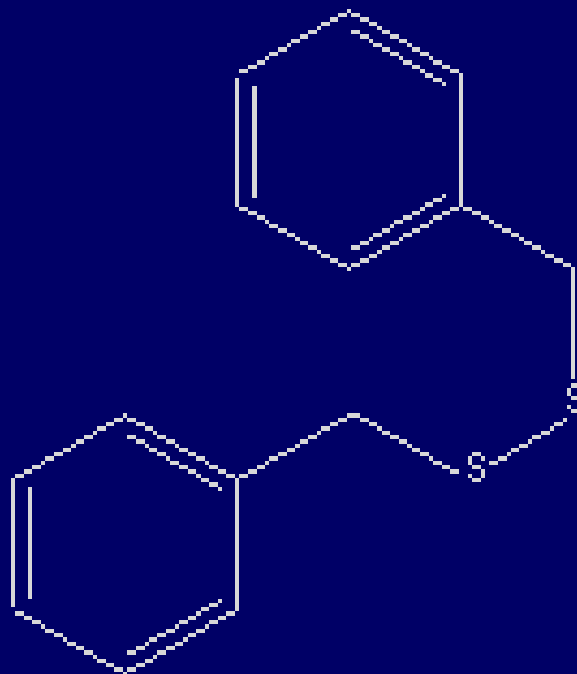


# DSI Sulfur Inhibitor:

How A  
Multi-Directional  
Approach Can Stop  
Corrosive Sulfur in  
Transformer Oil

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# Corrosive Sulfur problems threaten service disruptions and financial loss



**Power Transformer Winding Damage**

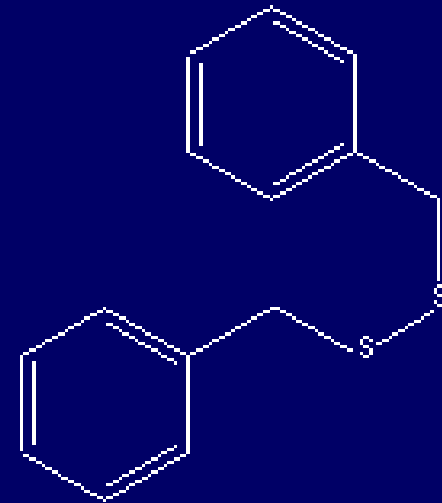
Sulfur occurs naturally in transformer oils. Several types of sulfur can combine with dissolved metals in the oil – usually copper. The resulting metal-sulfur salts form deposits in cellulose insulation, eventually causing dielectric breakdown.



**Corrosive  
Sulfur  
Damage**

Research has shown that there are several types of sulfur involved, but dibenzo-disulfide (DBDS) is one of the most aggressive

