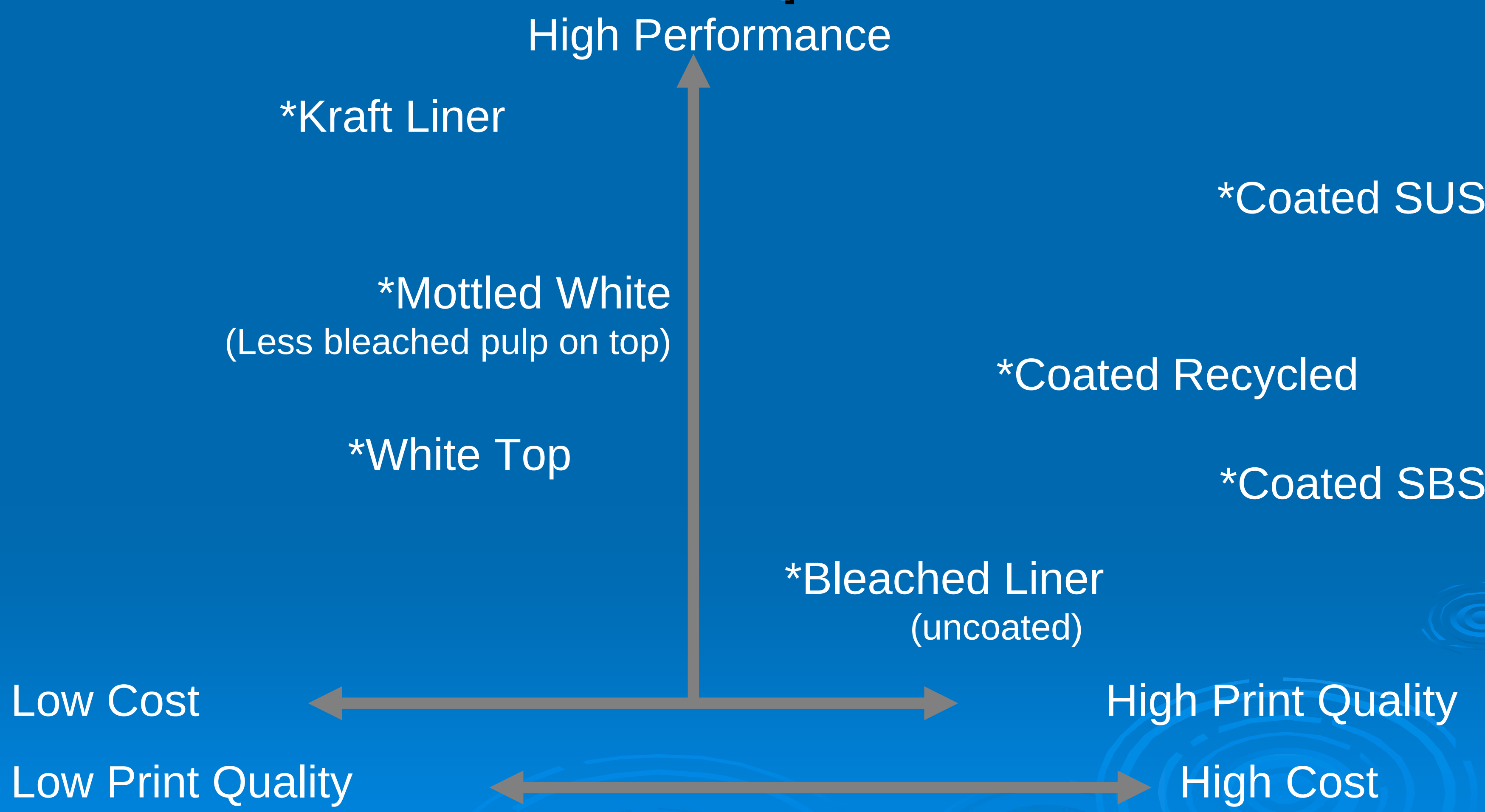
Stochastic Screening

- Paper surface quality implications
  - Holdout critical
  - Surface uniformity critical
  - Requires excellent film former
  - Pigmented surface size on uncoated papers
- Pigment choices
  - Brazilian clays well suited
  - Aragonite PCC well suited

