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Part III: Chemical Exposure from Manufactured Gas Plants: Naphthalene?

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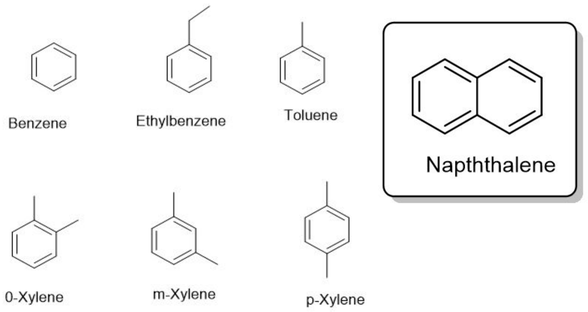
ABSTRACT

In the previous parts of this research, we studied the historical, sociological, and public policy impact of the former manufactured gas plant site at Gowanus. Gowanus Canal is heavily contaminated with coal tar and was found to be a concern of public health risk from chemical exposure to naphthalene, benzene, toluene, ethylbenzene, and xylene pollutants on former Manufactured Gas Plant (MGP) sites when developed. We studied all these chemicals and their risks to the public around the site. We concluded that Naphthalene is a toxic chemical and has carcinogenic properties. In the present study, with an emphasis on the Chemistry and the metabolic processes, we found that the chemical is not directly harmful. It is the various metabolites of Naphthalene which, in vivo, lead to the observed toxicity. All the chemicals found under the former MGP site we studied are aromatic compounds. Our primary focus for this research is the chemistry and the metabolic processes of Naphthalene. This research may lead to a better understanding of the toxicity of aromatic compounds.



MATERIALS AND METHODS

-Extensive Literature Research Conducted on Naphthalene
-Critical Understanding of Organic Chemistry and biochemistry
-Keywords: Naphthalene, chemicals, chemistry,
-Research Experts Consulted: Professor Tony Nicolas

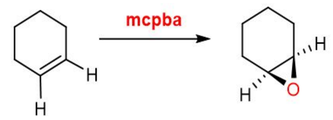
INTRODUCTION

The research we conducted in Part I and Part II of the former manufactured gas plant (MGP) site at Gowanus, we found that it was heavily contaminated with coal tar and was found to be a concern of public health risk from chemical exposure to many chemicals. Out of those many chemicals we found Naphthalene. Naphthalene is a polycyclic aromatic hydrocarbon that is commonly encountered in indoor and outdoor environments around gas plants. There is growing awareness of the environmental health risks associated with inhalation exposure to naphthalene in the environment. Acute (short- term) exposure of humans to naphthalene by inhalation, ingestion, and dermal contact is associated with hemolytic anemia, damage to the liver, and neurological damage. EPA has classified naphthalene as a Group C, possible human carcinogen. The Occupational Safety and Health Administration (OSHA) in the United States has established a permissible exposure limit (PEL) of 10 ppm for naphthalene. This research was conducted to find out why and how Naphthalene is toxic by understanding the organic chemistry and its metabolic processes. We found out that it is not Naphthalene that is directly harmful but actually its metabolites, such as its corresponding epoxide and its nucleophilic ring-opened products.

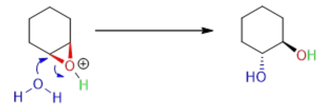
RESULTS

There are two key reactions that transform Naphthalene into toxic metabolites.

1.The Epoxidation of carbon-carbon double bonds of alkenes.
In vitro, peracids, such as mcpba ,oxidize the carbon-carbon double bond and generate an epoxide.

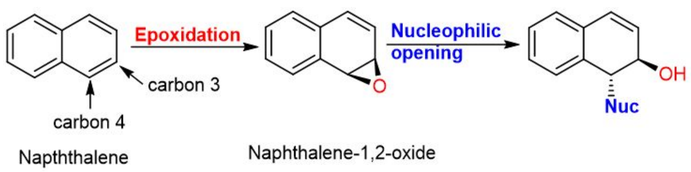


2. The opening of Epoxides with Nucleophiles.
In vitro, nucleophiles, such as water, for example, are capable of opening the epoxide to generate diols.

