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Surface Modified Pigments for Inkjet Ink Applications

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Outline

- **Cabot Corporation and Inkjet Colorant Division**
- **Pigment Requirements in Inkjet Inks**
- **Pigment Particle Stabilization Overview**
- **Surface Modification Technology by Cabot**
  - Pigment Surface Modification Chemistry
  - CAB-O-JET® Colorants for Inkjet Inks
  - Properties of CAB-O-JET® Colorants
  - Versatility of Surface Modification Technology
- **Next Generation Pigments (Paul)**

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Cabot Corporation

- **Founded in 1882, public 1963 on NYSE**
- **Operates 39 plants in more than 20 countries**
- **4,500 employees**
- **2000 sales of $1.8 billion**
- **Technical Competencies:**
  - Nano-particle manufacturing
    - carbon black, fumed metal oxides
  - Nano-particle surface modification technologies

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Cabot's Inkjet Colorants Business

- **Division created in 1995**
- **Provides pigment dispersions for Inkjet printing applications**
- **Headquarters in Billerica, MA**
  - Offices in:
    - Billerica, MA
    - Tokyo, Japan
    - Stanlow, UK
    - Atlanta, GA
  - Manufacturing facilities in
    - Woburn, MA
    - Wilmington, MA

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The Ink Challenge

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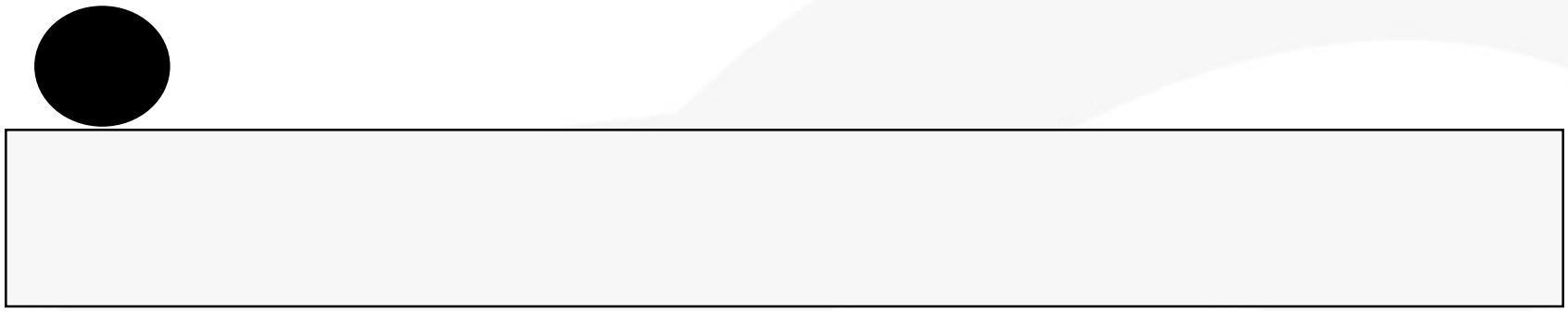

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THE IDEAL INK

- Contains a colloidally stable black pigment
- Reliably jets from a thermal ink jet head