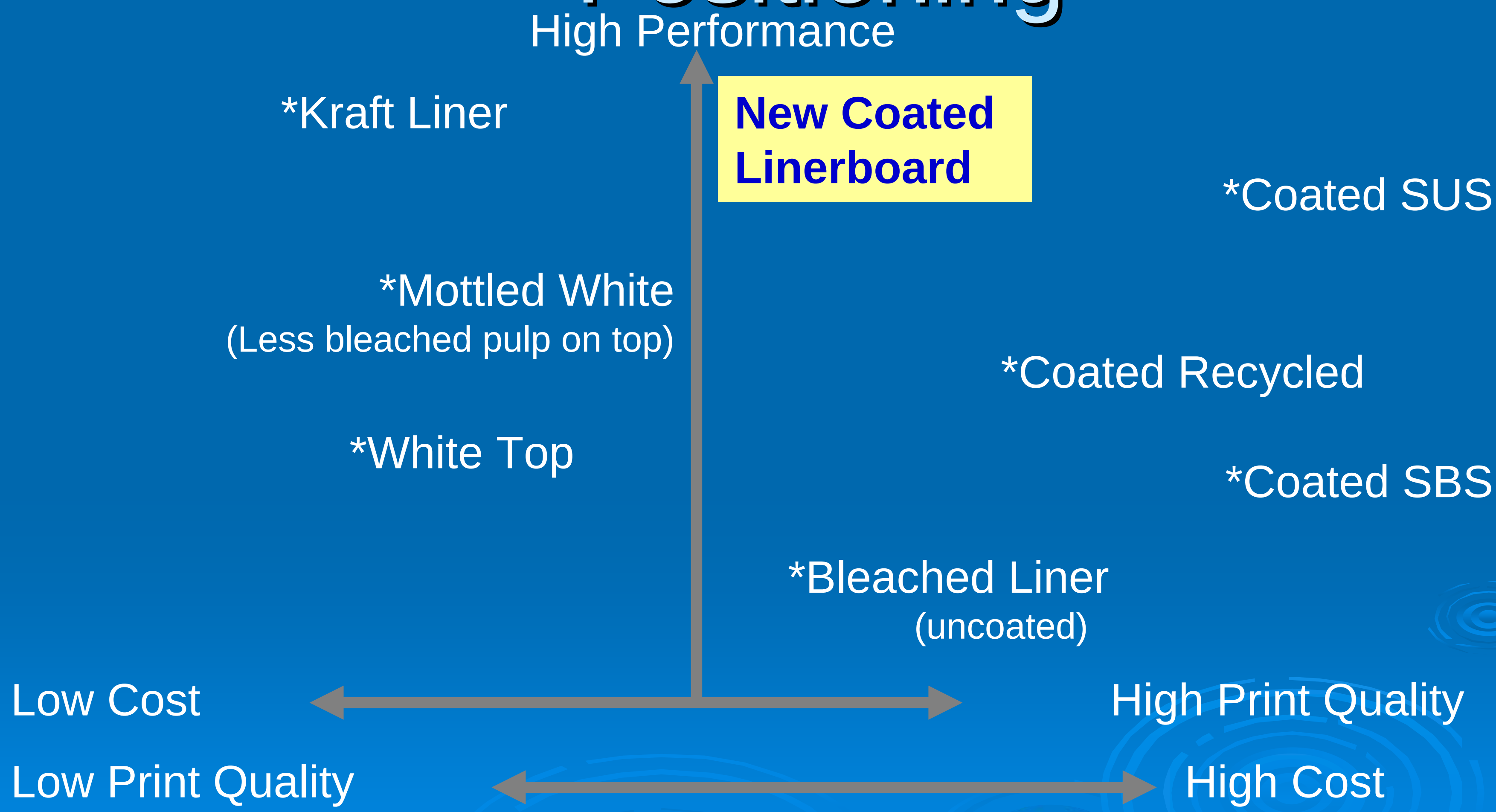
Flexo Printing

- Fastest growing impact printing process
- More colors
- Finer screens
- Need for open coating structure
  - Pigment choices
  - Binder systems
  - Synthetic rather than stearate lubricant

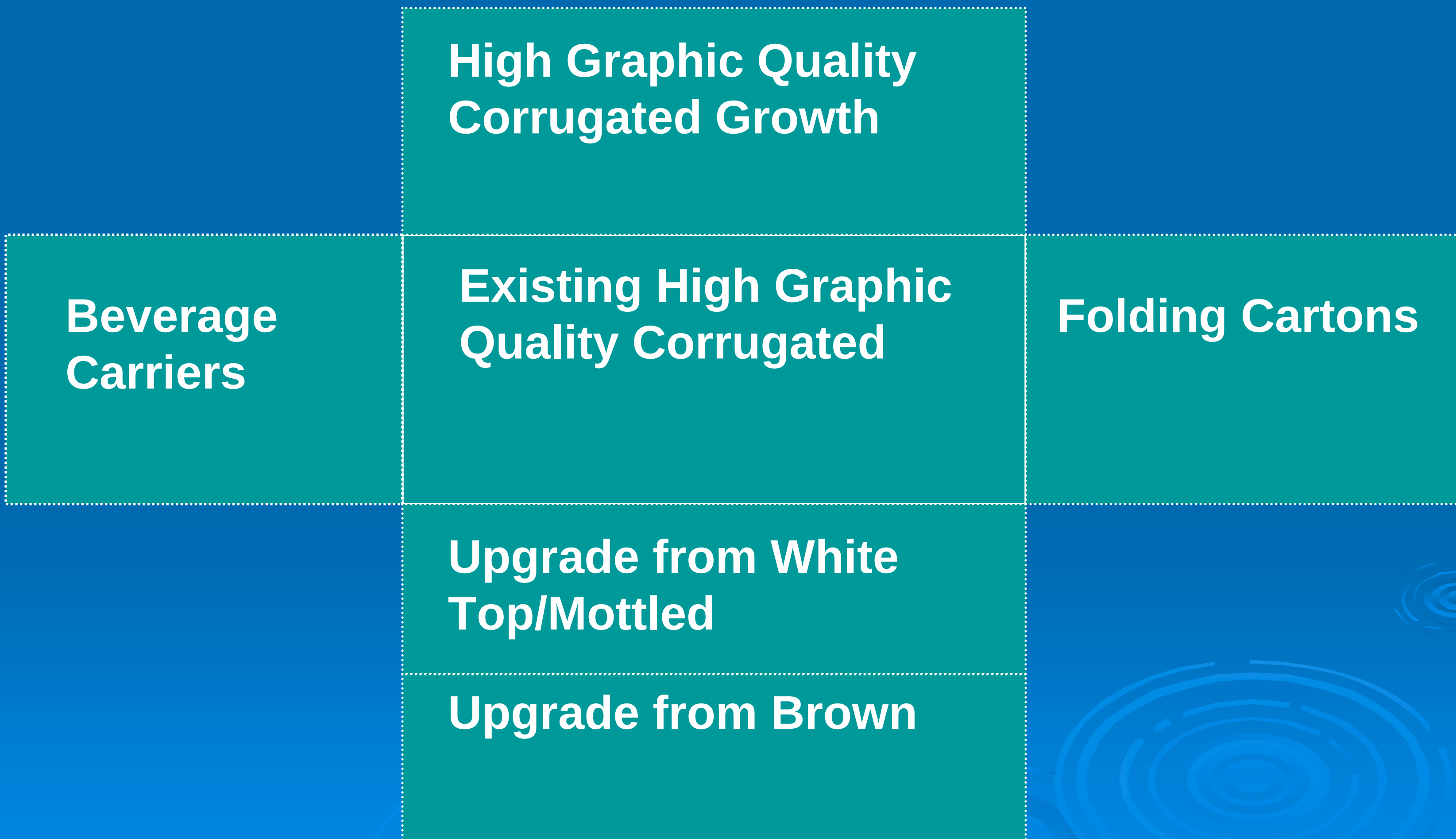
Graphic Quality Linerboard Grade Spectrum



New Coated Linerboard Positioning



High Graphic Quality Corrugated Growth Patterns



Microflute Corrugated

- Competes with coated multi-ply recycled paperboard
  - Lighter weight ~35 – 40%
  - Stronger
- Can be converted in regular folding carton machinery
- Requires coated surface for offset printing
- Lighter weight than regular linerboard