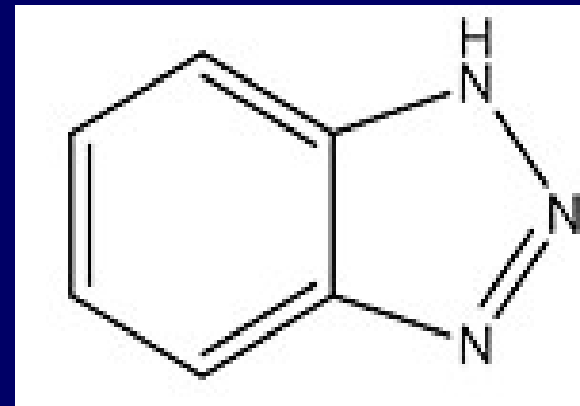
## Dibenzyl Disulfide



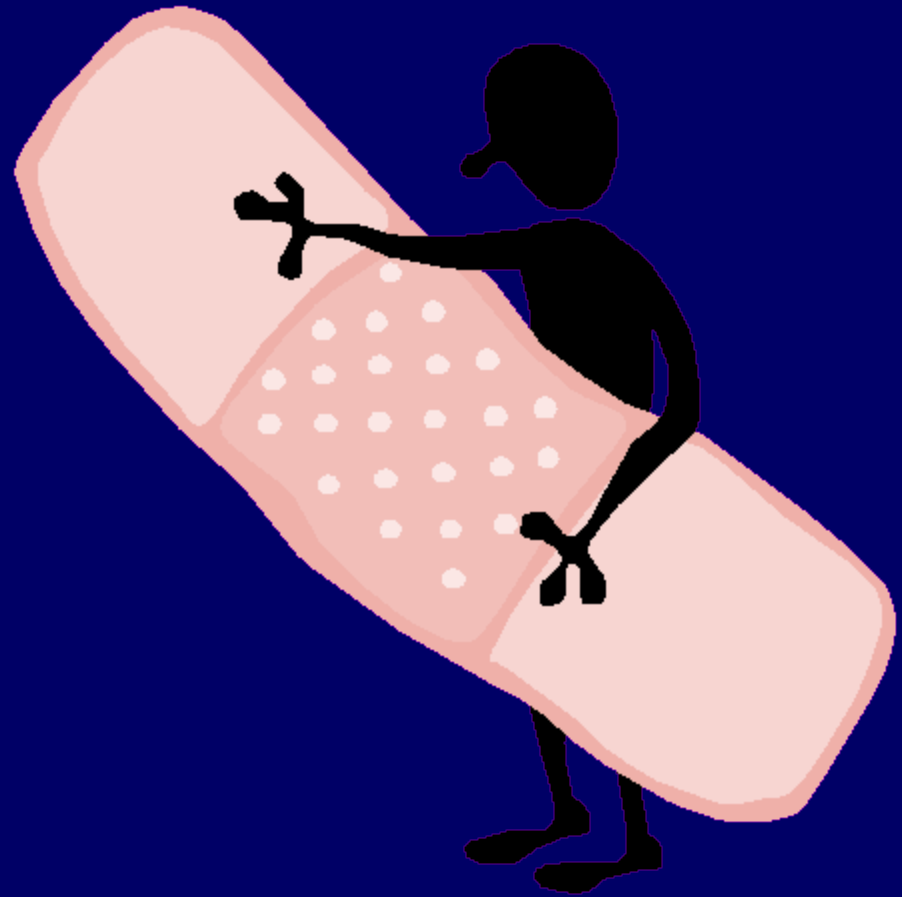
The traditional method of treating this problem: “Copper Passivators”

Copper passivators form a protective layer on copper surfaces to prevent  $\text{Cu}^+$  ions from reacting with sulfur.

Benzotriazole:  
the most commonly  
used copper passivator



However, simply adding a metal passivator is a “One Size Fits All”, “Band-aid” approach that doesn’t solve the problem.



# So why doesn't a Copper Passivator Solve the Problem of Corrosive Sulfur?

Stopping “Corrosive Sulfur” (metal-sulfur salt deposits) in a transformer is more than just passivating the copper surfaces. It requires a comprehensive approach, for three reasons.

First - There are many different copper alloys present in every transformer.





We know that each copper alloy reacts differently to different passivators:

Passivator

Type of Copper

Benzotriazole

*Brasses*

*Bronzes*

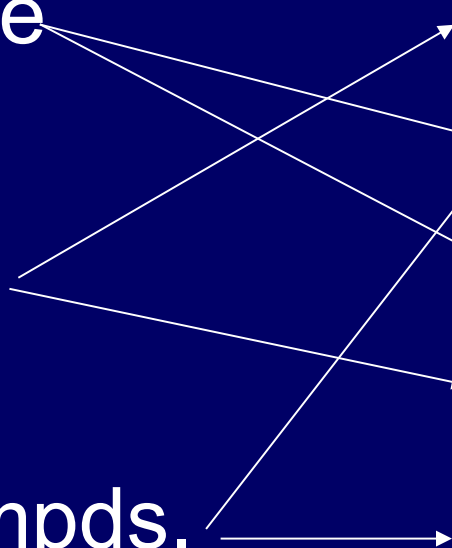
Tolyltriazole

*Wire copper*

*Buss bar copper*

Tetrazole Cmpds.

*Other Cu types*



A mixture of metal passivators is needed to protect the different types of copper present in a transformer.