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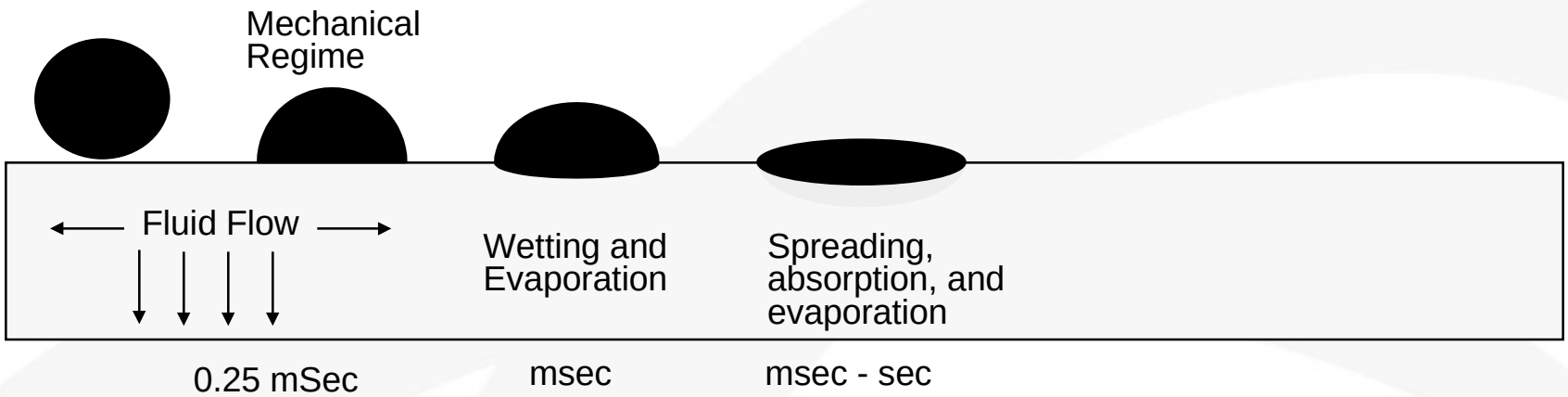

THE IDEAL INK

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- Reliably jets from a thermal ink jet head
- Hits, wets, and penetrates the media

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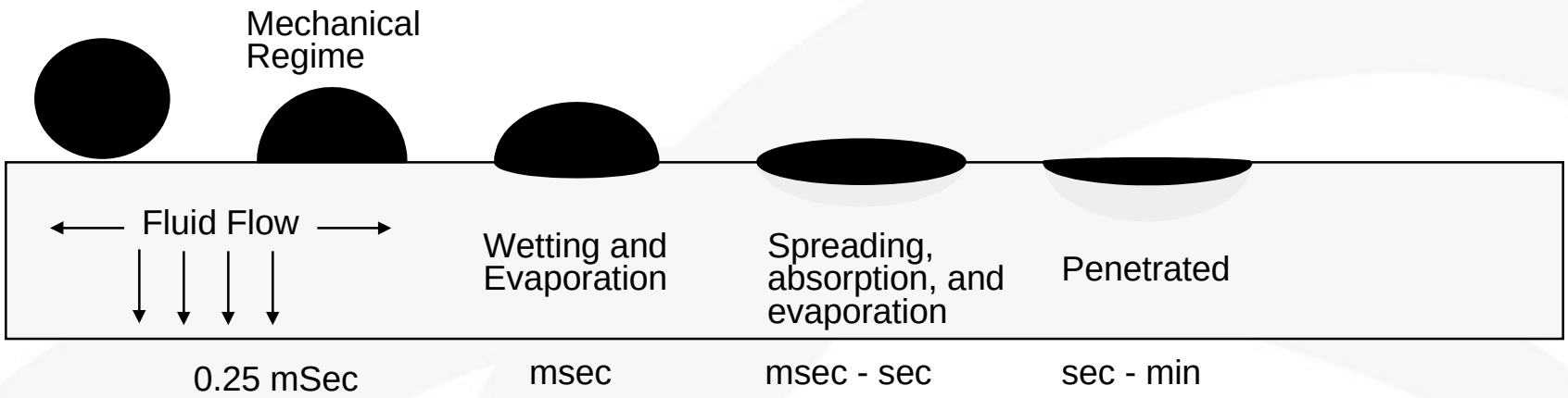

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- Hits, wets, and penetrates the media
- Bulk of the non-colored ink vehicle penetrates the media
- Pigment stratified with some penetration into the media