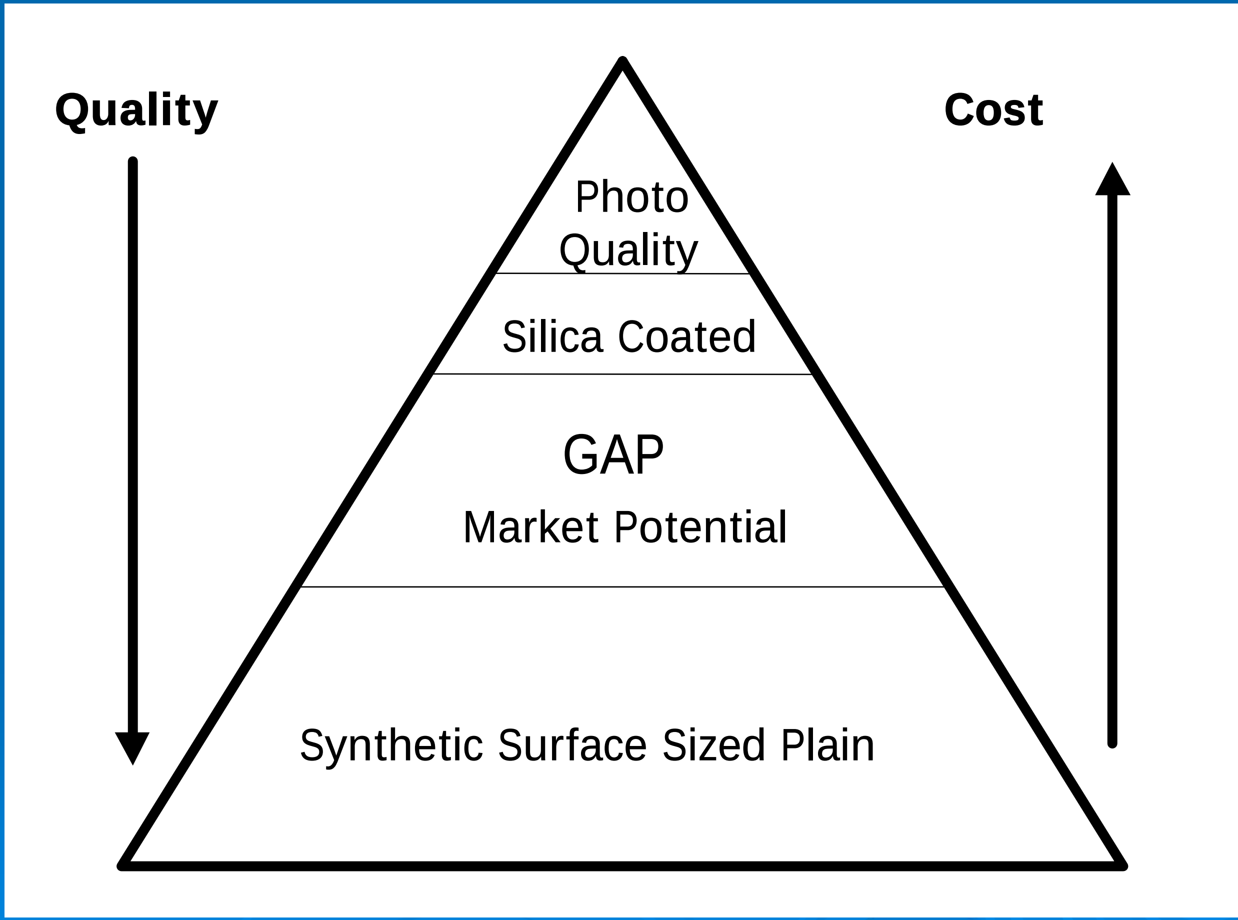
Digital Printing of Corrugated

- Likely to grow rapidly over the next decade
- Fiber top linerboard not adequate
- Will require new coated linerboard grades
- Ink jet likely to be the dominant technology

Ink Jet Printing Papers

- Market tiers
- Coated and uncoated
- Quality pyramid

Ink Jet Papers Market



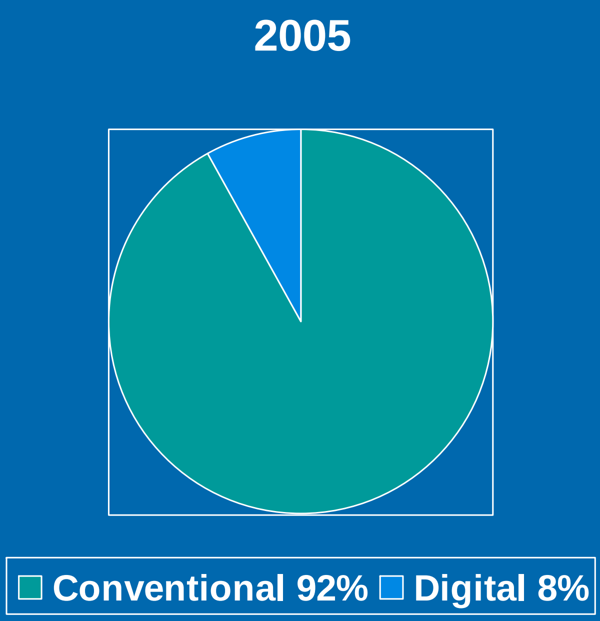
Need for Dual Purpose Papers

- Driven by changes in direct mail and financial media
- Combination offset preprint with variable digital printing a single high-speed line
- Paper must provide high quality multi-color printing by both offset and digital
- No papers currently on the market meet this need
- Likely to be a high growth market

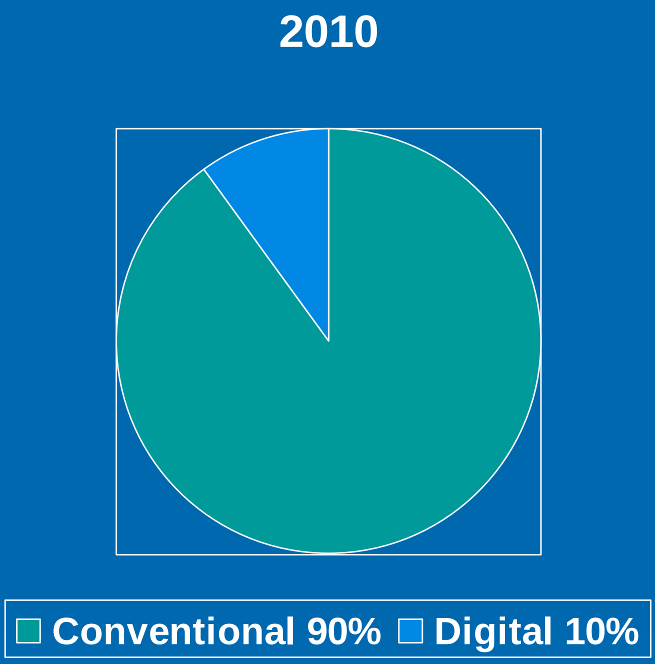
Trend Toward Digital Printing

- Digital printing growing as a commercial printing method
- Driver is desire for customization and shorter press runs
- Digital printing eliminates prepress and make ready
- Will grow rapidly in direct mail, publications and packaging

