

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

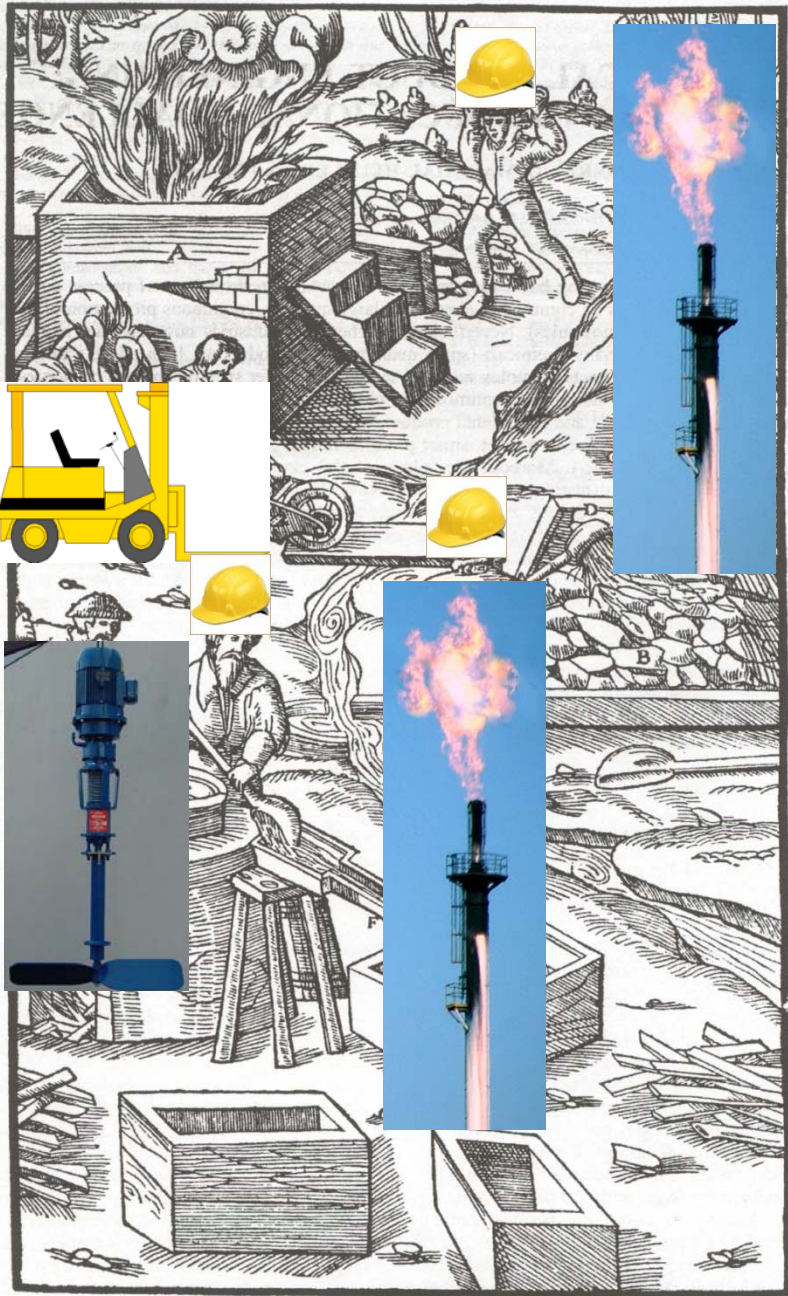
Materials sophistication is key to improving performance at reasonable hardware cost and complexity



“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




A—FURNACE. B—ENCLOSED SPACE. C—ALUMINOUS ROCK. D—DEEP LADLE. E—CALDRON. F—LAUNDER. G—TROUGH.

Figure 1. Product engineering in the early ages: processing of iron in the 15th century according to G. Agricola¹.

