Huntsman Corporation

Five business divisions 15,000 associates, approx. $13bn revenues

- Advanced Materials: Synthetic and formulated polymer systems
- Performance Products: Intermediate chemistries and technologies
- Pigments: TiO2 pigments, color pigments, functional additives and timber and water treatment
- Polyurethanes: MDI-based polyurethanes
- Textile Effects: Chemical & dye products
Pigments

Naturals vs. Synthetics

An overview of their primary properties and how they relate to flowability and dosing
Outline

• Pigments - Naturals vs. Synthetics
  – General Classification
  – Mining and or/ Manufacturing
  – Different Forms- powder, granules, liquids
  – Tint Strength
  – Color Space
  – Comparison
Classification

Inorganic Pigments

Colored

White

Natural

Synthetics

Metal Oxides

Fe₂O₃, FeOOH, Fe₃O₄

CCIP

Spinels...

Metal Salts

Cd, Cr, Mo...

Others

Special effect, Ultramarines...
Naturals
Naturals

- Red $\rightarrow$ Hematite
- Yellow $\rightarrow$ Hydrated iron Oxide
- Black $\rightarrow$ Magnetite
- Umbers

- Limited color space
- Generally $\sim\frac{1}{2}$ the tint strength of synthetic iron oxides
- May contain 2 primary types of contaminates, but not limited to:
  - Non coloring contaminates:
    • Clays, sand, Calcium carbonate, Talc, ETC.
  - Coloring contaminates:
    • Magnetite, Manganese, umbers ETC.
Mining of Naturals
Different Naturals

• Generally supplied primarily as powder, or more recently in a granular form
Synthetics
Synthetics

• Broad color space palette

• Generally twice the tint strength of naturals

• Quality governed by an ASTM C979

• Does not contain contaminates

• Color space determined by size and shape of the individual crystal
Different forms of Synthetic

• Commonly supplied as liquids, powders, or spray dried, built up or compacted granules
Manufacturing of Synthetics

- Synthetic red iron oxide pigments were first produced in a laboratory setting in the 14th century.
- Originally referred to as “Mars Red” was followed by yellow shades in 1920’s.
- By modifying the manufacturing process of red and yellow, brown evolved.
- Various manufacturing methods include, but are not limited to:

  Precipitation (“Cooking”)

  Calcining (“Baking”)
Synthetics can contain 60% recycled content
Synthetic I/O Color Production
Red & Black – Streams

Neutral Liquor
ES612905
502_2
RNEUT
ZALB

ECB
ES612910
516_2
REDEC
ZALB

Copperas Dryer
ES612915
517_2
RCOPDRY
ZALB

Dehydration
ES612920
520_2
RDEHKYL
ZALB

Oxidisation
ES612925
522_2
ROXIDKLN
ZALB

Black Precipitation
ES613915
509_3
BLKREACT
ZALB

Black Filter, Dry, Mill & Pack
ES613990
559_3
561_3
562_3
563_3
597_3
ZFP

Wash & Thicken
ES612930
545_2
RWASHTHK
ZALB

Blend, Filter & Dry
ES612940
550_2
559_2
562_2
ZFP

Mill & Pack
ES612990
563_2
597_2
ZFP

Acid Plant
ES680910
106

ZALB

RWETGRND
ZALB

ZFP

RNEUT
ZALB
Properties: Particle Shape

Yellow Iron Oxide
- FeOOH

Red Iron Oxide
α - Fe₂O₃

Microscopic images show differences in primary particle shapes – Yellows vs. Reds
**Properties: Particle Shape**

Black Iron Oxide
- Spherical Fe$_3$O$_4$

Black Iron Oxide
- Cubic Fe$_3$O$_4$
## Synthetic vs. Natural Iron Oxides

<table>
<thead>
<tr>
<th>Synthetic Iron Oxides</th>
<th>Natural Iron Oxides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufactured, close color control</td>
<td>Ore deposits, variable by nature</td>
</tr>
<tr>
<td>Small particle size</td>
<td>Large particle size</td>
</tr>
<tr>
<td>Greater color power / unit of weight</td>
<td>Generally, lower tinting strength</td>
</tr>
</tbody>
</table>
Primary Points of Comparison
Synthetic vs. Natural

- Synthetic I/O properties are governed by ASTM C979.
- Color space of I/O is determined by the size / shape of the individual mineral crystal.
- Primary differences between synthetic and natural I/O:
  - Natural I/O often contain contaminants that reduce tinting strength.
  - Natural contaminants that impact color are Manganite, (MNO) that gives umbers their dark colored masstones.
  - Non-coloring contaminants are often natural extenders. (i.e.. clays, talc, and calcium carbonates.)

Don need to expand here to talk about color space, costs, revisit tinting strength, etc. This is your wrap up slide so go touch on all primary points above.
Handling characteristics of I/O pigments

• Powders came first and are generally the most economical.
• Liquids evolved in an attempt improve housekeeping, metering and general handling.
• Granules were introduced in the late 1980’s to address liquid shortcomings.
• Naturals (because of larger particles and contaminants) usually flow better than synthetics.
• Synthetic powders can absorb moisture leading to clumping / bridging. This inconsistent flow creates bottlenecks in some applications such as metering, dispensing or conveying.
• In most cases these bottlenecks can be resolved by equipment design changes or mechanical intervention.
Conclusion

- Generally naturals I/O flow better than synthetics.
- Improved flowability in naturals can be attributed to particle size, purity, and type of contaminates, but this can adversely impact tinting strength and color performance.
- Synthetic handling is improved with introduction of mechanical and/or air intervention.
- To move synthetic iron oxides, steeper angles are required.
- Increased angle creates less restrictions / bridging and improves flow.
- Synthetics are a stronger colorant often by over 50%.
- Due to tinting strength superiority, synthetics require ~ ½ the dosage rate therefore require more accurate handling systems.
- Synthetic I/O have greater opacity which results in reduced visible production related color variations.
- Synthetics will give you a more consistent product.
Augusta Site Commissioning in Q1, 2016

• Huntsman is currently the only manufacturer of construction grade I/O pigments direct from the particle precipitation process in North America
• Augusta’s capacity will be ~70M lbs. of capacity.
• Site represents investment of over $172M and will create over 100 employment opportunities.
• Warehousing and various blending locations will be spokes.
Huntsman’s Regional Warehousing

United States-

Beltsville, MD  Atlanta, GA  Houston, TX
Phoenix, AZ  Denver, CO  Orlando, FL
Seattle, WA  Oakland, CA  LA, CA

Canada-

Vancouver, BC  Mississauga, ON
Thank You
Any Questions?