1/26/2012

How FreshAWL® Solutions Work

The use of FreshAWL products usually results in the question, "How does it work?" The intent of this communique is designed to provide help in understanding of how the products function without giving away their recipe.

1. The FreshAWL WOW-Air™ molecule **initiates** an <u>Organic Imine</u> bonding with hydrogen sulfide (H_2S), see Figure 1:

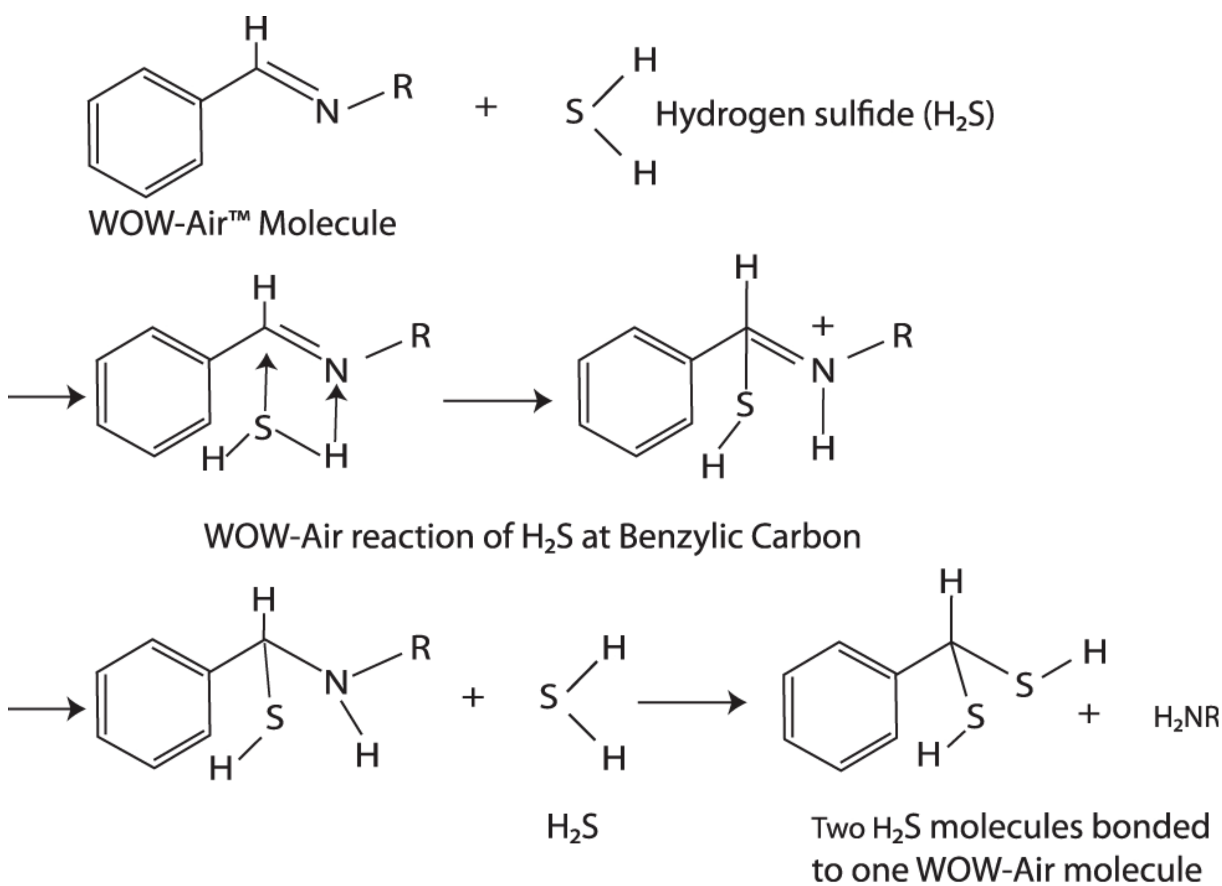

Figure 1 WOW-Air – Organic Imine bonding with H_2S

   a. The C=N bond is the most attractive site for bonding with sulfur (S) atoms
   b. In the book, <u>The Chemistry of Organic Sulfur Compounds</u>, the author specifically states that "**the interaction between sulfur and the π orbitals of the C=N links is far greater than anything that occurs with oxygen or nitrogen substituents**"
   c. The C=N bond is far less reactive to organics than amines or the C=O bond
   d. The sulfur d-orbitals interact with the double bond