Global Printed and Imaged Pages



48 Trillion Pages



54 Trillion Pages

Digital page growth = 600 Billion pages in 5 years

Digital Printing Trends

- Continuous ink jet will be the fastest growing area
- Prototype ink jet web press running at commercial speed and width – quality equivalent to offset
- Web ink jet will replace sheet-fed and web offset – likely to expand into newspaper and magazines
- Will require new grades of paper with cationic surface functionality

RFID Tags

- Wal-Mart and other large retailers mandating that packages have RFID tags to automate logistics
- Requires inserting a chip in the package surface to be read by a scanner
  - Chips are expensive
  - Inserting the chip is cumbersome
- Research at WMU is developing economical print-on RFID tags as part of the regular packaging material printing process
- Extension into printed electronic circuits

Recyclable Barrier Coating Drivers

- Cost of disposal
- Availability of OCC
- Environmental concerns
- Overseas regulations
- Concerns about fluorochemicals

Drivers - Cost of Disposal and Availability of OCC

- Cost of disposal
  - Tipping fees range from $40 to $160 per ton
  - Need to segregate recyclable from non-recyclable waste increases handling cost
- Availability of OCC
  - About 20% of OCC goes to landfill or burning
  - Mini-mills and export demand keep OCC supply tight

Drivers - Environmental Concerns Recovery/Recycling

- Repulpability
- Biodegradability
- Minimal impact on reprocessing
- Energy recovery
- Low environmental impact
- Chlorine free

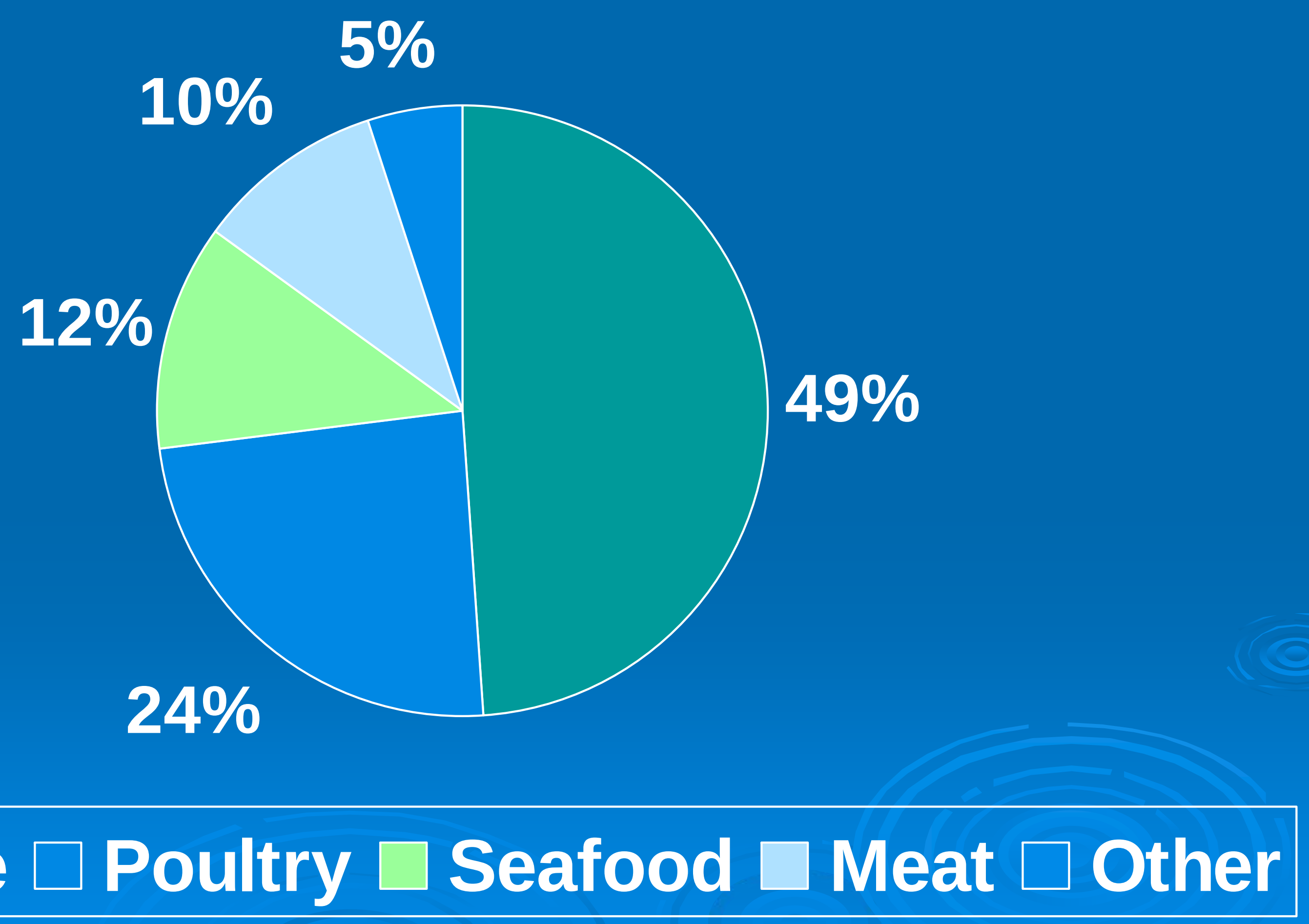
Drivers - Concern about Use of Fluorochemicals

- Major food packagers and fast food chains looking for alternatives
- Concern about liability and litigation
- Paper mill concern about exposure to workers
- Concern extends to new fluorochemicals
- Search for alternative OGR treatments

Wax Replacement in Corrugated

- A major opportunity for recyclable barrier coatings
- A lot of attempts over the past decade but no large scale commercialization
- Cost is still a major concern - wax is cheap!
- Separation and disposal cost is also a major concern

Waxed Corrugated by Product



Waxed Corrugated Market Overview

- Market size about 1.5 million tons of containerboard
- Two methods of waxing
  - Curtain coating: 12 - 15% wax content
  - Cascade waxing: 35 - 50% wax content
- Upcharge for waxing
  - Curtain coating $9 - $15/MSF
  - Cascade waxing $24 - $31/MSF

Waxed Corrugated Performance Requirements

- Curtain wax coated boxes: Retain 60% of original strength after 1 hour water soak
- Cascade waxed boxes: Retain 90% of original strength after 8 to 24 hour water soak
- Cold humid compression: Retain specified percentage of strength after exposure to 90% RH at 40°F (5°C) for 24 hours