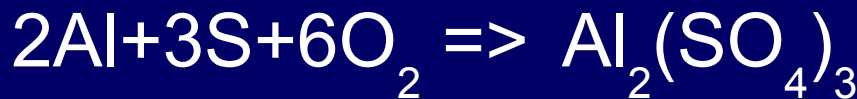
Second,  
research has  
shown that  
copper is not the  
only problem.

Dibenzo disulfide  
combines with all of  
the different metals in  
a transformer, not just  
copper.



In addition to copper, other metals in a transformer are reactive, too.

Iron, aluminum, zinc, nickel, and magnesium also dissolve in oil and combine with sulfur, causing sulfur salts and problems for your transformer:



These other metals respond poorly to copper passivators, if at all.

Therefore, simply adding a copper passivator doesn't stop metal-sulfur salt deposits.

# Third: Oxidation

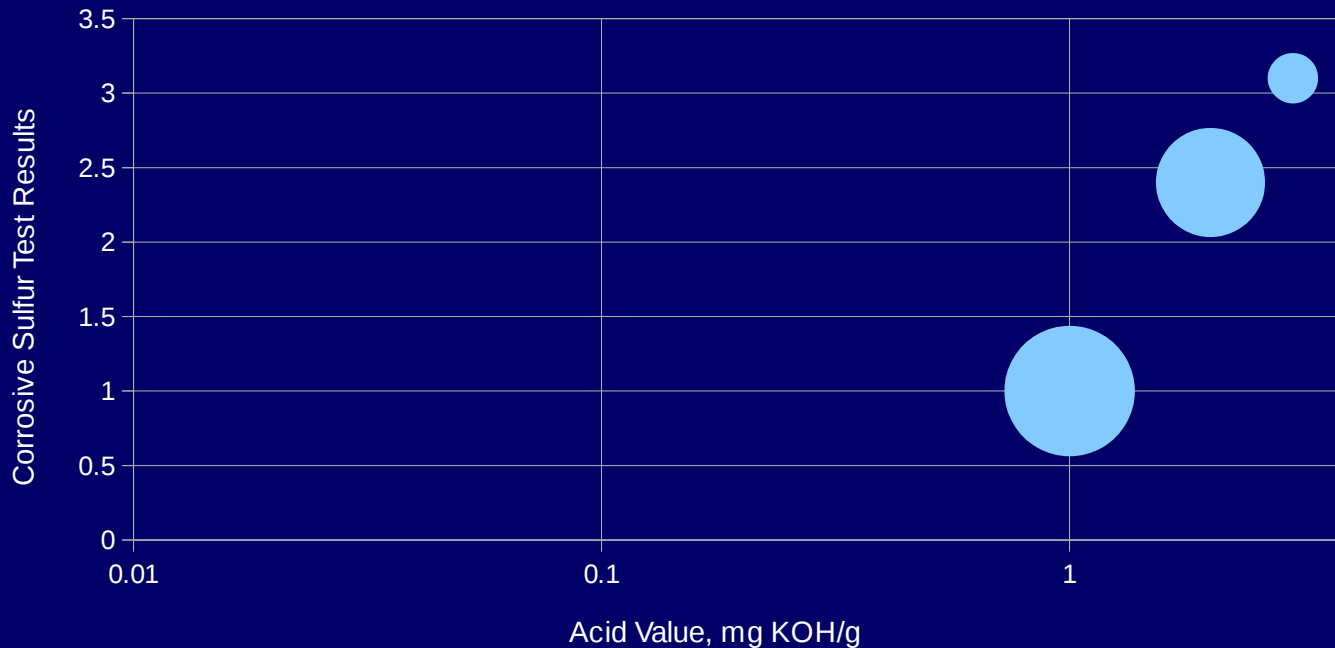
Research and field tests show a correlation between oxidation stability and corrosive sulfur problems (1,2)

“The Role of Corrosive Sulfur in Transformers and Transformer Oil” - L. Lewand, Doble Engineering

“Corrosive Sulfur in Transformer Oil” - Siemens Technical Bulletin

# Transformers with sulfur-metal salt deposits tend to have oils with weak oxidation stability

Correlation Between Corrosive Sulfur and Oxidation Stability



Simple copper passivators don't address the relationship between oxidation and metal-sulfur deposits.

