New N-nitrosodimethylamine (NDMA) precursors that react with ozone: Implications for water reuse

Erica Marti1,2, Dr. Aleks N. Pisarenko3, Dr. Eric R. V. Dickenson2
Advised by Dr. Jacimaria Batista1
1Dept. of Civil and Environ. Eng. and Construction, Univ. of Nevada Las Vegas, 2 Southern Nevada Water Authority, 3 Trussell Technologies

Key Terms

DBP = Disinfection Byproduct
An unintentional product resulting from a disinfection process

Nitrosamines
A class of compounds containing an amine group with various substituents (e.g., methyl, ethyl, phenyl) and a nitroso group

Introduction

Nitrosamines are a toxic class of disinfection byproducts commonly associated with chlorination, but recent studies indicate that direct formation during ozonation is a possible pathway. Six nitrosamines are listed in U.S. EPA’s Unregulated Contaminant Monitoring Rule 2, several nitrosamines are included on the most recent U.S. EPA Contaminant Candidate List, and the California Department of Public Health (CDPH) has already established drinking water notification levels of 10 ng/L for N-nitrosodimethylamine (NDMA), N-nitrosodiethylamine, and N-nitrosodi-propylamine.

Research Issue

Initial Question:
What compounds (precursors) are in wastewater that react with ozone to form NDMA?

Hypothesis:
Research suggests that compounds with the N-N-(CH3)2 building block will form NDMA.

Choosing Precursors to Test:

<table>
<thead>
<tr>
<th>Name</th>
<th>Structure</th>
<th>Yield</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3-Dimethylhydrazine (UDMH)</td>
<td><img src="image1" alt="Structure" /></td>
<td>80%</td>
<td>1</td>
</tr>
<tr>
<td>Dimethylamine</td>
<td><img src="image2" alt="Structure" /></td>
<td>55%</td>
<td>1</td>
</tr>
<tr>
<td>TMDS</td>
<td><img src="image3" alt="Structure" /></td>
<td>27%</td>
<td>2</td>
</tr>
<tr>
<td>Dimethylsulfamide (DMS)</td>
<td><img src="image4" alt="Structure" /></td>
<td>52%</td>
<td>1</td>
</tr>
<tr>
<td>Methylene blue (and other dyes)</td>
<td><img src="image5" alt="Structure" /></td>
<td>[8.3 x 10^{-10}]</td>
<td>3</td>
</tr>
</tbody>
</table>

Methodology

Ozonation of dimethylamine N-(CH3)2

forms an aldehyde as the major product

Results

Conclusions & Implications

- Molar Yields vary
  - Structural differences play a role
- Low NDMA formation with chloramination
- Different group of precursors for ozone
- Increased formation in wastewater
  - Constituents that cause this?
- Ozone for water reuse is a concern
  - Mitigation and/or prevention

Future Work

- Investigate wastewater constituents to isolate the cause of increased formation
- Identification of precursors in wastewater influent
- Investigate reaction kinetics and transformation products

Acknowledgements

Funding: Water Research Foundation, WaterReuse 12-01; Research and Analytical Support: SNWA Personnel; Conference Travel: Graduate & Professional Student Association at UNLV

Figure 1: Example nitrosamine compounds

Figure 2: Representation of the disinfection process and formation of disinfection byproducts

Figure 3: Water reuse treatment processes: a) "gold standard" and b) ozonation

Figure 4: Strategy for determining potential NDMA precursors

Figure 5: Experimental Design and Analysis by LC-MS/MS

Figure 6: Molar Yield for Precursors in Deionized Water

Figure 7: Molar Yield for Precursors in Wastewater

*Target compounds at 100 uM, ozone spiked at 1 mM (10 fold excess), pH 7