Waxed Corrugated Performance Requirements

- Cyclic humidity performance: Retain 80% of original strength after exposure to:
  - "Jungle conditions" 90% RH at 100°F (38°C) for 8 or 24 hours
  - Followed by exposure for same period of time to:
  - 50% RH at 72°F (22°C)

Costs of Using Waxed Corrugated

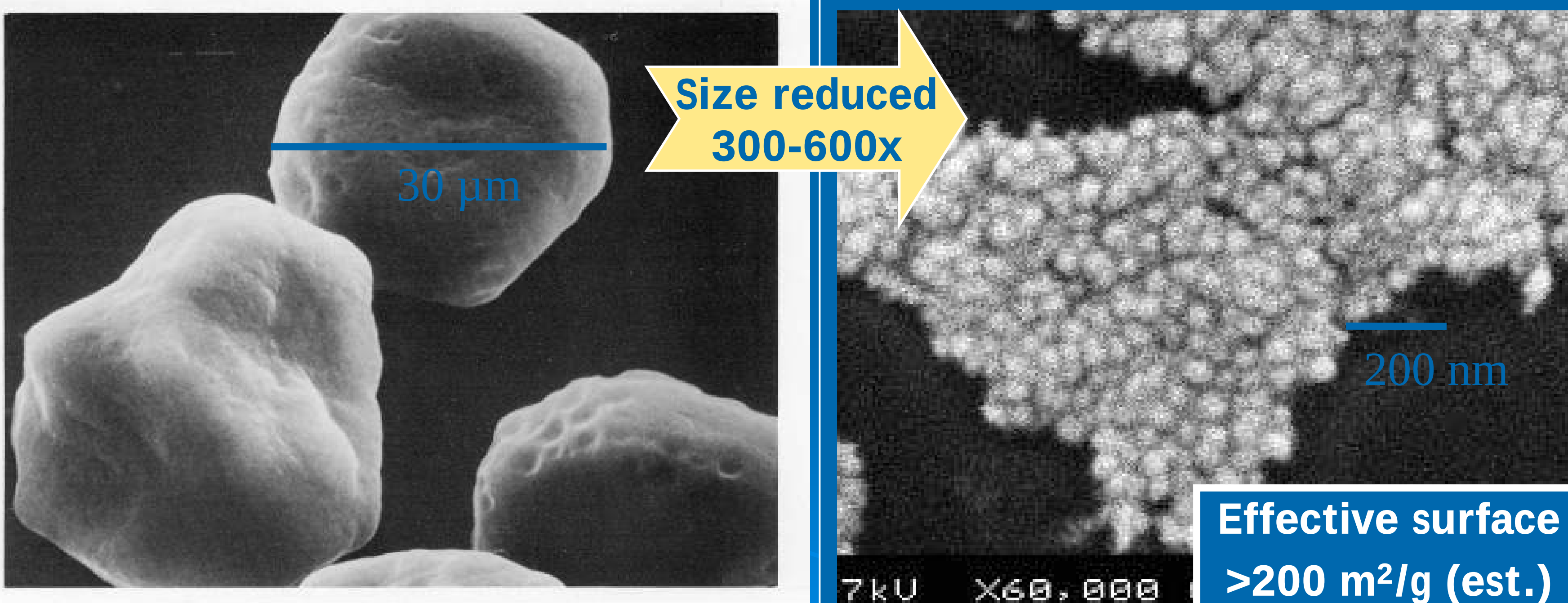
- Higher cost boxes
- Cost of sorting at supermarket: $15 - $25 per ton
- Hauling cost and tipping fees: $55 - $130 per ton

Benefits of Wax Replacement

- Reduce the amount of material in box designs - most coatings would add 4 - 5% to weight compared to 12 - 50% addition by waxing
- Reduce labor along the supply chain
- Better graphics and box appeal
- Reduced disposal cost
- Increased recycling

Biopolymer Nanoparticle Latex Technology

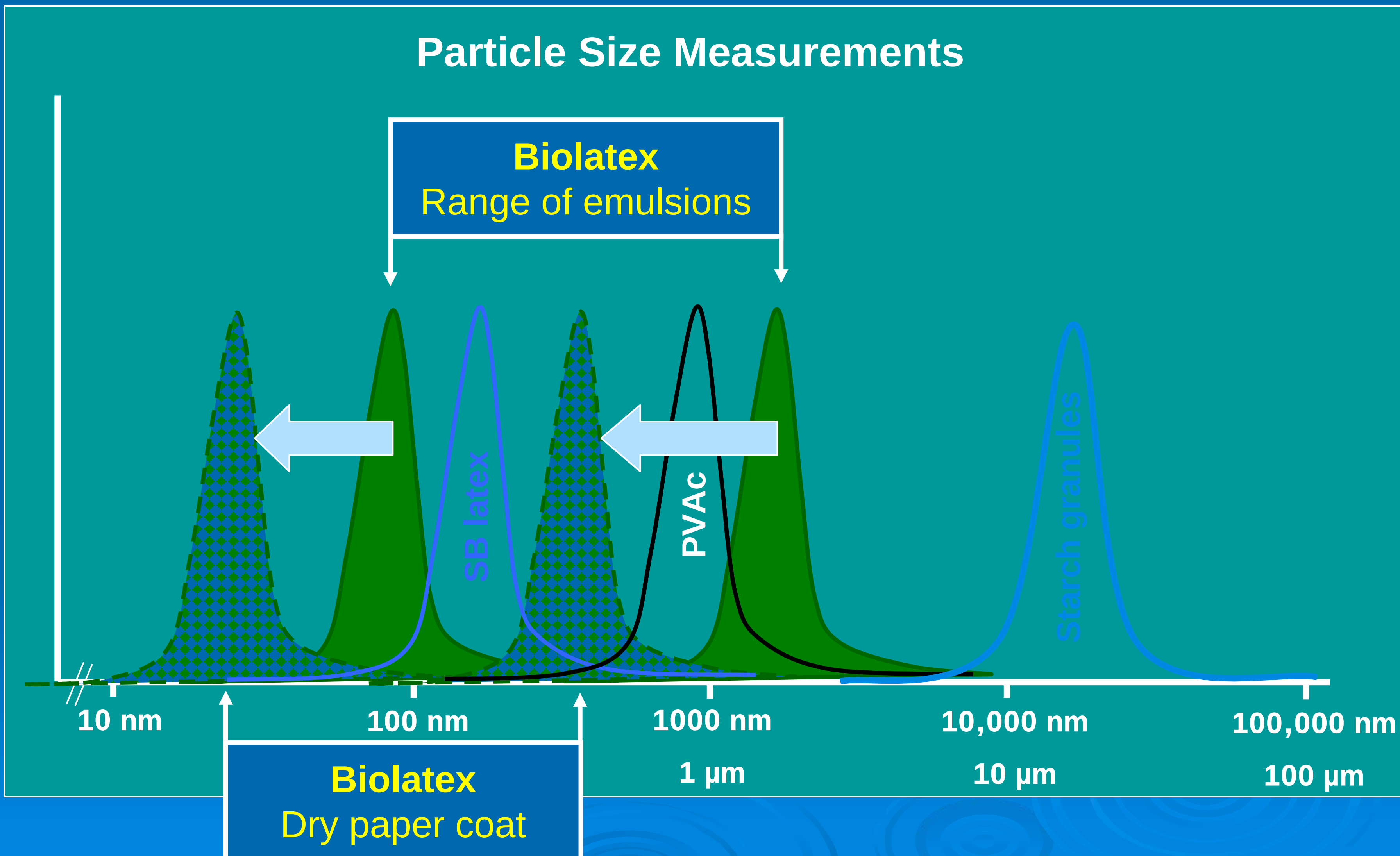
New properties from re-engineering biopolymers into nanoparticles