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

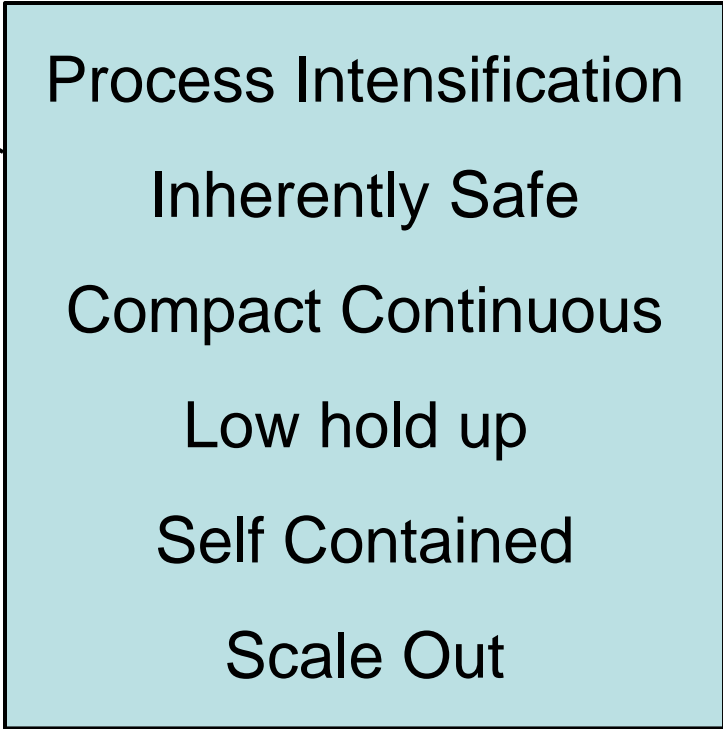


Easily obtained
Benign
Biodegradable
Reusable
Recyclable
Renewable

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

Delivering a Green Solution

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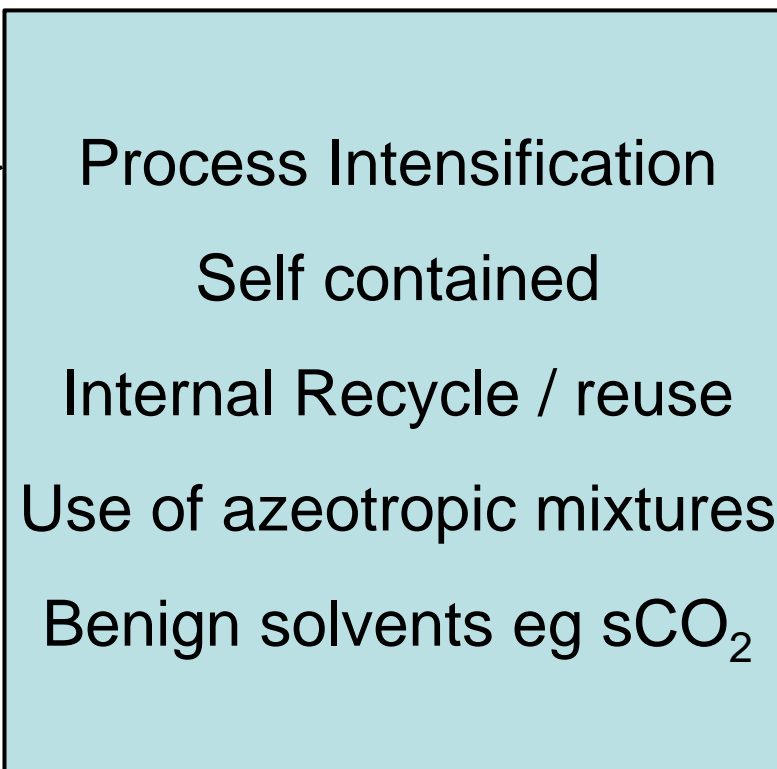
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Process Intensification
Smaller Scale by XX
Compact / single level
Close proximity of unit ops
Scale out multiples of
Inherently safe
Short residence times

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Toner Manufacturing Techniques

Uncontrolled Fracture
(Mechanical)

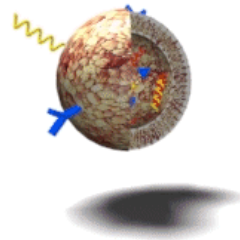
Large Particles



Random, Uncontrolled
breakage

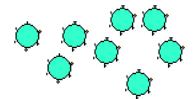


Broad particle
Composition & Size
No shape control

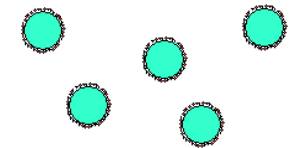


Controlled Growth
(Chemical)

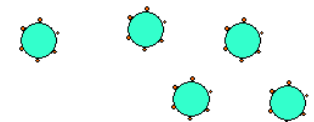
Nanoparticle Dispersions



Controlled Growth



Uniform particle
Composition & Size
Shape control



Simplification through Process Intensification

Using the Spinning Disc Reactor as an example it will be shown how it PI drives advantages in

- ***Technology***
- ***Environmental Impact and Economics***
- ***Manufacturing Flexibility***