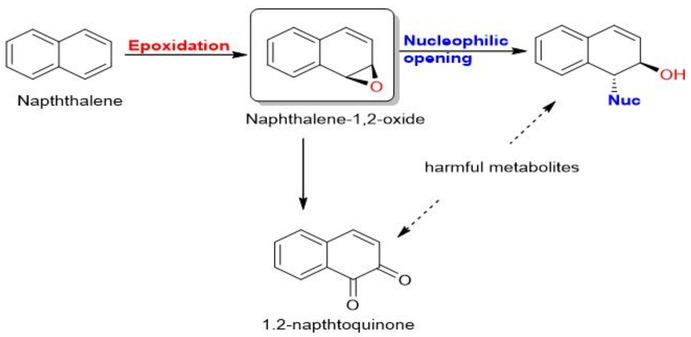


CONCLUSION

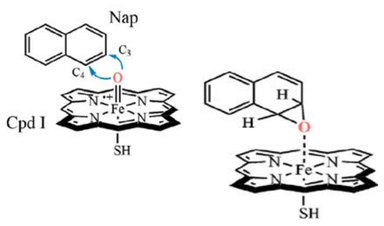
In vivo,. Naphthalene is enzymatically converted to an epoxide by oxidation of the carbon 3 and carbon 4 double bond. Nucleophilic ring-opening of the toxic metabolite generated , **Naphthalene-1-2-oxide**, leads to various other metabolites which are themselves toxic.



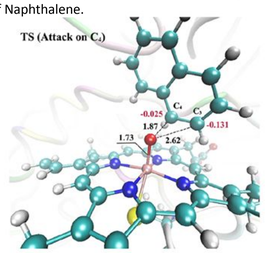
In addition to ring-opening products, **1,2-Naphtoquinone** can also be generated. Since Napthalene-1,2-oxide is the source of these metabolites, we have researched the mechanism by which it is generated. It is not Naphthalene itself which is harmful but its metabolites.



In vivo, the catalytic process occurs by the transfer of the oxygen of the heme to Naphthalene. This generates Napththalene-1.2-oxide.



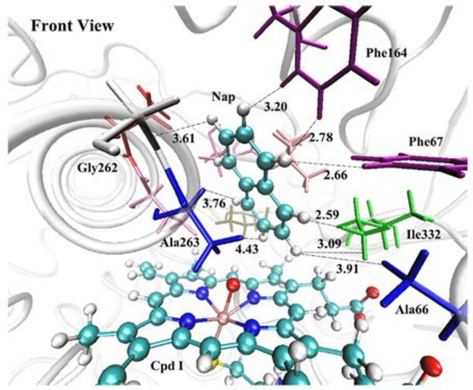
The results of calculation depict the delivery of the oxygen to C3 and C4 is in the transition state of the enzyme-substrate complex and show bonds being formed between the oxygen of the heme and C3 and C4 of Naphthalene.



DISCUSSION

Through our research we found, two universities in China got together with the Massachusetts Institute of Technology and did a Computational Study on Carcinogenic Metabolic Activation Process of Naphthalene by the Cytochrome P450 Enzyme 1B1. They determined that that naphthalene 1,2-oxide is unstable and the O−C bond cleavage easily occurs via cellular hydronium ion, hydroxyl radical/anion; then it will convert to the potential ultimate carcinogen 1,2-naphthoquinone. (Bao, L., 2019)

The city has planned to develop Public Place into “Gowanus Green” and place a school and low-income housing units on this site. The chemicals from former gas plants will remain underneath the ground and can cause harm to current living and coming generations in the area. The century old chemicals underneath the ground will eventually find their way up whether it is in the water line or in the air. Many toxic chemicals that the state environmental officials have found in the dark viscous material, known as “black mayonnaise,” at depths of more than 150 feet in the area. By understanding these chemicals at the reaction level, we may be able to help the state make the decision whether this site is a good idea to make it a public place.



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