

## Musty off-odors

**Russell Bazemore, Ph.D.,**  
Chief Scientist, *Volatile Analysis Corporation* – Huntsville, AL - U.S.A.

### Overview

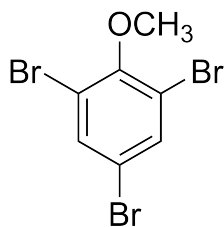
**Earthy, dirty, moldy** are just a few of the aroma descriptors that are collectively known as “**musty**”. These odors leave consumers with a “**spoiled or unclean**” impression (think of a damp basement, or more extreme - a dirty, moldy refrigerator that was unplugged and fermented for a few hot summer days. Musty odors are **very common** in all sorts of packaging materials (paper and corrugated, plastics, and natural cork), foods (aquaculture fish such as catfish and tilapia), beverages (dairy, juices), and even cosmetics. **There are as many different types of chemicals** responsible for



*Musty odor is associated with “spoiled or unclean”*

these foul smells as there are sources responsible for them (both are numerous). Common sources for musty odors are in fact **microbiological** in origin. Many species of fungi, algae, and bacteria produce volatile compounds that smell musty.

**Recently** (and frequently) in the news were recalls associated with plastic containers intended for medicinal products. Consumers reported musty odors emanating from plastic bottles. Some of the chemicals responsible for the odors were reported to be **trichloroanisole** (TCA), and **tribromoanisole** (TBA). Both chemicals have extremely low odor thresholds (sub parts per trillion). To put this in perspective think of one square foot of floor tile on a kitchen floor the size of Indiana, or less than half of a drop of oil in a super tanker containing six million gallons! Both of these compounds are formed via microorganism metabolism of indigenous substrate.



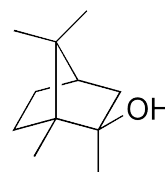
### Tribromoanisole chemical structure

Not so dramatic, but equally problematic, are **eight to eleven carbon containing hydrocarbons, aldehydes and alcohols** such as cis-3-octenal, nonanal, decanal, and undecane and undecene. Fortunately these chemicals have much higher odor thresholds (parts per million). Unlike TCA and TCB, aldehydes (and others) may be produced **either** by microorganisms, **or** they may be introduced via a processing step such as oxidation of a precursor alkene compound (such as octene). One way to distinguish whether or not the chemicals originated from microorganisms or from chemical reaction (oxidation) is by quantity. Frequently **oxidation of polymeric materials** will result in fairly large quantities of odorous compound present in sample headspace. If microorganisms were the cause, there would be less nonanal and more of other known fungal, algal, or bacterial metabolites including possibly **geosmin** or **methylisoborneol** (MIB), along with potentially TCA, TCB. Other odors such as putrid or rancid associated with short chained fatty acids may also be present in cases of microbiological infestation.

Another class of chemicals that may be interpreted as musty includes **terpenes**, naturally occurring chemicals **present in many plants including woody species**, as well as fruits and herbs. **Beta pinene** exhibits different aroma based on the amount present. At lower levels it is musty but at higher levels it is more metallic.

This type of musty is more prevalent in products that contain a high concentration of **virgin paper materials**.

In **aquaculture**, warm waters and bright sunshine are ideal for the growth of **blue-green algae**. Upon algae cell death and decomposition, the chemicals **geosmin** and **MIB** are released into the pond water and absorbed into fish fatty tissue. Like TCA and TBA, geosmin and MIB have very low odor thresholds and this presents a very big problem for catfish and tilapia farmers because tainted fish (contains geosmin and/or MIB) tastes distinctly muddy. Consumers are turned off by this unpleasant taste so a rigid quality control procedure that catches tainted fish is necessary. The value of tainted fish is considerably lower if fish are not sold as human food however if fish are sold for human consumption then the demand may decrease due to poor quality.