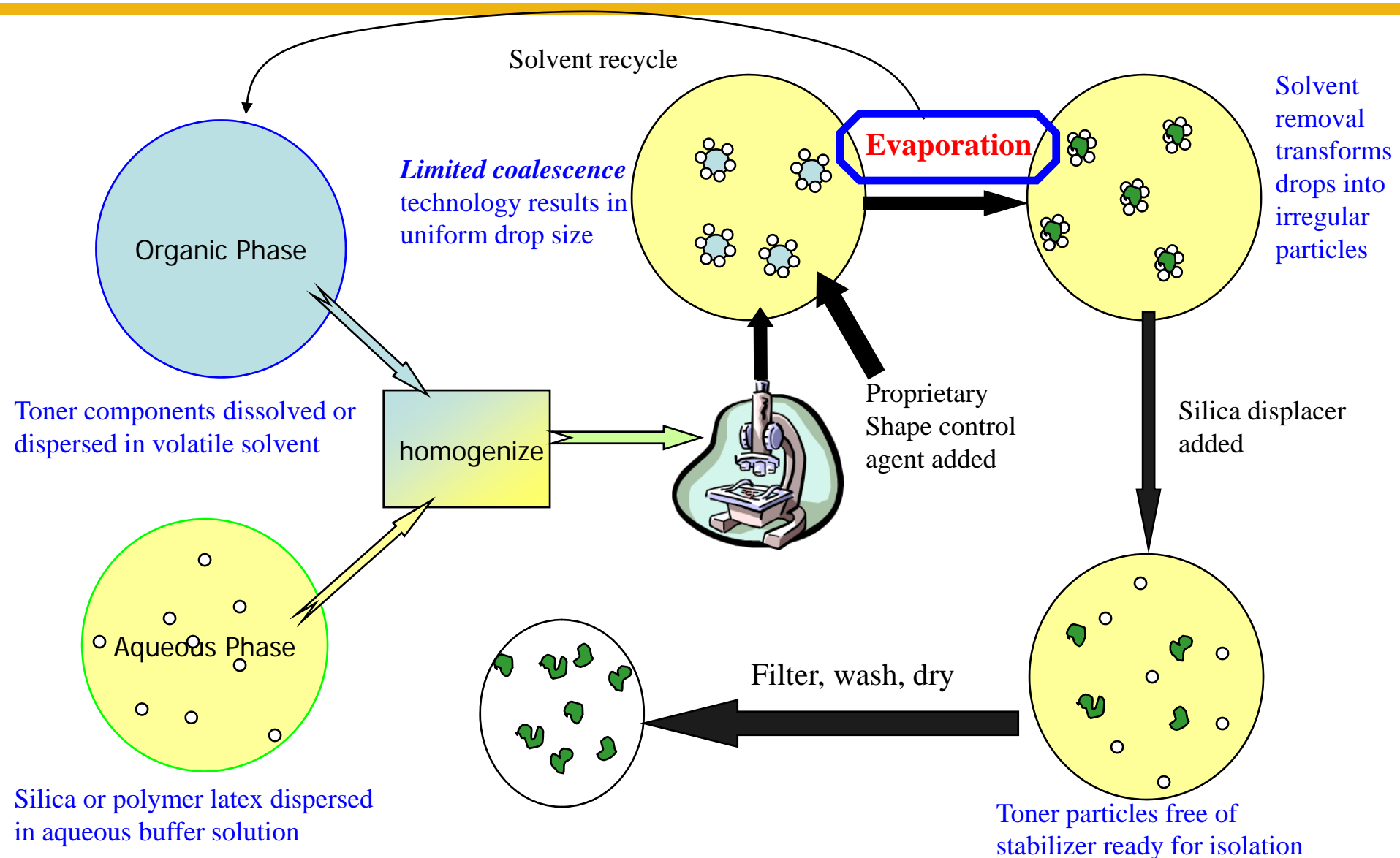
Process Intensification – Business Driven Approach

