Green Products from Green Processes
A New Industrial Revolution

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Materials: A Required Key Competency

ElectroPhotography results from a balanced and controlled interaction between materials and hardware to produce the image.

High quality and color EP demands high sophistication from materials and hardware.

Materials sophistication is key to improving performance at reasonable hardware cost and complexity.
"To provide designed functional products by intensified manufacturing processes that are…

• Technologically advantaged and have NO environmental impact in their production or in their use and provide huge barriers to competition

• Economically and Environmentally advantaged to traditional chemical processing methods

• Providing a flexible manufacturing solution tailored closely to capacity and customer needs."
A history of the Chemical Industry

Many steps (quality, cost, time)
Inefficient / poor energy utilisation
Little regard for the environment
High levels of waste for disposal
Inherently unsafe processes
Large Physical size, lots of steel
High environmental impact in build.
Delivering a Green Solution

No stone uncovered...address the whole picture

- Raw material selection
- Design of Processes
- Materials of construction
- Processing Materials
- The Human factor
- Support Processes
- Energy utilization
- Packaging
- Delivery to consumer
- End of life

Easily obtained
Benign
Biodegradable
Reusable
Recyclable
Renewable
Delivering a Green Solution

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Process Intensification
- Inherently Safe
- Compact Continuous
- Low hold up
- Self Contained
- Scale Out

10/29/2009
Graphic Communications Group
Delivering a Green Solution

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Process Intensification
Smaller Scale by XX
Compact / single level
Close proximity of unit ops
Scale out multiples of
Inherently safe
Short residence times
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Process Intensification
Self contained
Internal Recycle / reuse
Use of azeotropic mixtures
Benign solvents eg sCO₂
Toner Manufacturing Techniques

Uncontrolled Fracture (Mechanical)

- Large Particles
- Random, Uncontrolled breakage
- Broad particle
- Composition & Size
- No shape control

Controlled Growth (Chemical)

- Nanoparticle Dispersions
- Controlled Growth
- Uniform particle
- Composition & Size
- Shape control
Using the Spinning Disc Reactor as an example it will be shown how PI drives advantages in ....

• **Technology**

• **Environmental Impact and Economics**

• **Manufacturing Flexibility**
Process Intensification – Business Driven Approach

A design approach from Customer Driven Product features

• What unique features give the product its desirability

• What is the optimum unconstrained way to best make this complex product
  – Micro approach not Macro
  – Reaction Kinetics, Reaction media, energy requirements, environment (P,T)
  – Purity, Yield, Specificity, morphology, activity

• Do not focus on the transformation alone.
  – Product isolation, purification, process fluid recovery / recycle / re-use

• Eliminate unnecessary steps, combine linked steps.

• Design the process around this optimum environment.
  – Don`t be constrained by what you know
  – Requires invention

Delivers unique products from unique processes
Organic Phase

Aqueous Phase

Limited coalescence technology results in uniform drop size

Toner components dissolved or dispersed in volatile solvent

homogenize

Evaporation

Proprietary Shape control agent added

Solvent recycle

Solvent removal transforms drops into irregular particles

Silica or polymer latex dispersed in aqueous buffer solution

Filter, wash, dry

Toner particles free of stabilizer ready for isolation

Silica displacer added

Chemical Toner Manufacturing
Spinning Disc

First used by Kodak 1933 for the production of Vitamin E
Spinning Disc Reactor (SDR)

Features

- Intense micro mixing in the thin liquid film
- Short liquid residence time (may allow use of higher processing temperatures)
- Plug Flow characteristics
- Easy cleaning
- High levels of heat / mass transfer

Applications

- Polymerization
- Fast precipitation, production of mono-dispersed particles
- Catalyzed organic reactions
Current Technology v`s SDR

**Thin Film Flash Evaporator**

- Uncontrolled evaporation
- Non uniform environment (hot/cold spots)
- Long residence time
- Violent conditions
- Fouling
- Diffusion limited
- Moderate heat mass transfer rates
- Pre-heating required
- Large footprint
- High Capital Cost
- Downstream processing required

**Spinning Disc Reactor**

- Controlled evaporation (shape control)
- Multiple processes (evaporation, shape, wash)
- Identical particle experiences
- Short residence time
- High heat mass transfer rates
- Stable conditions / ambient operation
- Non fouling
- Shear induced micro mixing
- Low Energy
- Compact design
- Low Capital Cost
Why does an SDR work for Kodak

Technologically

✓ Performs the evaporative requirement but also provides a handle on particle shape and smoothness in a clean and predictable way.

✓ Allows for other processing steps to be incorporated alongside evaporation in the same unit (silica removal and washing)

Environmentally

✓ Much more compact equipment, less material of construction (20x)

✓ Much higher levels of heat and mass transfer so lower running costs

✓ Energy efficient, easy to clean

✓ No waste, solvent streams recovered in line and reused….internal recycle

Manufacturing Flexibility

✓ Scale out (more discs on the same shaft)

✓ Lab device same as production device

✓ Compact, low cost, self contained.
A New Industrial Revolution

The adoption of this approach to technology development and the adherence to the principles of Process Intensification will provide considerable advantages to EPS as it moves through this technology change. Kodak will be advantaged in many respects but specifically in

- **Cost**
  - In the materials and their production
  - In how our customers opportunities are enhanced.

- **Technology ownership and barriers to entry**
  - Design unique structures and clean chemistries that provide unique customer advantages.
  - Manufacture these through a unique clean and environmentally advantaged process, that allows for no competitive copying.

- **Manufacturing Flexibility**
  - to closely match business, demand, supply chain and customer needs.
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Low/No Exposure
Inherently Safe
Pristine Plant
Total Operator Ownership
PV/RCM/LEAN
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Often Disregarded
Critical to use PI principles in upstream and downstream processes
Constantly strive to minimise / recover energy
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Voice of the Customer

How can the customer reuse rework or re-cycle

PI leads to Global Presence

Market Green

Kodak
In Summary

For Kodak and other manufacturers to be competitive we must

- Adopt and invent Green technologies
- Provide Green products
- Lead the revolution
- Enjoy the benefits

- But most of all be single minded and persistent