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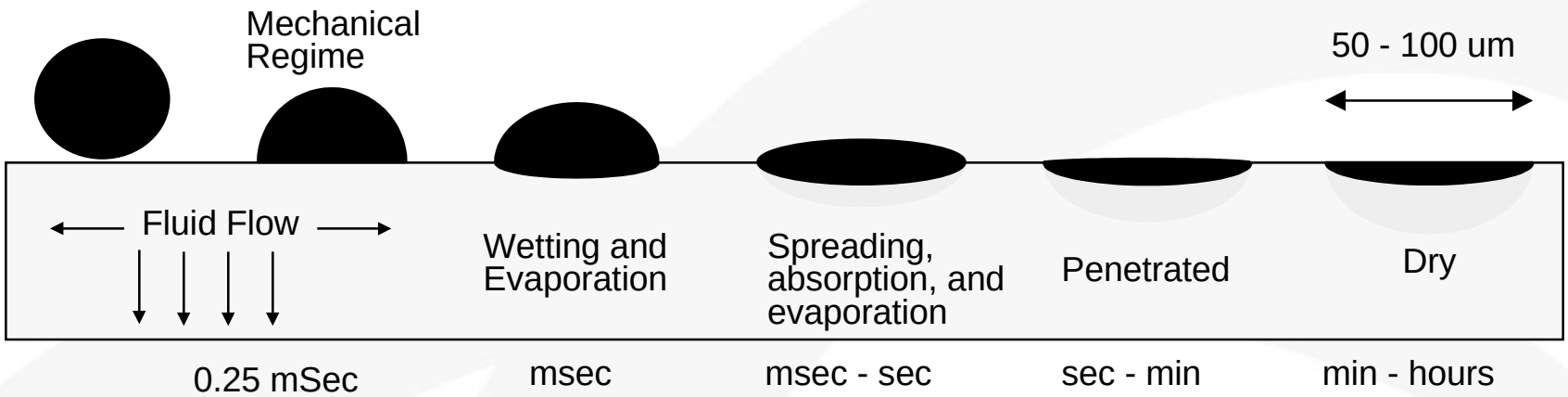

THE IDEAL INK

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- Hits, wets, and penetrates the media
- Bulk of the non-colored ink vehicle penetrates the media
- Pigment stratified with some penetration into the media
- Once stratified and dried the pigment and non-volatile ink components form a cohesive network with each other and adhesive bond with the media

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The Challenges

- Find treatments that give colloidally stable inks
- Find chemistry to promote flocculation and immobilization during absorption, penetration, and drying
- Find polymers that once dried form mechanically strong networks

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Stability Requirements in Inkjet Inks

- **Pigment dispersions need**
  - Colloidal stability: No particle size growth
  - Compatibility with various ink components
  - Purity for the Inkjet environment
  - Particle size less than 150 nm
  - Favorable physical properties:
    - Low viscosity and high surface tension

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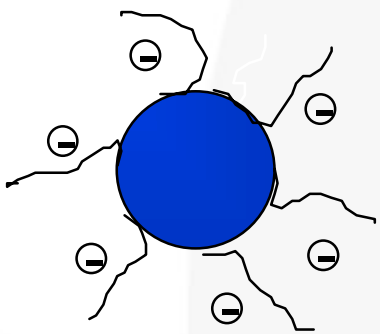
Pigment Stabilization Technologies

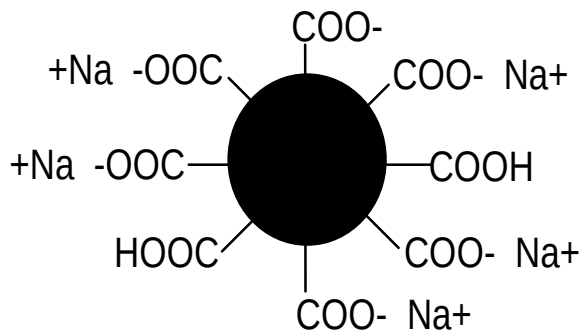
Conventional Method

- Stabilizing groups are **adsorbed** to pigment surface
  - Small molecules and/or polymers
  - Non-ionic and/or ionic
- Milling is generally required
- Dynamic equilibrium
  - Particle surface and stabilizing groups



Cabot's Technology

- Stabilizing groups are **attached** to pigment surface
  - Small molecules and/or polymers
  - Non-ionic and/or ionic
- Pigments are self-dispersible
- No dynamic equilibrium
  - Better compatibility with other ingredients