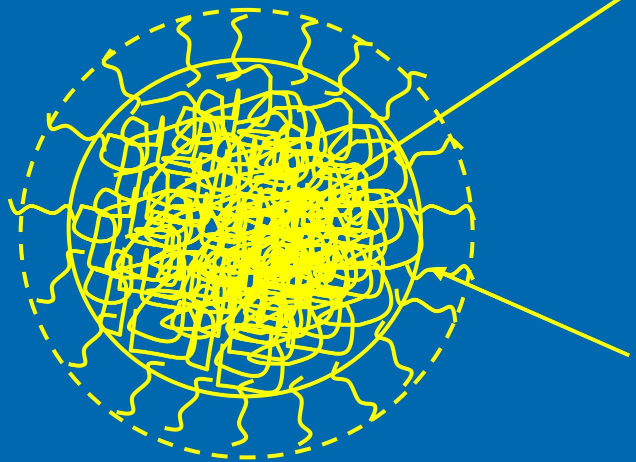
e.g. Native Starch Granules

ECOSPHERE® Biopolymer Nanoparticles

Biopolymer Nanoparticle Dispersions

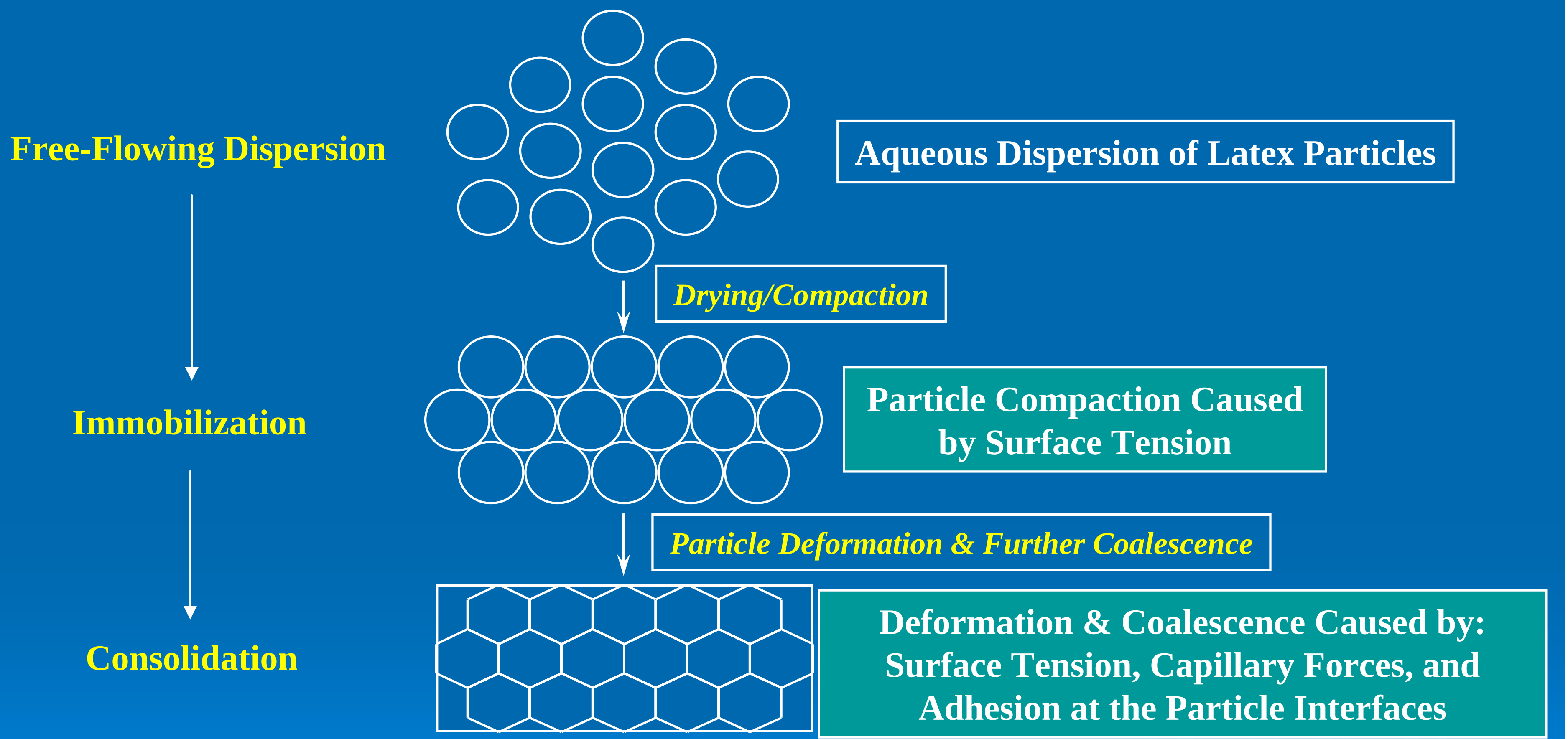


Hypothesized Structure of a Water-Swollen, Crosslinked Biopolymer Nanoparticle



Effective volume factor, f, of biopolymer nanoparticles (relative viscosity method) is:
f = [V(Core) + V(Shell)]/V(Biopolymer) = 6.67
Assuming V(Shell) = 2 x V(Biopolymer), then swell ratio is:
V(Core-swollen)/V(Core-unswollen) = 4.67 for ECOSPHERE®
V(Core-swollen)/V(Core-unswollen) = 1.00 for S/B Latex Control

