Controlling Bacteria and Spore in Food Packaging Paper

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Microbiological Related Problems

- Contamination in raw materials
  - High Inoculation of bacteria and spore into the process
  - Fiber Discoloration and Strength

- Contamination in the Process
  - Microbiological fouling / slime
  - Microbiological odor
  - Rapid growth of spore formers
  - Spoilage of coating and additives

- Contamination in finish products
  - High bacterial and spore count in finish paper/board
  - Microbiological Odor in finish paper / board
Dry food-contact requires biocides that are approved in manufacturing if the board is to meet FDA, BfR, and also meet the regulations for the country the board is produced in or where the board is eventually used.

At this point in time, there is no upper limit as far as microbial counts in dry food contact board. However, some mills are producing board with lower counts for marketing purposes to increase sales.
Board used for liquid packaging has special requirements. If the papermaker is meeting “Dairyman’s Standard” the final board must contain less than 250 CFU/gm of board using TAPPI or ASTM test methods.

Testing of the final product for ‘total counts’ can be performed using TAPPI Method 449.
China’s LPB Requirements

- GB 9685 – 2008: Hygienic Standards for uses of additives in food containers and packaging materials
- USFDA 21CFR 176.170 and 176.180
- 2002/72/EC Commission directive relating to plastic materials and articles intended to come into contact with food stuffs (2002/72/EC was already replaced by EU 10/2011)
Controlling Bacteria and Spore Contamination

• Process and operational Control
  - Adjusting physical and chemical parameters that affect microbiological growth; eg pH, temp, dissolved oxygen
  - Reducing stock and water retention time
  - Raw material sorting and screening
  - Tank / chest design

• Proper Housekeeping
  *Machine boilout, washups*

• Biocide Application
  - Proper selection of toxicant agents
  - Proper biocide applications (POA, dosage, frequency, monitoring)
  - Compliance against regulatory requirements

• End Product handling, Storage, and Delivery
  - Contamination from external sources
  - Moisture control
Life Cycle of Spore Forming Bacteria

Vegetative Cells → Cell Growth → Sporulation

Germination → Spore

Factors:
- Temp shock
- pH shock
- Toxicant agent
- Low water

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Life Cycle of Spore Forming Bacteria

Vegetative Cells → Cell Growth → Sporulation

Germination → Spore

KILL

Temp shock, pH shock, Toxicant agent, Low water
Minimizing Bacteria and Spore Contamination in Finish Paper / Board

- End to End Approach
- Detailed mapping of bacteria and spore contamination in all raw materials gives insight to proportional contribution of bacteria and spore contamination in finish product
- Thorough survey of wetend, coating, and additives preparation system and operations
- Effective machine Cleaning between shuts to remove old deposits
- Strict screening on type of biocides used followed by effective implementation and monitoring of biocide program
- Establish effective team work with mill’s production, R&D, and QA department
Case Study in Liquid Packaging Board

Trend of Spore Contamination in Finish Product

- spore content in final product (cfu/g)

Grade: Unbleached LPB 235 gsm
Biocide Program: combination oxidant and non oxidant

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A main purpose of food packaging is to protect and conserve the food’s flavour. If the packaging material itself has any flavour, there will be a substantial risk of unacceptable flavour interactions. Odorous compounds from the packaging material may be transferred to the food and affect the food’s flavour.

Transfer of odorous compound from food packaging to the food can results in consumer dissatisfaction. And serious commercial loss.
Difficulties with Odor problems

• The problem with odour and taste is complicated by the lack of simple and easy-to-use assessment methods.

• Further complications are caused by the fact that the flavour often changes during paper storage. The flavour experienced by the consumers may thus differ from the flavour detected by the mill quality control systems.

• For paper and board used for packaging, there are several potential sources for odors.
Distinctive odor and taints observed in paper and board products