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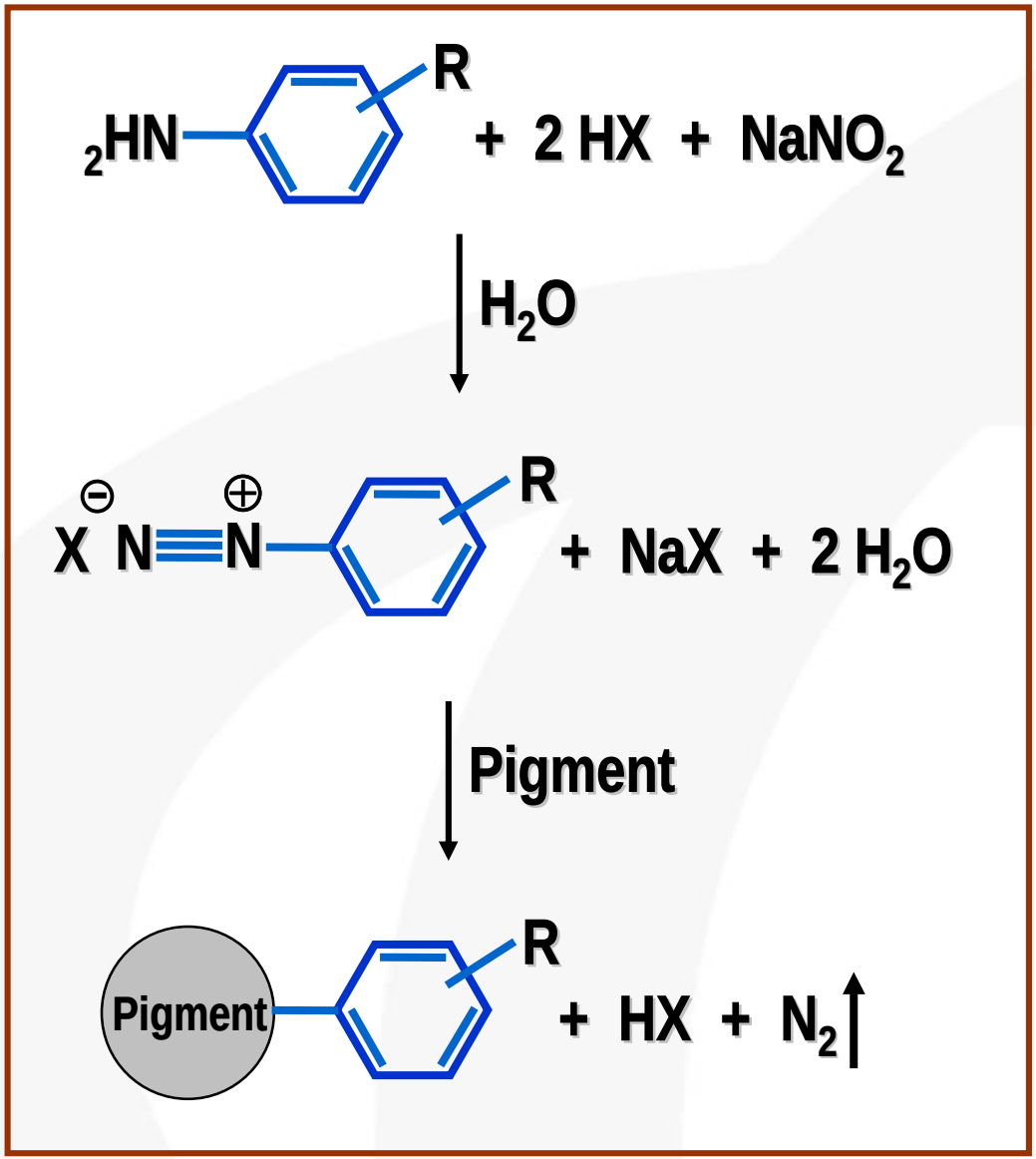
Surface Modification with Diazonium Salts



