Case Histories: Biocide Interactions and Development of Microbial Tolerance/Resistance to Biocides in the Paper Making Process

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May 1-4
PaperCon 2011
Northern Kentucky Convention Center

RETHINK PAPER:
Lean and Green

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- Health and Safety
- Biocide Addition
- Biocide Chemical / Environment Incompatibility
- Tolerance / resistance to Biocides
- Maintenance of microbiological control
- MB Control in Paper Coating

HEALTH and SAFETY

- Worker Exposure
  - **Carcinogenicity**
    - **Formaldehyde**
  - **Toxicity**
    - **Spills: Bucket Brigade, Totes**
    - **Leaks: Pumps, Lines, etc**
  - **Corrosiveness**
    - **Burns (Boots)**
  - **Lachrymation/ Irritation**
  - **Sensitization**
    - **Paper Mill employees (isothiazolin, neat chemical)**
  - **Chemical Fumes**
    - **MITC (Paper customer's customer)**
    - **Formaldehyde**
    - **Glutaraldehyde**

BIOCIDE ADDITION

- Addition / Mixing
  - Addition to top of slurry
  - Injection into outlet side of recirculation pump
  - Inadequate mixing
    - Improper blade type/size
    - Inadequate rpm
    - Improper baffle design
    - Improper tank design
    - Absence of recirculation system
- Flocculation
  - pH
  - Non-uniform distribution
    - Untreated slurry
  - Inadequate biocide/pigment contact

BIOCIDE CHEMICAL/ENVIRONMENT INCOMPATIBILITY

- **Biocide – Biocide**
  - **Thione incompatible with**
    - **Glutaraldehyde**
    - **Isothiazolin**
    - **Benzisothiazolin**

- **Biocide – Chemical**
  - **pH (alkaline – isothiazolin, glutaraldehyde)**
  - **Temperature**
  - **Dye**
  - **Protein (primary amines)**
  - **Ammonia (other primary amines)**
  - **Reductants (bisulfite, hydrosulfite)**
  - **Oxidants**
    - **H2O2**
    - **Hypochlorite**
    - **Chlorine**
    - **Chlorine dioxide**

DEVELOPMENT OF TOLERANCE/RESISTANCE TO BIOCIDES (initially effective)

- **Definition**
  - **Tolerance**
  - **Resistance**
- **Causes**
  - **Biofilm (inadequate housekeeping)**
  - **Use of minimal level of biocide(s)**
  - **Use of single biocide**
- **Prevention**
  - **Dual biocide or biocide/oxidant programs**
  - **Alternating biocide programs**
  - **Housekeeping**
- **Examples**
  - **Benzisothiazolin (Screen blinding – e.g, DTBBA)**
  - **Glutaraldehyde (Valerolactone)**
  - **Isothiazolin**
  - **Hydrogen peroxide (Catalase - all aerobic organisms)**
  - **Sodium ortho phenyl phenate**
  - **Bromonitropropanediol**

MAINTENANCE OF MICROBIOLOGICAL CONTROL

- **Frequency (typically inadequate)**
  - **Exponential growth (don't wait until TNTC to treat)**
- **Sampling (typically improper)**
  - **Representative**
  - **Contamination**
    - **Sampling site**
    - **Sampling container**
- **Testing**
  - **Microbial**
    - **Procedures**
    - **Microbial "specs"**
    - **"Challenge" testing**
  - **Chemical**

- **KEY Simultaneous microbial and chemical testing are critical for making treatment decisions.**

COATING PROCESSES

- Coating Preparation
  - MB quality of individual components
    - Knowledge of what biocide(s) the supplier is using (FDA, compatibility)
    - Clay/Carbonate/TiO2 pigments
    - Latex
    - Starch (butyric acid)
    - Protein
    - Water based dyes
    - CMC (other stabilizers)
- Intermediate Coating Storage
- Coating
  - Recycled to/from coater run tanks
  - Dead headed to coater run tanks
- Coater Run Tanks
  - Recycled coating (contaminated)
- Housekeeping / Biofilm (typical source of tolerant/resistant microbes)
- Water Quality
- Closed water systems
- Recovery of Spoiled Coating
  - Odor
  - Color
  - Viscosity

SUMMARY

- **Paper Mill – Supplier relationship**
  - **Agreement**
    - **Biocides (type, level, regulatory)**
    - **Microbial and biocide levels when vessel is unloaded**
    - **Biocide(s) in incoming slurry will not control microbes subsequent to vessel**
- **Paper Mill**
  - **Housekeeping**
    - **Unloading and storage systems (clean frequently)**
    - **Preventing biofilm formation (recontamination, tolerance/resistance development)**
  - **MB control (stored raw materials)**
    - **Frequent sampling / testing for microbes and biocides**
    - **Safe handling**
    - **Facilitate biocide addition and mixing**
  - **Coating**
    - **Raw material MB control**
    - **Biocide addition to coating / coating storage time**
    - **Housekeeping**
    - **Recycled coating MB control**
  - **Water quality**