Literature sources show that the benzylic carbon can react and couple with H_2S producing a thiobenzaldehyde or a thioacetal. This chemical reaction would occur in a molar ratio of one-to-one or one-to-two. This is the preferred pathway for the WOW-Air and H_2S reaction.

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2. Chemical reactions can also occur with the aromatic ring allowing reversible substitution, either electrophilic or nucleophilic.
    a. In nucleophilic substitution, see Figure 2:

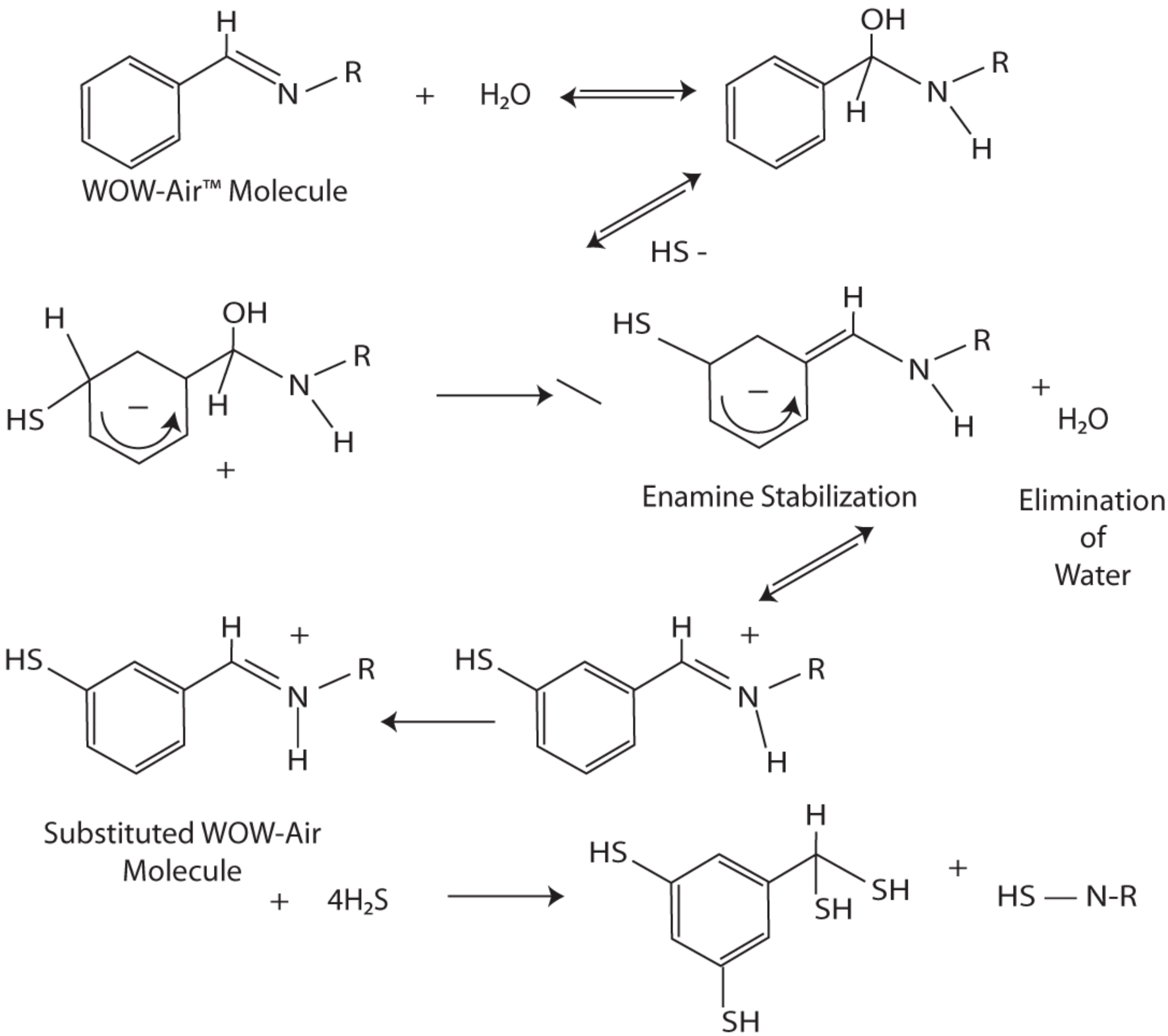

Figure 2, Nucleophilic Substitution