R = COOH
SO_3H
Polymers
Mixed

US Patents

5,554,739

5,922,118

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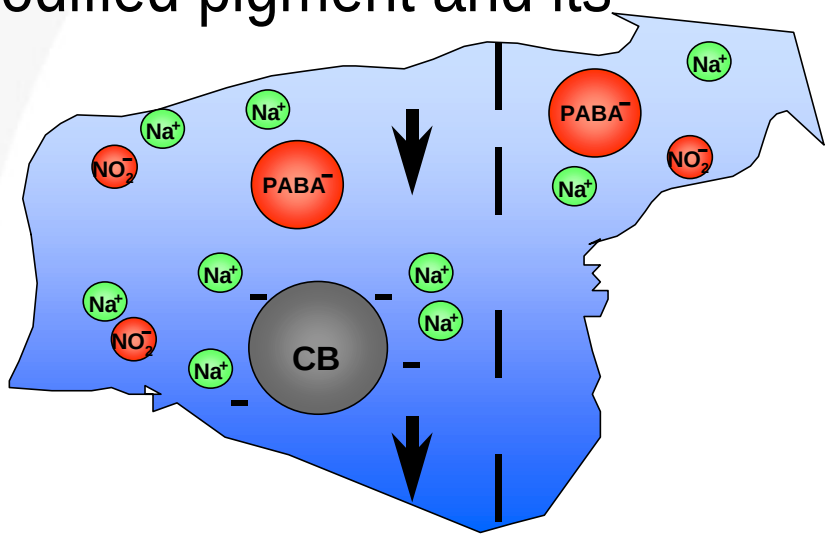
Dispersion Purification - Ultrafiltration

- Essential to remove reaction byproducts, excess salts and unreacted starting materials
- Purification is done using ultrafiltration with DI water makeup
  - Soluble impurities pass through membrane leaving surface modified pigment and its counterion



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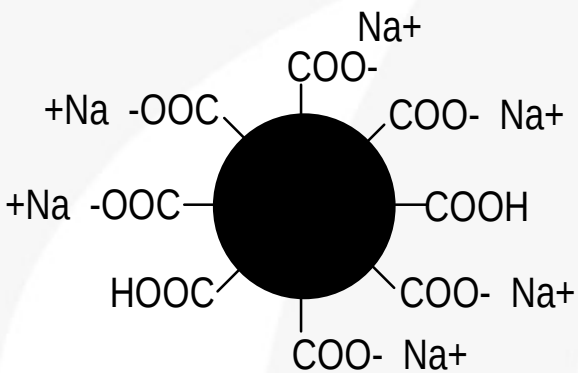
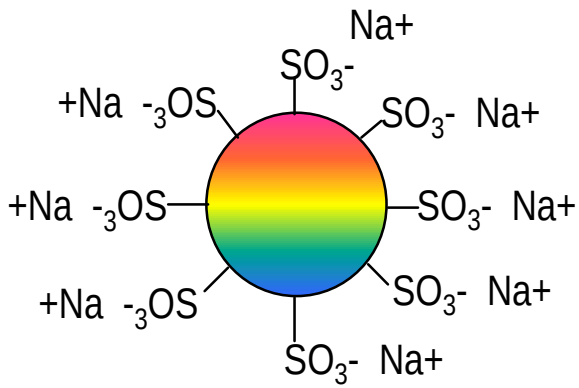
CAB-O-JET® Colorants: *KCMY set*

- Black: **CAB-O-JET® 300 and 200**
- Cyan: **CAB-O-JET® 250**
- Magenta: **CAB-O-JET® 260**
- Yellow: **CAB-O-JET® 270**



CAB-O-JET® 300



CAB-O-JET® 200, 250, 260, 270

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Physical Properties of CAB-O-JET® Colorants

CAB-O-JET® Colorants

Properties	300	250	260	270
Color	Black	Cyan	Magenta	Yellow
Pigment Type	Carbon Black	PB 15:4	PR 122	PY 74
Pigment Loading	15%	11%	11%	11%
Viscosity[1]	3.7 cP	2.1 cP	2 .4 cP	2 .0 cP
Surface Tension[2]	70 dynes/cm	70 dynes/cm	72 dynes/cm	72 dynes/cm
pH	7.8	7.0	7.5	6.5
Particle size[3]	130 nm	91 nm	105 nm	137 nm

[1]Brookfield viscometer
[2]Kruss Digital Tensiometer K-10
[3]Mean volume particle size determined by Microtrac® Ultrafine Particle Analyzer (Honeywell)

