BEER OFF FLAVOR:
SULFUR DIOXIDE (SO_2)

Sulfur dioxide (SO_2), also called by the collective name "sulfites", is a byproduct of beer fermentation and is therefore naturally occurring in beer. At low levels this compound is considered beneficial to the overall flavor and aroma profile of beer; however, at higher concentrations it is considered an off flavor. It is used in the wine industry as an antimicrobial and antioxidant and has similar effects in beer. Through the management of yeast health, oxygenation, and lipid concentrations, brewers can control levels of SO_2 in their products.

HOW DOES SULFUR DIOXIDE SMELL OR TASTE?

SO_2 plays a crucial role in the chemical reaction that occurs when a match is ignited. Consequently, it is understandable that we refer to SO_2 as "burnt match" or "struck match" when it is detected in beer as an off flavor at elevated levels. Other descriptors compare SO_2 to the aroma of "young white wine".

HOW IS SULFUR DIOXIDE MEASURED?

There are multiple methods for testing SO_2 that have unique pros and cons. The Monier-Williams method, also called the aeration/oxidation method, and the *p*-rosaniline method, a spectrophotometric method, are two options. Unfortunately, the Monier-Williams method is not accurate at the concentrations seen in beer, and the *p*-rosaniline method, while validated in beer by the American Society of Brewing Chemists (ASBC), utilizes multiple highly hazardous reagents which raise safety concerns for its implementation. Other methods utilizing chromatography and segmented flow analysis are available but are typically less accessible to brewers due to the advanced equipment needs and associated costs. More affordable test strips can be found online; however, this method has the lowest accuracy and resolution. Brewers will most typically work with a third-party lab to perform quantitative SO_2 testing.

When quantifying sulfites, it is important to understand that sulfur dioxide exists in three forms when dissolved in a solution depending on the solution pH: molecular sulfur dioxide (SO_2), bisulfite (HSO_3^-), and sulfite (SO_3^{2-}). In the pH range of beer, the most common form found is bisulfite. With these varying forms, SO_2 can be measured as either free, bound, or total, and therefore, the method used should be chosen appropriately.

HOW IS SULFUR DIOXIDE PRODUCED IN BEER FERMENTATION?

SO_2 is a byproduct of primary fermentation and is an intermediary of the biosynthesis of sulfur containing amino acids. Primarily, sulfate is converted into sulfite, then sulfide, which is then synthesized into methionine and cysteine. Generally speaking, lager yeasts will produce higher concentrations of SO_2 than ale yeasts.

SO_2 serves dual roles as an antimicrobial and an antioxidant, depending on its specific form. In terms of flavor stability, it plays a vital role by binding to carbonyl byproducts resulting from Maillard reactions. These bonds form non-volatile SO_2^-carbonyl complexes that effectively mask the stale flavors that would otherwise be contributed by the carbonyl compounds. This important reaction has led to the utilization of SO_2 as an additive in both the wine and beer industries, aiding in the preservation of flavor stability. Furthermore, SO_2 exhibits antimicrobial properties, particularly against gram-negative bacteria. Over time, as various reactions take place with other components in beer, the concentration of SO_2 gradually decreases.

Sulfate
↓
Sulfite
↓
Sulfide
↓
Sulfur containing amino acid
(methionine, cysteine)

WHEN DOES SULFUR DIOXIDE BECOME AN OFF FLAVOR?

Due to its natural production by yeast, sulfur dioxide is inherently found in almost all beers, albeit at varying levels, and it is only regarded as an off flavor when it surpasses the sensory threshold of 10 mg/L (ppm).

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HOW IS SULFUR DIOXIDE REGULATED?

Due to the sensitivity of certain consumers, SO_2 is classified as an allergen, as it can elicit adverse reactions in some individuals. In the context of beer and other beverages, the concentration of SO_2 is subject to legal regulations. Any product containing more than 10 ppm of total SO_2 must be appropriately labeled as "containing sulfites." Additionally, in the European Union and several other countries, there is a legally stipulated maximum concentration of 20 ppm for SO_2 in beer. This regulation highlights the significance of accurately measuring and monitoring this parameter to ensure compliance and consumer safety.

HOW IS SULFUR DIOXIDE CONTROLLED IN THE BREWERY?

The production of SO_2 by yeast is influenced by various factors, such as pitching rate, fermentation temperature, wort pH, starting gravity, trub content, and aeration. To effectively manage SO_2 levels, it is crucial to prioritize normal and healthy fermentation and maturation conditions. Maintaining optimal yeast health is essential, as poor yeast health can elevate SO_2 production. Moreover, achieving optimized levels of lipids and oxygen can help decrease SO_2 levels. Another key consideration is the selection of yeast strains, as different strains have varying capabilities to produce SO_2. Below are some general recommendations to help maintain concentrations below sensory threshold.

Do:

- ❏ Thoroughly remove trub
- ❏ Transfer finished beer off yeast to reduce autolysis
- ❏ Oxygenate wort appropriately with sterile air or pure oxygen
- ❏ Pitch sufficient viable and vital yeast according to starting gravity
- ❏ Sufficient back pressure and taller fill heights will suppress SO_2 formation

Avoid:

- ❏ Under-oxygenating wort
- ❏ High gravity brewing (>16°P)
- ❏ Extended warm temperature maturation
- ❏ Leaving non-viable yeast in maturation phase for extended periods of time

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