Copper passivators do not protect oil from oxidation.



DSI's Sulfur Inhibitor uses a multi-directional approach to stop sulfur problems and protect transformers.



# DSI Sulfur Inhibit works in three ways:

- 1) A blend of several metal passivators protects all types of copper in the transformer.
- 2) Chemical reactions change corrosive sulfur (DBDS) into non-corrosive types.
- 3) A mixture of powerful antioxidants stops the oxidation-sulfur reaction link.

DSI Sulfur Inhibitor is the only product that does all this!

First:  
DSI Sulfur Inhibitor  
has a mixture of  
copper passivators  
to treat all copper  
alloys.

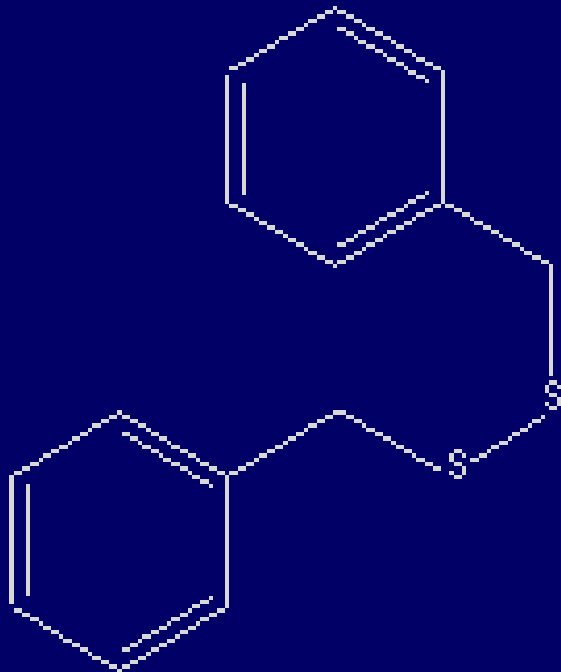


Second:

DSI Sulfur Inhibitor has chemical additives that react with corrosive sulfur and change the molecular structure to non-aggressive types.



When added to a corrosive oil,  
DSI Sulfur Inhibitor can reduce  
the concentration of Dibenzo  
Disulfide by more than 25%! <sup>3</sup>



Sulfur Inhibitor changes  
DBDS to a non-corrosive  
type of sulfur

Third:

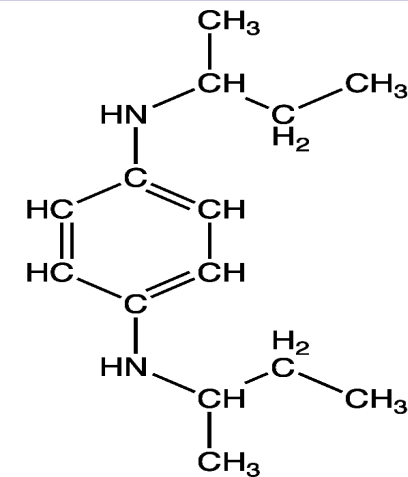
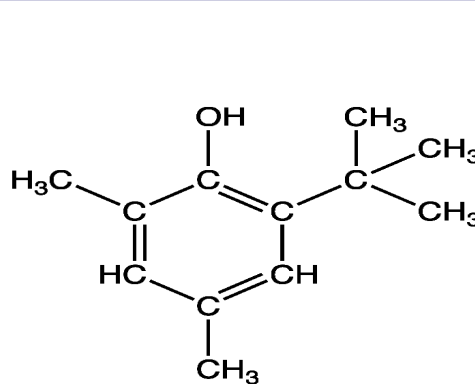
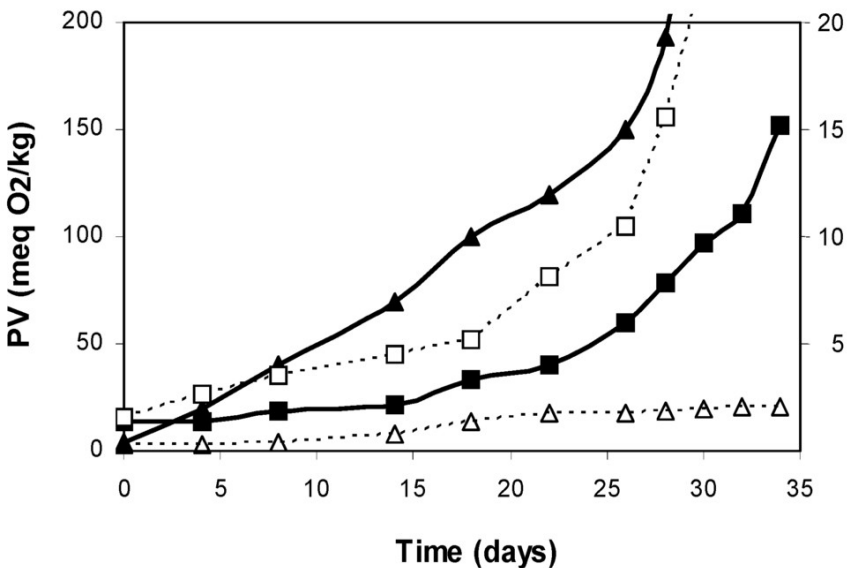
DSI Sulfur  
Inhibitor has a  
Powerful Blend of  
Antioxidants to  
slow oxidation in  
paper and oil