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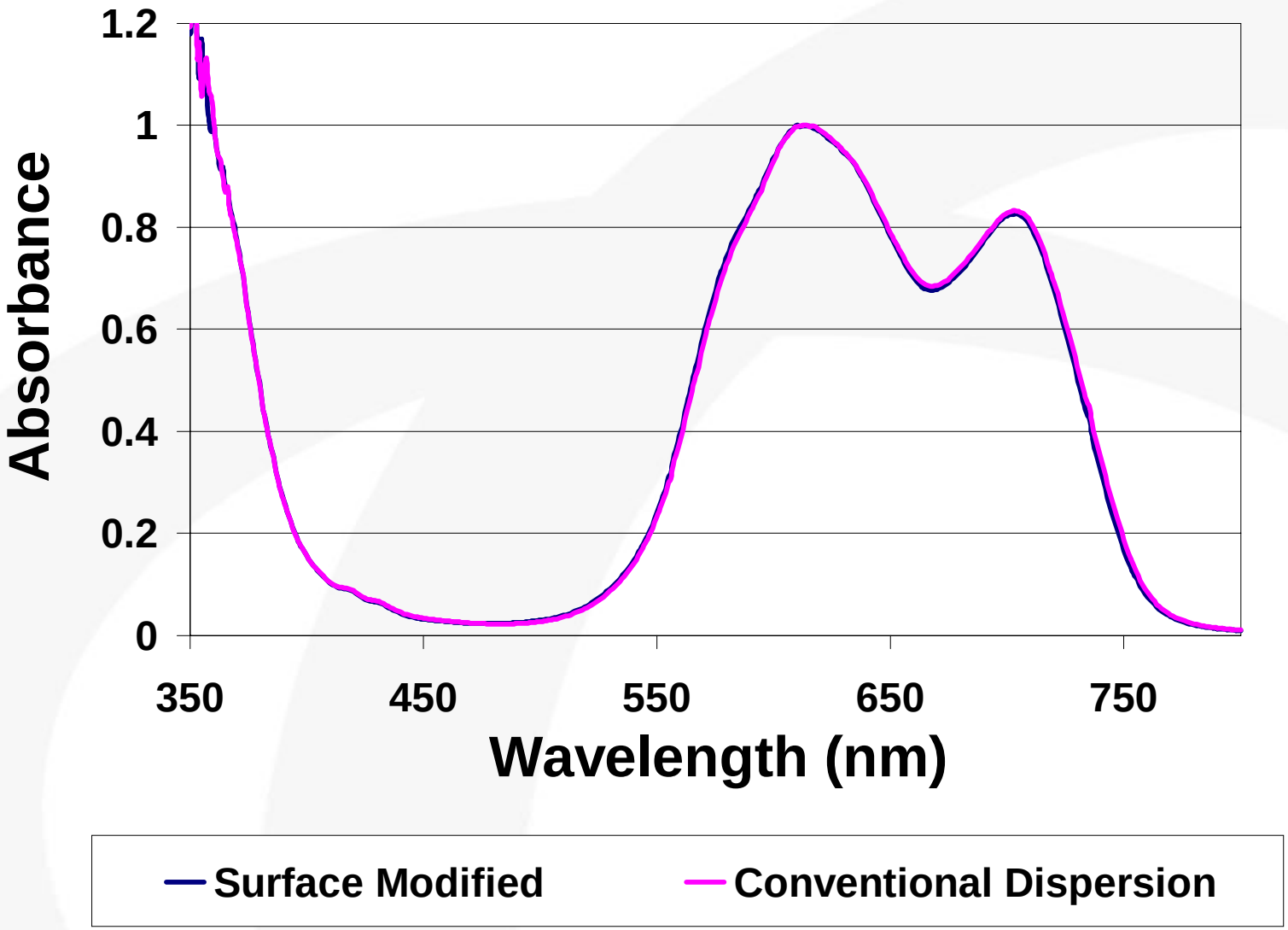
UV-VIS Comparison (PB15:4)



