Diacetyl and Diketones: A Manageable Risk in Coffee Processing

What's the first thing you think of when you hear “Diacetyl”? Most likely “Popcorn Lung” will come to mind. And while that case may have seemed to be an extreme outlier in what might be possible, the core exposure scenarios it raised have not gone away. Further scientific research into the microwave popcorn manufacturing space has led to potential discoveries of exposure pathways in other industries. First on this list is the coffee roasting and processing industry, but respiratory risks could arise in other industries as well.

When considering occupational respiratory illnesses, we don’t often immediately associate flavorings as a prime suspect. Physical substances such as asbestos, metal dusts & fumes, general particulate matter, silica, and even mold spores, are commonly linked to respiratory illnesses in the workplace, especially when considering chronic exposures. However, as more and more studies are conducted, these flavoring chemicals are being linked to lung damages in workers who are exposed to them.

What is Diacetyl?

Diacetyl, is a chemical in a group of volatile chemicals known as alpha-diketones. According to the National Institute for Occupational Safety and Health (NIOSH), alpha diketones can be both manufactured and are naturally occurring. Two common diketones include diacetyl and 2,3-Pentanedione (a common diacetyl substitute). When manufactured, they are used to make flavorings that are added to food products such as buttered microwave popcorn, bakery mixes, and flavored coffees. Additionally, diacetyl has made its way into e-cigarette liquid. These diketones are also found naturally in coffee beans, and are released during the roasting process due to the addition of the heat source as well as during grinding. The grinding process may increase the off-gassing of the diketones, due to a larger available surface area. Two other diketones, including 2,3-hexanedione and 2,3-heptanedione, have not been studied, but are believed to cause similar damages.
In general, the diketones are extremely volatile, and readily evaporate into the air from either a liquid or solid form. Additionally, if dusts are formed, for example in the coffee grinding process, the diketones can be inhaled in a powder form. This presents an exposure challenge as employees must be protected from both the gaseous and solid phase forms of the chemicals. Since these chemicals are volatile, it generally means that the closer in proximity you are to the off-gassing source, the higher the potential concentration you may be exposed to. However, in facilities where ventilation is poor, or there are numerous operations ongoing, potential exposures can occur further away from the source.

**Health Effect Studies**

Exposure to diacetyl has been linked to a respiratory illness known as Obliterative bronchiolitis, which is an irreversible form of lung disease in which the bronchioles of the lung become scarred and constricted. When these small airways of the lung become damaged, it limits lung function, which can be best identified by pulmonary function testing, also known as spirometry. NIOSH conducted a study (health hazard evaluation) in 2015 where several workers in a coffee processing facility were diagnosed with Obliterative bronchiolitis. NIOSH found elevated levels of diacetyl and 2,3-pentanedione in the air and linked these levels to three possible on-site sources including: the flavoring area where flavoring chemicals were added to roasted coffee, the grinding and packaging area of unflavored coffee, and the storage hopper area for roasted coffee. NIOSH found that current workers were experiencing shortness of breath and obstruction on spirometry (meaning air is exhaled slower than normal), which was consistent with undiagnosed lung disease.

A peer-reviewed NIOSH publication documents that acute inhalation exposures to 2,3-pentanedione causes airway epithelial damage that is similar to diacetyl in laboratory studies. Early data suggests that diacetyl can cause central nervous system changes similar to those caused by 2,3-pentanedione. These publications raise concerns that the toxicological effects of diacetyl may be shared across all alpha-diketones, meaning that the focus should not be placed on diacetyl alone, but rather the group as a whole.

Currently, the Occupational Safety and Health Administration (OSHA), does not have a set permissible exposure limit (PEL) for diacetyl or its substitutes, however they have realized the potential hazard, and have recommended employers implement safety measures to prevent worker exposures. Based on their current research, NIOSH has recommended a proposed exposure limit of 5 parts per billion (ppb) for diacetyl, and 9.3 ppb for 2,3-pentanedione, as 8-hour Time Weighted Averages (TWA), based on a 40 hour workweek. Additionally, NIOSH recommended a 15-minute short term exposure limit (STEL) of 25 ppb for diacetyl and 31 ppb for 2,3-pentanedione.

In order to minimize occupational exposures, NIOSH recommends the standard hierarchy of controls be implemented by employers. These controls include:

1. **Substitution** – utilizing less toxic materials
2. **Engineering Controls** – this would include isolation, local exhaust ventilation or closed systems. NIOSH conducted a three year evaluation of exposure controls at a microwave popcorn facility, including engineering controls, which showed that they greatly reduced airborne concentrations of flavoring chemicals.
3. **Administrative Controls** – includes worker rotation to reduce exposure times and good housekeeping
4. **Personal Protective Equipment** – always last on the hierarchy of controls, personal protective equipment such as respiratory protection can be provided to employees to reduce exposures. Respiratory protection, if used, would need to protect against both gas and particulate phases.

Additional controls would include employee training as to the hazards of the flavoring compounds, PPE training, and a worker exposure assessment program which evaluates exposure levels over the various processes (i.e. grinding, flavoring, roasting, etc.) as well as medical monitoring (spirometry).

**What It Means for You: Expanded Risks and Best Practices**

Butter popcorn manufacturers and coffee roasting facilities are not the only locations where workers may be exposed to alpha-diketones. These compounds are also used in flavorings within the snack food industry as well as commercial bakeries, retail baking mix production, candy manufacturers, margarine and other vegetable oil-based cooking products, and butter/dairy products. IV

Based on their widespread usage, it is likely that the number of worker illness cases related to these flavorings will increase over time, which may ultimately result in litigation and insurance claims. These claims may be against the workplace, particularly if there were contract workers; but third-party claims are also likely against the various flavoring or compounding companies who supplied the allegedly causative ingredients to the facility. V

**Following the hierarchy of controls** of industrial hygiene has been a proven recipe for reducing worker exposures to many previous chemicals known to be hazardous to workers. While there have been no regulatory exposure limits issued as of yet by OSHA, NIOSH has proposed exposure limits for diacetyl and 2,3-pentanedione. NIOSH has proven through its research that engineering controls are an effective means to reducing worker exposures to these flavoring chemicals. If engineering controls cannot be implemented, substitution, administrative controls, and personal protective equipment are also effective at reducing employee exposures.

**Conclusion**

As research into the health effects and operations where flavoring chemicals including diacetyl, 2,3-pentanedione, and other alpha-diketones are used, employers are cautioned to exhibit safe work practices to prevent worker exposures. While in numerous instances workers are exposed to numerous potential contaminants in the workplace besides alpha-diketones, NIOSH research continues to draw links between exposure to these flavoring chemicals and irreversible lung disease. Discuss the issue with your worker safety and risk management teams, and reach out to your partners at AIG’s Client Risk Solutions for help.

**For more information, please visit:**

- The National Institute for Occupational Safety and Health: https://www.cdc.niosh.gov/niosh/index.htm
- Occupational Safety and Health Administration: www.OSHA.gov

**AIG’s Client Risk Solutions stands ready to help your institution manage risk.**

- For inquiries, contact CRS@aig.com
- For more solutions from AIG please visit Client Risk Solutions at www.aig.com/crs
References

i NIOSH-CDC: Coffee Workers at Risk for Lung Disease (https://blogs.cdc.gov/niosh-science-blog/2016/01/25/coffee-workers/)


iii NIOSH-CDC: Flavorings-Related Lung Disease, Exposure Control (https://www.cdc.gov/niosh/topics/flavorings/control.html)


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