The Film Formation of Latex Particles: A Guide for the Hypothesized Film Formation of Biolatex

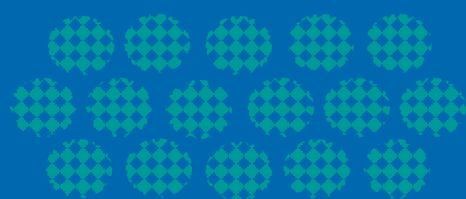


Hypothesized Film Formation of Water-Swollen, Crosslinked Biopolymer Nanoparticles

Free-Flowing Dispersion

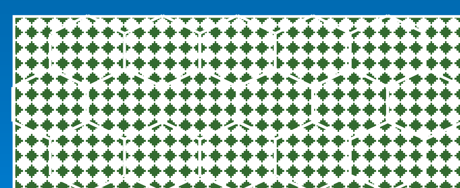
Aqueous dispersion of water-swollen biopolymer nanoparticles

Gelling/ Immobilization



Entanglement & insolubilizing at the particle interfaces

Consolidation with Partial Collapse



Water liberates, but biopolymer cores do not collapse and form "nano-cellular foam-like" film, yielding air voids

Stiff water-swollen crosslinked biopolymer nanoparticles do not collapse much during film formation. Consequently, film shrinkage is much less than starch and more like S/B latex, yielding better gloss and improved opacity under optimized calendering conditions.

Emerging Biopolymer Nanoparticle Technology:

- Independent control of particle sizes and swell ratios
- Surface modifications: e.g., Carboxyl, amide, amine, amphoteric, quaternary ammonium, etc.
- Formation of hybrid products: e.g., Starch/protein hybrids, biopolymer/synthetic polymer hybrids, etc.

Relative Comparisons of ECOSPHERE®, Starches, and Synthetic Latexes

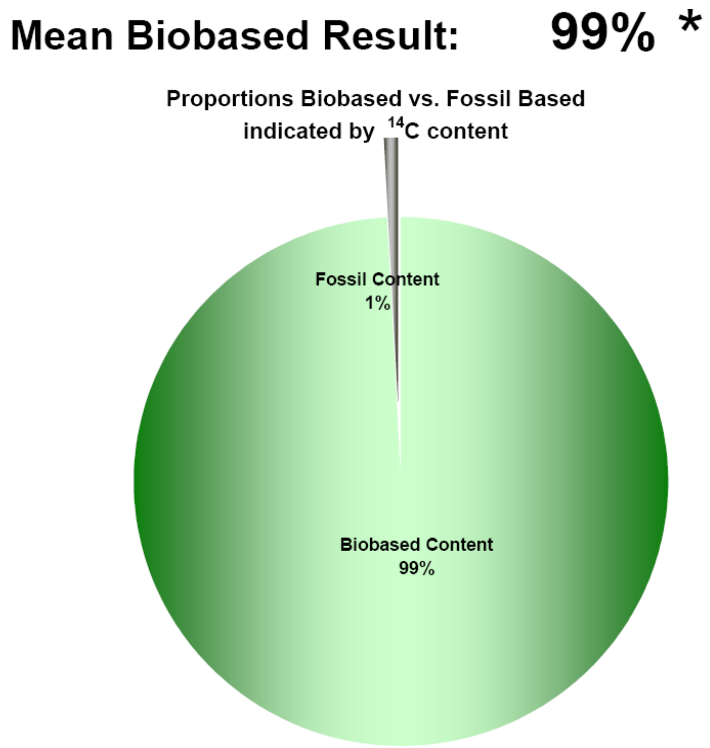
Properties of Paper Coatings	Biolatex	Starches	Synthetic Latexes
Ease of Formulation	+	-	+
Water Retention	++	+	0
High-Solids Coater Runnability	+	-	+
Dry Strength	++	-	++
Wet Strength	+	-	++
Stiffness	++	+	0
Coating and Print Gloss	+	-	+
Brightness w/o & w/OBA	+ & ++	0 & ++	+ & 0
Whiteness w/o & w/OBA	+ & ++	0 & ++	+ & 0
Opacity	+	-	+
Printability	+	0	+

Relative Scores Based on Paper Coating Trials

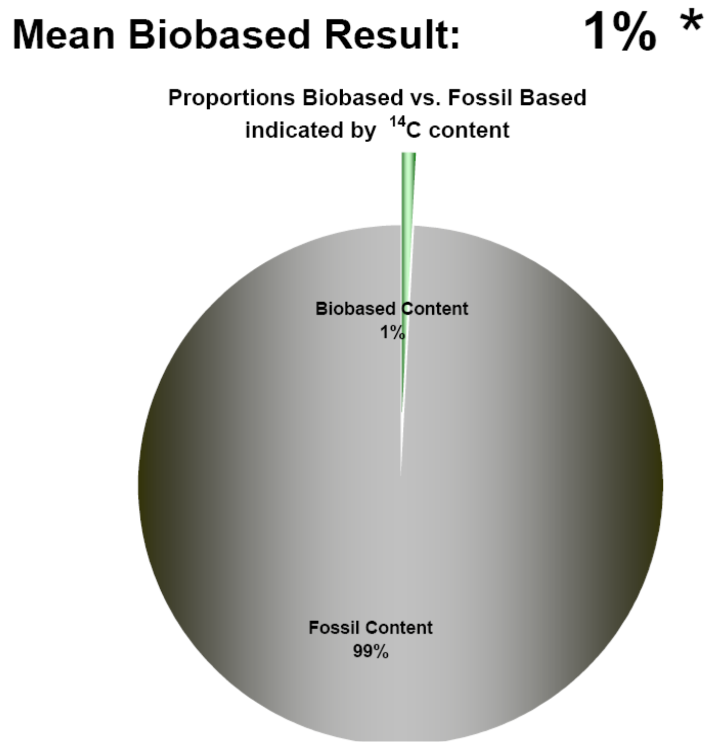
Biolatex Benefits vs. Emulsion Polymer Latex

Features	Benefits
Lower latex cost	Significant annual savings
Requires no cooking	Energy and labor savings
Renewable resource based (modified biopolymer)	Price stability, not linked to rising petroleum prices, carbon neutral
Substitute for latex binder	Similar performance in coating colors
Viscosity & ultra-high shear rheology = synthetic latex	Simple adjustment of existing coating recipe – similar or better runnability
Reduce rheological modifier	Additional potential saving
Available dry or liquid	Freight savings & formulation flexibility