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Colloidal Stability Testing

- **Testing Conditions**
  - Pigment dispersion at 10%
  - Generic ink
    - 5% pigment
    - 10% 2-pyrrolidone
  - Four-month aging at 70°C
  - Monitor particle size growth

Aging test of CAB-O-JET® Colorants

CAB-O-JET®		Mean volume particle size (nm)[1]		Number of particles > 0.5 µm	
		INITIAL	AGED	INITIAL	AGED
300	Dispersion	130	130	3.0E+9	3.5E+9
	Generic Ink	130	130	3.0E+9	3.0E+9
250	Dispersion	92	91	2.7E+8	1.8E+8
	Generic Ink	89	90	2.4E+8	1.6E+9
260	Dispersion	110	94	3.8E+8	1.5E+8
	Generic Ink	105	100	4.0E+8	1.3E+8
270	Dispersion	135	130	1.6E+8	1.3E+8
	Generic Ink	105	105	1.7E+8	5.0E+7

[1]Mean volume particle size determined by Microtrac® Ultrafine Particle Analyzer (Honeywell)
[2]Determined by AccuSizer Model 780 available from Particle Sizing Systems NICOMP

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Printing Performance on Plain Papers

CAB-O-JET® Colorants in generic inks

	Pigment	L*[1]	a*	b*	OD	WF[2]	LF[3]
300	Carbon Black	-	-	-	1.5	< 1hr	>99%
250	PB 15:4 Cyan	52	-18	-37	1.0	5 min	90%
260	PR 122 Magenta	56	47	-9	1.0	5 min	93%
270	PY 74 Yellow	89	-6	84	1.2	5 min	<50%

[1]L*a*b* readings determined by a Hunter LabScan II

[2]WF: Waterfastness is time taken by print to dry sufficiently that the runoff of .25 ml DI water does not cause colorant transfer

[3]LF : lightfastness expressed as % OD retention after 400 hrs of continuous UV-A irradiation using a Accelerated Weathering QUV/SE Instrument (Q-Panel Co.)

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Summary of CAB-O-JET® Properties

- **Conclusions**
  - Favorable physical properties: low viscosity, high surface tension
  - Particle size of all pigment dispersions and inks grew less than 10% after aging
  - Number of particles greater than 0.5 µm did not change after aging
  - Color and light stability of pigment seem unaffected by surface modification
  - No dye appears to be formed by surface modification

Benefits of Surface Modification

- **Technology**
  - Ability to tailor surface properties and impart functionality to the pigment
- **Physical Properties of Pigment Dispersions**
  - High surface tension (~ 70 dynes/cm)
  - Low viscosity (< 2.5 cP at 10% solids)
  - Superior colloidal stability
  - High purity (material covalently attached)
- **Ink**
  - Formulation flexibility
  - No dispersants required
  - Superior reliability