        i. The empty nitrogen orbital can expand its bonding capability to allow enamine stabilization to help use the ring structure lock up sulfide molecules.
        ii. WOW-Air reacts with mercaptans creating disulfides and other low odor chemicals.
        iii. Results have shown that one WOW-Air molecule can remove up to 6.8 molecules of H_2S in gas streams as demonstrated in a plant test with very high concentration levels of H_2S.
    b. Catalytic oxidation/reduction of the ethanolic tail end of the molecule occurs in aerobic conditions that will scrub up to 240 molecules of H_2S for each WOW-Air molecule, see Figure 3:

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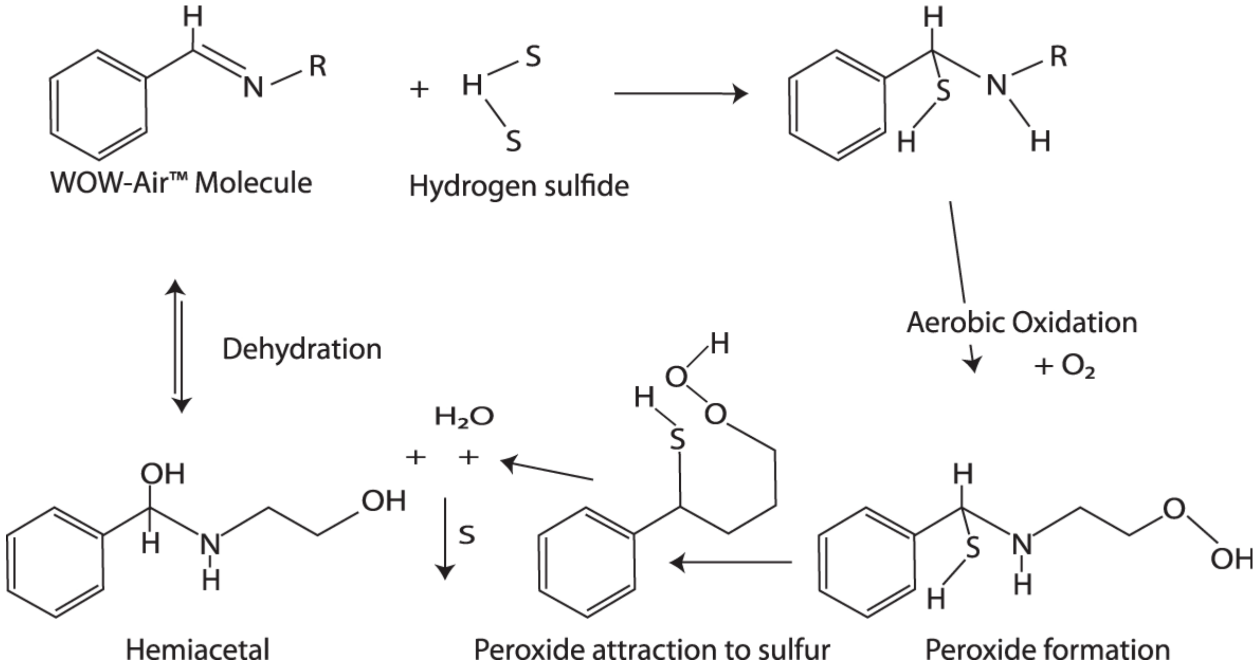