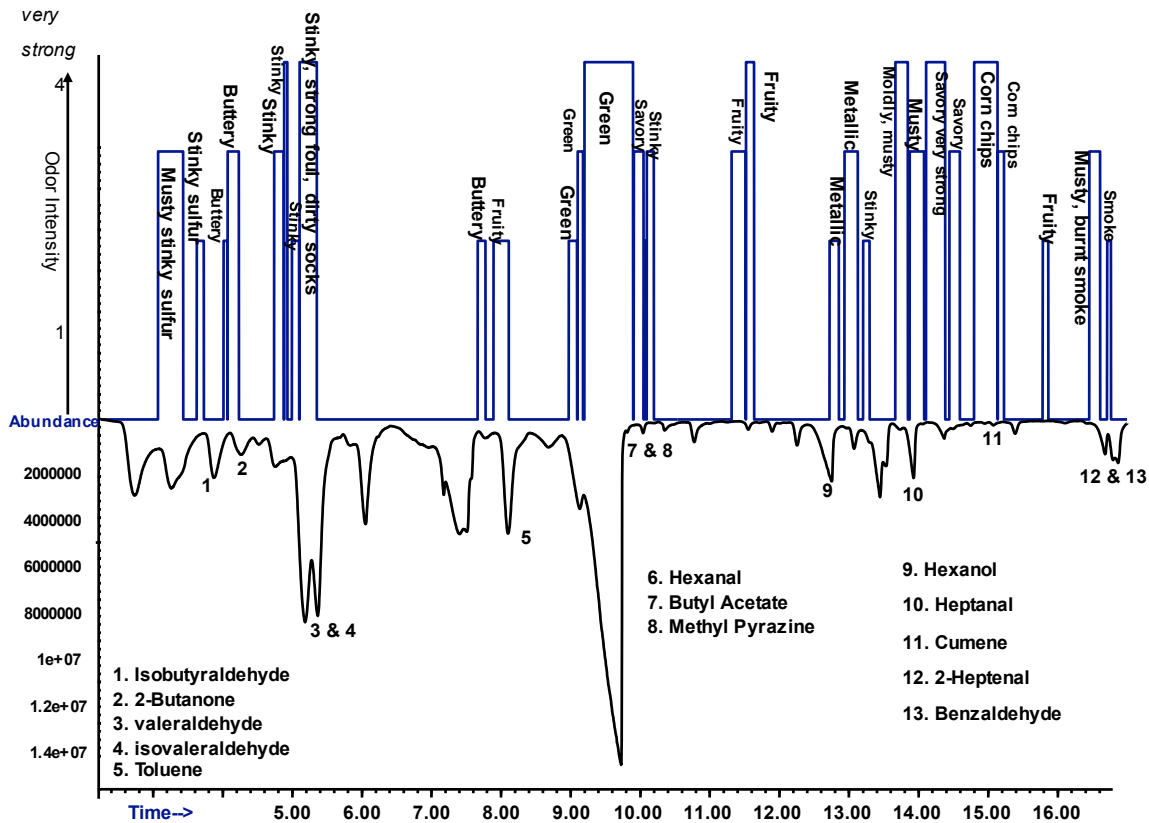
### Methylisoborneol chemical structure

**Dairy products**, particularly milk, generates a musty odor when exposed to UV light. This odor is known as "**light struck**" and depending on severity, it may range from musty to burnt hair or feathers. Similarly, **beer** also develops a musty odor that may be more skunky based on exposure to UV light. One chemical responsible for this odor is **3-methylbut-2-ene-1-thiol**, also known as skunky thiol.

## Odor analysis and identification.

Headspace extraction and gas chromatography mass spectrometric analysis (GC-MS) is the analytical method of choice for analyzing volatile compounds, including those with odor, that originate in a paper, corrugated, plastic, or food product. However due to the plethora of volatile compounds often present, and because the most odorous chemicals may be present at extremely low levels e.g. TCA, MIB, **gas chromatography mass spectrometry/olfactometry (GC-MS/O)** is a better tool and allows for odor screening so that the portions of

a total ion that exhibit odor may be further investigated. This is accomplished by splitting GC column effluent and routing a percentage through a heated tube. Effluent is mixed with humidified air and upon exiting the heated tube, it is sniffed by a trained sensory judge. Odor character (descriptors) and intensities are chromatogram electronically recorded and correlated by retention time with chemical abundances recorded in the total ion chromatogram. A sample "aromagram" is shown below. Please download additional information about GC-MS/O from our website by following this [link](#).



GC-MS/O analysis of sample headspace

---

## Summary

Musty odors are complex and are associated with spoiled or unclean conditions. There are numerous odorants responsible for musty with diverse odor thresholds, and numerous sources including microbiological (fungi, bacteria, algae), natural (trees and plants), and from

chemical reactions (oxidation, reactions associated with UV light). Headspace extraction and GC-MS/O analysis is an effective tool for identifying problem musty odorants.

For a comprehensive analysis of your samples please contact Volatile Analysis or visit us on the web at [www.volatileanalysis.com](http://www.volatileanalysis.com).

**Volatile Analysis Corporation conducts GC-MS/O analysis for clients and we also provide expert training.**

---

### Contact Information:

Volatile Analysis Corporation  
2315 Triana Blvd.  
Huntsville, AL 35805  
[info@volatileanalysis.com](mailto:info@volatileanalysis.com)  
256.489.0168

---

Copyright © Volatile Analysis 2011 All Rights Reserved. No part of this document may be reproduced without written consent from Volatile Analysis Corporation.

---