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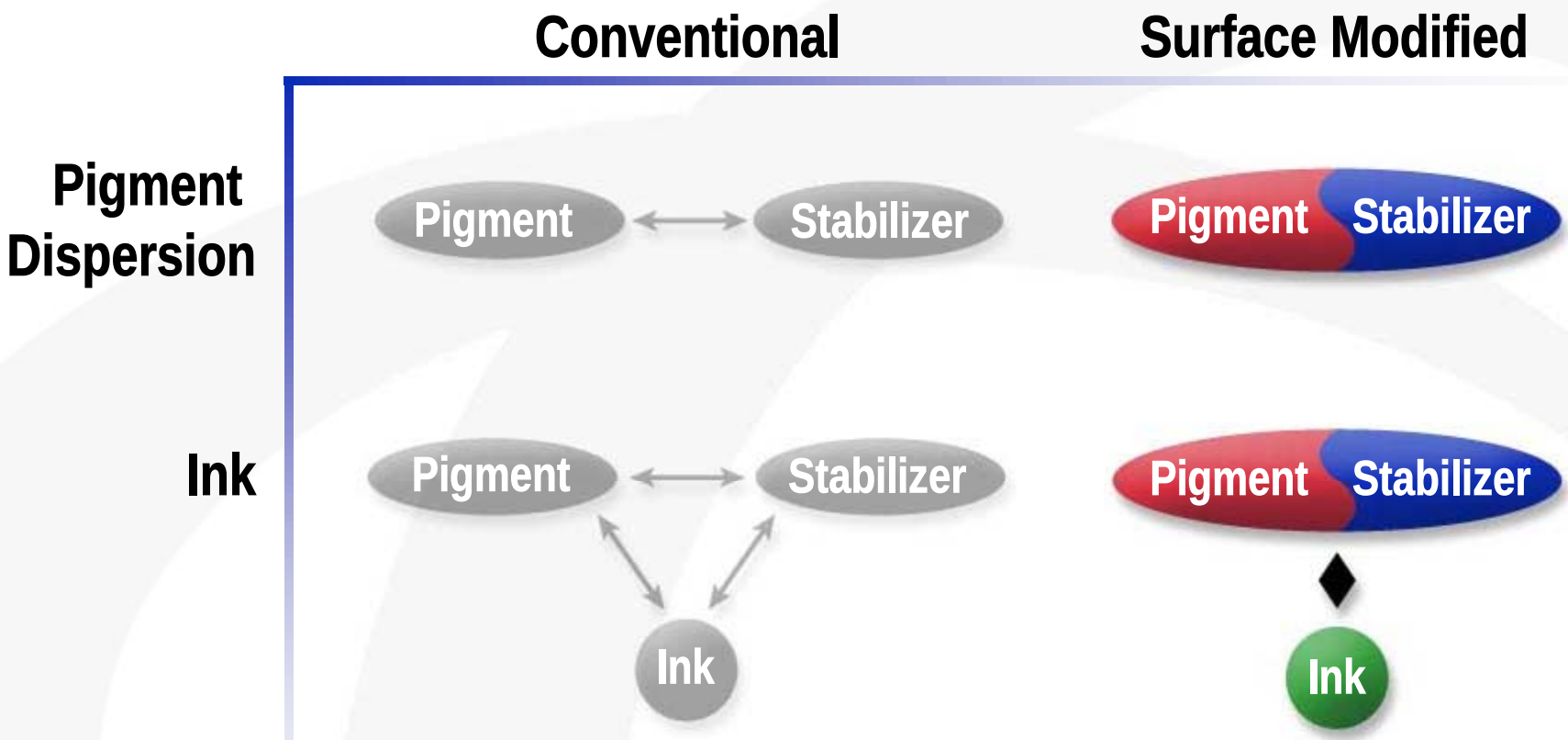
Formulation Flexibility



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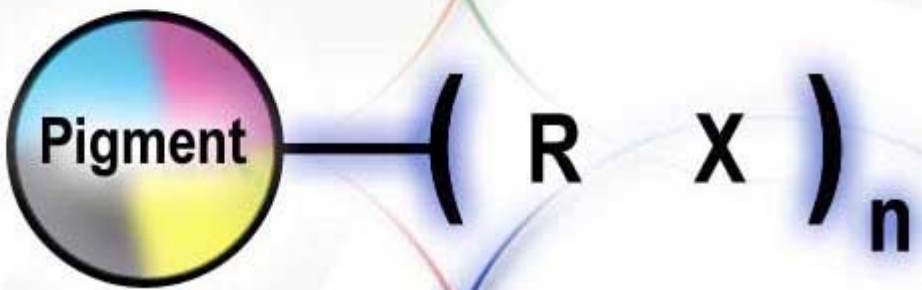
Surface Modification Versatility

Treatment Type

- Ionic (+ and -)
- Non-ionic
- Multiple/additional treatments
- Polymers

Counterion Type

- Negative/Positive
- Organic/inorganic
- Small molecules/polymers



Pigment Type

Black
Cyan
Magenta
Yellow

Treatment Level

adjusted for desired properties

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Summary

- **High performance pigments are required for IJ to grow into new applications**
- **Surface modification technology can deliver performance**
  - Stable IJ quality dispersions (C, Y, M, K)
  - Ink functionality on pigment surface
  - Provides unique and valuable properties for the end use applications
- **Ideally suited for Digital Imaging Applications**

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