Figure 3, FreshAWL WOW-Air Aerobic Catalysis

3. The literature also supports that the unusually large amount of H_2S removed by WOW-Air in aerobic environments can also be explained by enzymatic reduction of the aromatic imine to create free radicals that contain an extra electron.
    a. Once formed, the free radicals react with oxygen to produce superoxides and then regenerate the unchanged imine compound.
    b. These superoxides (dissolved radical oxygen molecules) may be the source of increased oxygen observed in aerobic systems.
    c. These superoxides can also participate in oxidizing H_2S molecules in situo or by themselves.
    d. This process is described by enzymatic futile cycling, and has been observed in proceedings from the National Academy of Sciences.
4. Other literature states that intermolecular peroxide formation can encourage a catalytic process involving oxidation of a complexed culfide group – as quoted:

    "**They reveal that this oxygen exchange commonly proceeds in concert with hydrogen exchange within an inter- or intra-molecular peroxy complex during interaction with the sulfide.**" Organic Sulfur Compounds, p 229. N-alkyl aromatic amines in combination with base also have a catalytic effect on the air oxidation of thiols to disulfides. A free radical chain process introduces oxygen into the sulfide at a position alpha to the sulfur atom, **and then several secondary and in part competitive reactions, which are broadly definable, rapidly ensue to yield a complex product mixture.**
5. Similar literature states that the chemical reagents necessary to create the oxidation or the peroxide type radical only require aeration group – as quoted:

    "**The oxidation can be brought about by mild reagents such as air or oxygen** or chemical reagents – **more vigorous conditions can convert the disulfide into** more highly oxidized products . . ."
6. This phenomenon has been documented that ethanolic groups in oxygenated solutions like aerobic digestors can be oxidized to the corresponding peroxide compounds in small quantities. This peroxide can oxidize sulfur molecules trapped at the nucleophilic carbon due to their proximity to the ethanolic

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tail. The ethanolic side chain stabilizes and encourages Sulfur/Oxygen interaction by hydrogen bond coupling. Physical models of these molecules show that the bond distances of the ethanolic side chain are the perfect distance for hydrogen bonding of the sulfur atom trapped at the nucleophilic carbon and:

   a. Does not form a salt
   b. Is not an oxidizer
   c. Produces sulfur compounds that revert to elemental sulfur in anaerobic digestors
   d. Is similar to other aldehydes but does not kill bacteria and has no hazards
   e. Is safer to use as it has no chemical hazards
   f. **Is NOT Corrosive** – it prevents corrosion (see attached test results)

7. Fogging of the FreshAWL molecule at 500-3,000 ppm will remove H_2S from headspaces in manholes, lift stations and headworks.
8. Vapor density of the compound is 2.75 times that of air – heavier than carbon dioxide. It therefore holds odors out of the breathing zone and close to the floor.
9. Degradation molar levels:
   a. WOW-Air Molecule + H2S will produce 7 CO_2 + 2 CH_4+1 NH_3 + H_2O + 1S.
   b. 3 gallons of 15% WOW-Air per million gallons of wastewater gives a mass balance prior to treatment of 2.3 CO2, 1.69 lbs. of methane, 0.9 lbs. of ammonia, 5.7 lbs. of water and 1.69 lbs. of sulfur.
   c. FreshAWL WOW-Air and Z-FOG™ products remove most odors, but would contribute about 2lbs. of solids (TS) per million gallons of water treated.
10. FreshAWL removes most odors, contributing only a mild cherry-like aroma.
11. Total Kjeldahl Nitrogen (TKN) for the FreshAWL molecule is 0.7 lbs. nitrogen per million gallons of wastewater treated.

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