Independent Analysis of Biobased Carbon Content



Biolatex



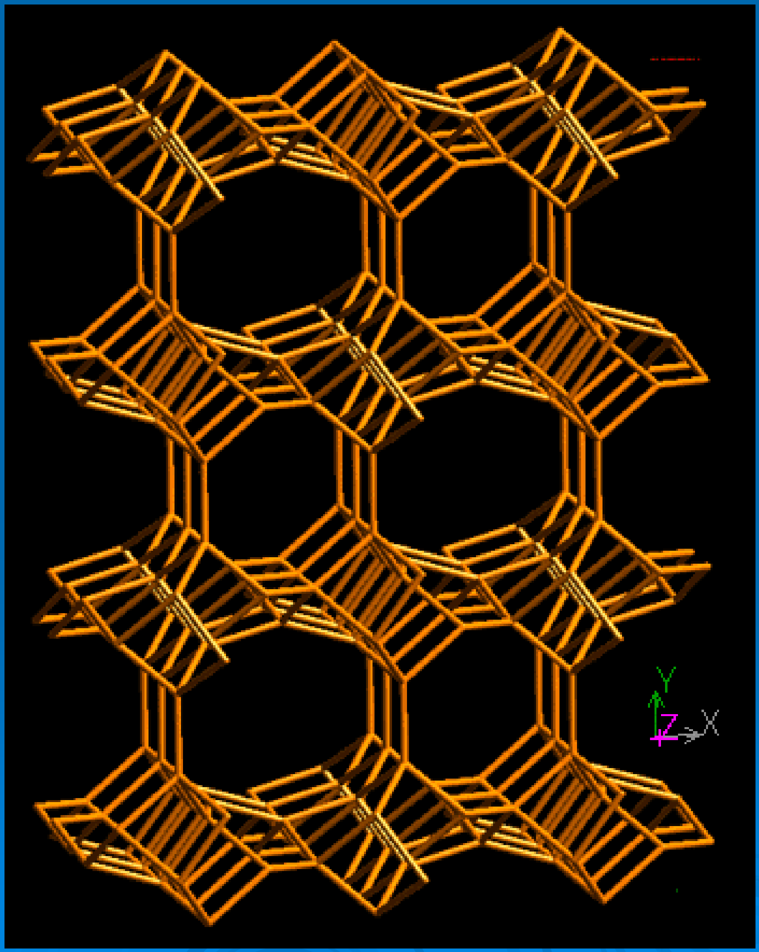
SBR Latex

Analysis by Beta Analytic Inc, Miami, FL

What are Zeolites?

- Crystalline hydrated aluminosilicates of alkali and alkaline earth metals
- Structure - interlocking tetrahedrons of SiO_4 and AlO_4
- Ratio of Si and Al to O 1/2
- Negatively charged with large internal “cages” to facilitate exchange with large cations and cationic molecules

Zeolite Structure



Zeolite Characteristics

- High degree of hydration
- Low density and large void volume when dehydrated
- Stability of structure when dehydrated
- Uniform molecular sized channels
- Ability to absorb gases and vapors
- Cation exchange properties

Zeolites in Papermaking

- Historically used in Japan and Hungary as filler to improve
  - Bulk
  - Printability
- Low in brightness - not useful in USA
- Expensive synthetic zeolites are useful in ink jet coatings but cannot be dispersed at high solids or coated on machine

ZOBrite Pigment

- Clinoptilolite purified and modified by a proprietary process
- Process works with only clinoptilolite zeolite from the ZO Resources reserve in west Texas
- Can make a product with 93 - 95% GE Brightness and good rheology

ZOBrite Pigment Properties

- GE Brightness and Color
  - GE Brightness 93.5%
  - L 97.1
  - a 0.31
  - b 1.14
- BET Surface Area 37.7 m^2/g

ZOBrite Pigment Properties

- Sedigraph Particle Size (%) - slurry at 50% solids
  - <10 µm 99.6
  - <5 µm 99.1
  - <2 µm 92.0
  - <1 µm 69.5
  - <0.5 µm 43.9
- 325 mesh Residue 0.0014%
- Einlehner Abrasion 2.0 mg loss

ZOBrite Pigment Slurry Properties

- Can be dispersed with either anionic or cationic dispersant
- Stable dispersions at 54% solids
- Viscosity at 50% Solids
  - Brookfield @ 20 RPM 114 cPs
  - Hercules at 1100 RPM 138 Kilodyne-cm
    - Apparent viscosity 24.0 cPs

ZOBrite Coating Development

- Initial work targeted at ink jet and digital printing
- Objective: Economical alternative to silica that could be coated at higher solids on machine
- First formulated with polyvinyl alcohol
  - CPVC = 1:1
  - No cracking or dusting at 14:1 pigment:binder

ZOBrite Ink Jet Coating Development

- Drawdowns showed performance comparable to silica at 2:1 pigment:binder
- CLC runnability excellent at 2500 fpm and 40 - 45% coating solids
  - Typical solids for silica 14 - 18%
  - Engelhard *Digitex*™ solids 30 - 33%
- Rheology showed MSP coating feasible

Other Implications from Ink Jet Coating Research

- Rapid drying time in ink jet prints and water-fastness -> could be applicable to direct post print flexo to prevent smudge
- Low abrasion -> minimize metal marking
- Could also benefit water-based gravure
- Evaluate dynamic contact angle with 10 parts ZOBrite in linerboard top coat

Pigmented Size Press

- Pigmented size press trials at 2:1 ratio with ethylated starch
  - Good runnability
  - No dusting
  - Improved offset and ink jet printability

Wet End Filler Evaluations

- Trials on pilot paper machine
  - Self retains at 2.5 to 4 time rate of PCC, GCC and filler clay
  - Improved formation
  - Potential for microparticulate silica replacement
- Higher tensile strength and stretch
- More open sheet
- Improved COF

Reduction in Print Through

- Sheet filled with 100 pounds ZOBrite per ton (4.59% ash) showed no print through
- PCC, GCC and clay at 250 pounds per ton showed print through
- Performance of zeolite at 100 pounds per ton better than 200 pounds per ton calcined clay - which required retention aid

Patents

- U.S. 6,679,973 - High Performance Purified Natural Zeolite Pigment for Papermaking and Paper Coating
- U.S. 6,616,748 - High Performance Purified Natural Zeolite Pigment for Papermaking and Paper Coating
- U.S. 7,201,826 – High Performance Natural Zeolite Microparticle Retention Aid for Papermaking

Thank you for your attention!