<table>
<thead>
<tr>
<th>Description</th>
<th>Source chemical</th>
</tr>
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<tbody>
<tr>
<td>Green, fruity</td>
<td>Hexanal</td>
</tr>
<tr>
<td>Green, soapy</td>
<td>Heptanal</td>
</tr>
<tr>
<td>Green, rancid</td>
<td>Pentanal</td>
</tr>
<tr>
<td>Fatty, sweet</td>
<td>Decanal</td>
</tr>
<tr>
<td>Rotten fish</td>
<td>Amines <em>heated</em></td>
</tr>
<tr>
<td>Putrid, nauseating</td>
<td>Putrescine, Cadaverine</td>
</tr>
<tr>
<td>Petrochemical, oily</td>
<td>Kerosene, Oil based inks</td>
</tr>
<tr>
<td>Swimming pool</td>
<td>Chlorine, bromine</td>
</tr>
<tr>
<td>Catty</td>
<td>4-methyl-4-mercaptopentan-2-1</td>
</tr>
<tr>
<td>Fishy, sulfur</td>
<td>Methyl isothiocyanate</td>
</tr>
<tr>
<td>Plastic</td>
<td>Styrene</td>
</tr>
<tr>
<td>Synthetic latex</td>
<td>4-phenyl cyclohexene</td>
</tr>
<tr>
<td>Medicinal</td>
<td>Chlorophenols</td>
</tr>
<tr>
<td>Sweet, flowery, spicy</td>
<td>Perfume (recycle)</td>
</tr>
<tr>
<td>Citrus, green</td>
<td>Limonene (cleaning agents)</td>
</tr>
<tr>
<td>Vinegar</td>
<td>Acetic acid</td>
</tr>
<tr>
<td>Swiss cheese</td>
<td>Propionic acid</td>
</tr>
<tr>
<td>Dirty socks, manure</td>
<td>Valeric acid</td>
</tr>
<tr>
<td>Rancid butter</td>
<td>Butyric acid</td>
</tr>
<tr>
<td>Rotten eggs</td>
<td>Hydrogen sulfide</td>
</tr>
<tr>
<td>Dirt, musty, earthy</td>
<td>Geosmin</td>
</tr>
<tr>
<td>Chicken house</td>
<td>2-Methylisoborneol, Chloranisole</td>
</tr>
</tbody>
</table>
Acidic microbial odors (VFA)
- Acetic vinegar
- Butyric rancid butter
- Valeric dirty socks manure
- Propionic Swiss cheese

Miscellaneous microbial odors
- Chloranisoles musty
- 2-methylisoborneol musty
- Geosmin musty
- H₂S rotten eggs at machine & air
- Putrescine putrid, nauseating

Hexanal green, fruity
- Pentanal rancid, green
- Heptanal green, soapy
- Nonanal citrusy, sweet, fruity

Butanal sharp, pungent
- Octanal citrusy, sweet, fruity
- Decanal fatty, sweet

Cleaning agents citrus, green
- Petrochemical Kerosene
- Oil based inks petroleum from printing solvent
- 4-methyl-4-mercaptopentan-2-1 "catty"
- Methyl isothiocyanate fishy, sulfur
- Perfume (recycle) flowery, spicy
- Amines rotting fish

Styrene plastic
- Autooxidized wood resins

Miscellaneous odors
- examples of malodors in paper products
ODOUR CAUSED BY MICROBIAL ACTIVITY

- Heat resistant spores may contaminate the final product, and microorganisms may produce odorous compounds.
- Under anaerobic (zero to low oxygen) condition, certain group of microorganisms capable of producing smelly organic acids (VFA) and H2S in the process, and may also end up in the finish products.
- Higher water closure speeds-up generation of anaerobic condition due to temperature increase, faster nutrient and contamination buildup, and lower ORP.
- Use of recycled water from effluent treatment plant with anaerobic treatment sends VFA and H2S rich water back to process.
- The occurrence of odor problems are often unpredictable, troubleshooting odor are often difficult.
Ways to reduce odour from microbial activity

• Reduce generation of VFA in wetend process by sufficient aeration. Good water circulation, direct aeration, and avoiding stagnant water volumes can easily be implemented.

• Proper stock management in huge chest / towers helps to reduce retention time and flow channelling problems.

• Implementation of good housekeeping practices help to remove deposits where anaerobic microorganisms may hide underneath.

• Effective biocide program are crucial to inhibit growth of anaerobic bacteria. Type of toxicant agent needs to be carefully selected and biocide feed program carefully designed.

• Odor monitoring program in process may include measurement of anaerobic growth, ORP, and total VFA. Odor measurement in process may include the use of odor sensory panel, and VFA / GCMS technique.
Ways to reduce odour from Other Sources

- Maximizing removal of wood extractives helps to reduce the odour problems caused by wood extractives. A combination of thorough pulp washing and fines removal by screening may be beneficial, however hardly acceptable from an environmental point of view. Both pulp washing and fines removal have proven to reduce the odour.

- As certain metal ions have a strong catalytic effect on the odour causing reactions, washing with chelating agents such as EDTA or DTPA is proven to be very efficient. The metal ions lose the catalytic effect when chelated, making the chelating agents beneficial even without subsequent washing.

- Degradation of paper additives are other main cause for paper odour. Sour starch and coating is a familiar problem.

- Some paper additives may be contaminated with compounds having flavour. Thus, sensory testing of the paper additives should be incorporated in the quality control systems.