DSI Sulfur Inhibitor attacks the link between corrosive sulfur and the oil's oxidation stability. No other product does this.



# DSI Sulfur Inhibit stops oxidation in its tracks.



- ▲— PV SO w/o AOX
- POL SO w/o AOX
- △··· PV TO w/o AOX
- POL TO w/o AOX



# DSI Sulfur Inhibitor Works!

Lab tests on corrosive oil treated with DSI Sulfur Inhibitor show a reduction in dibenzyl disulfide (average = 26%)

DSI Sulfur Inhibitor has protected hundreds of transformers since 2005, with many repeat customers!

All corrosive oils that have been treated were turned non-corrosive.

# Field Test Results on Sulfur Inhibit additive mixture show:

No Long-term problems found  
with material compatibility –  
paper, oil, plastics, conductors,  
etc.

# Summary:

Corrosive Sulfur problems cannot be solved by simply adding a copper passivator.

- A copper passivator doesn't treat all of the different types of copper available in a transformer
- Copper passivators don't protect other types of metals present
- Copper passivators don't change the aggressive sulfur compounds to noncorrosive ones
- Copper passivators don't address the link between sulfur corrosion and oxidation stability.

DSI's  
Sulfur Inhibitor  
Solves the  
Corrosive Sulfur  
problem.

Protect all coppers  
and all other metals

Stop Oxidation of oil  
and paper

Change corrosive  
sulfurs to non-  
corrosive types

## References:

“The Role of Corrosive Sulfur in Transformers and Transformer Oil” - L. Lewand, Doble Engineering

“Corrosive Sulfur in Transformer Oil” - Siemens Technical Bulletin

“Dibenzyl disulfide (DBDS) as corrosive sulfur Contaminant in used and unused mineral insulating oils” Riccardo Maina, Sea Marconi Technologies

TJH2B Laboratory Reports 11585543 – 1158555, October 20, 2006, TJH2B Laboratories.

“Influence of Corrosive Sulfur on the Worldwide Population of Power Transformers” L. Lewand, Doble Engineering - ENDESA/CIGRE Conference, Santiago, Chile, August 12, 2009

“Understanding the Presence of Corrosive Sulfur in Previously Non-Corrosive Oils Following Regeneration” Mats Dahlund, et al, Doble Client Conference, 2010

DSI's  
Sulfur Inhibitor is a  
proven solution to  
corrosive sulfur  
problems in  
transformers.

Sold since 2005, now  
protecting hundreds  
of transformers  
worldwide.

Proven in laboratory  
and field studies.

Every treated oil was  
changed to  
noncorrosive status.

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