A design approach from Customer Driven Product features

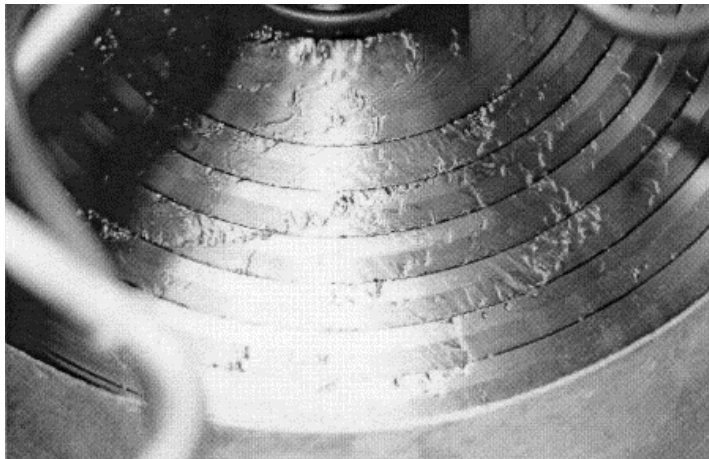
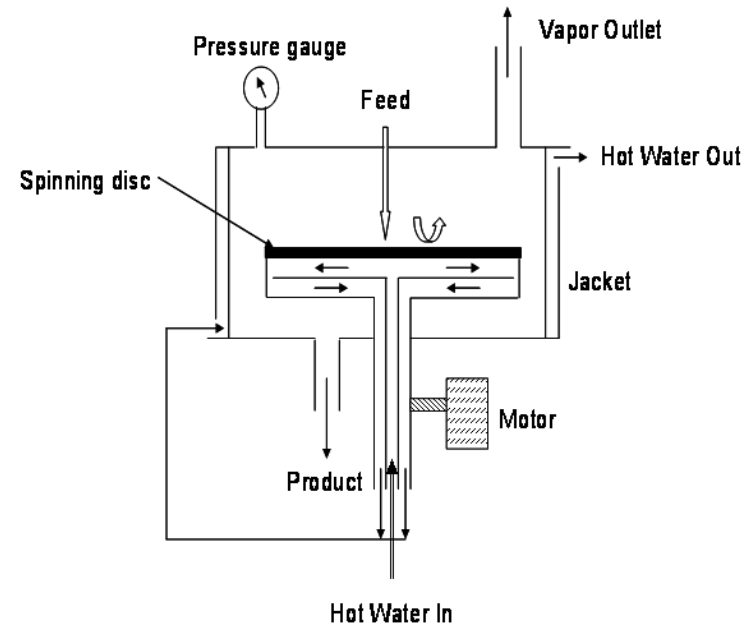
- What unique features give the product its desirability
- What is the optimum unconstrained way to best make this complex product
 - Micro approach not Macro
 - Reaction Kinetics , Reaction media , energy requirements , environment (P,T)
 - Purity , Yield , Specificity , morphology , activity
- Do not 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

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

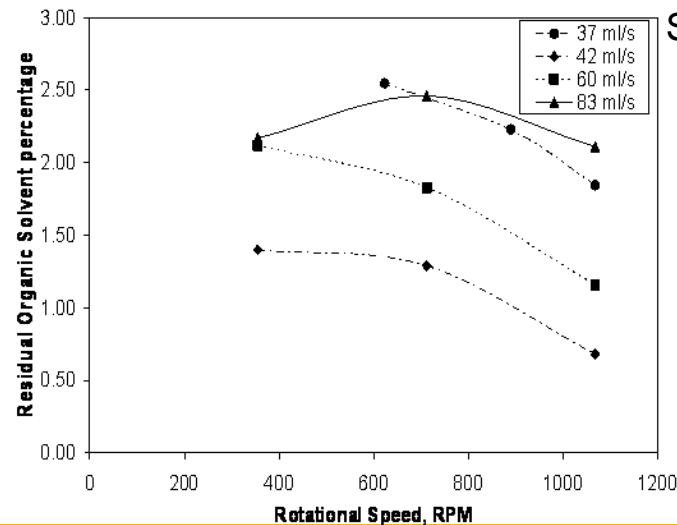
Non fouling

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

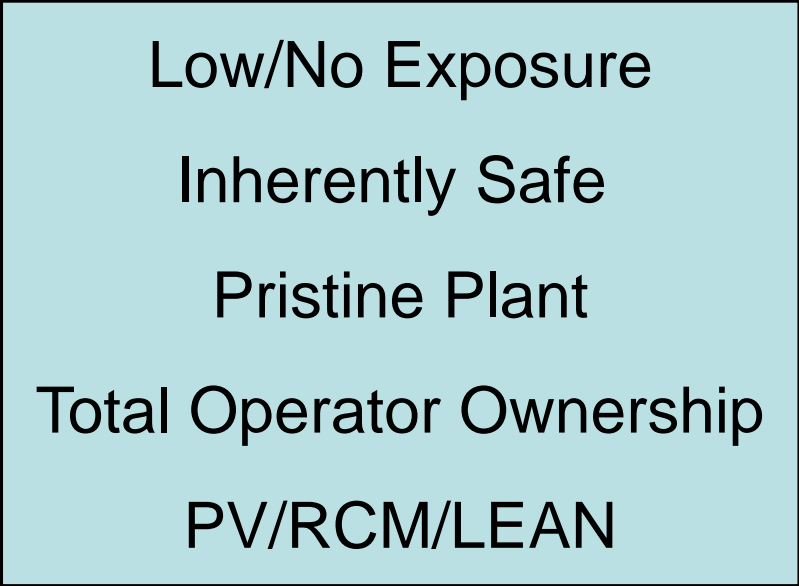
The adoption of this approach to technology development and the adherence to the principles of Process Intensification will provide considerable advantages to EPS as it moves through this technology change. Kodak will be advantaged in many respects but specifically in

- **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

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