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**Directed Study**

# Relative Toxicity Analysis of Alternative Chemicals in Hair Products using P2oASys

## Introduction

The Boston Public Health Commission has been conducting an investigation into the chemicals that make up the active ingredients in many hair relaxers and straighteners. These chemicals, specifically the relaxing agents, have known human health impacts that are of particular concern not only to the consumers of the products, who are largely black women, but also to salon workers who may be exposed to higher levels of these products. BPHC's ongoing work is to identify alternatives to these products that do not contain chemicals that carry the same level of toxicity and human health impacts, and to be able to confidently recommend these products as replacements for those currently in use.

The Boston Public Health Commission, and previous directed study groups identified chemicals of concern in typical hair relaxing products that were of particular risk to human health. BPHC and previous directed study groups also identified products that market themselves as safer, less toxic alternatives that presumably do not contain the chemicals of concern. Material Safety Data Sheets were collected for these products and examined to identify what chemicals are being used as the replacement relaxing agents in these products. These alternative chemicals can be compared to their "typical" counterparts to determine whether they are in fact less toxic, verifying that these products are safer alternatives.

The purpose of this directed study was to characterize the relative toxicity of these alternative chemicals compared the chemicals used in regular products. Six major chemicals of concern, as well as three alternative chemicals, were selected and assessed using the tool P2oASys. Part of this study included exploring P2oASys as a tool for toxicity comparison, both for the ongoing work on this issue, and for future studies.

## Methods and Data

### P2oASys

P2oASys is a tool developed by the Toxics Use Reduction Institute to assess the relative toxicity and health and environmental impacts of chemicals and methods based on quantitative and qualitative factors. Information about the chemicals can be input by a user either using P2oASys own format or in the format of standard Safety Data Sheets. Information may be inputted regarding several categories, including physical and chemical

properties, ecological impacts, exposure control, toxicological information, and hazard identification. As the purpose of our study was to assess the relative risks for human use, the latter three categories were of particular importance. We chose to use the SDS format for inputting chemical information.

For each piece of information that is input, the matrix assigns a score based on the hazards presented by that characteristic of the chemical. Scores are tallied at the end, and adjusted based on the other chemicals being compared and a relative score is calculated. This score can be used to make assessments about the relative risks of each chemical in question.

P2oASys includes additional functions that allow for comparison of "mixtures", that is, the relative scores for combinations of chemicals that are input into the matrix. These tools will also allow for comparison of toxicity based on concentrations of chemicals in the mixture, which would be useful for our assessment of products as often multiple "strengths" of a product are available that have different concentrations of the chemicals in question. However, at this time, as P2oASys is in beta, the mixture tool is not fully functional and could not be used for our assessments.

## Chemicals Assessed

A total of nine chemicals were input into the matrix for comparison, six of which are chemicals of concern often found in typical products, and three are chemicals found in "alternative" products.

- **Sodium Hydroxide and Calcium Hydroxide**

Sometimes referred to as "Lye", sodium Hydroxide is used most commonly in hair relaxers. There are significant health risks and concerns associated with even short-term exposure to sodium hydroxide ("Sodium Hydroxide (Lye) Safety"). It is one of the chemicals of concern that should be replaced.

Calcium hydroxide is often used as a replacement for sodium hydroxide, particularly in products that market themselves as "lye free" ("Types of Relaxers"). Though technically not lye, it is very similar to sodium hydroxide, and carries many of the same safety concerns as sodium hydroxide.

- **Ammonium Hydroxide, Ammonium Thioglycolate, and Cysteamine**

Ammonium Hydroxide and Ammonium Thioglycolate appear together in both straightening and curling perms.

Cysteamine products are often cited as an alternative to ammonium perms. It is typically used for curling hair, but straightening products using cysteamine do exist (Malhotra, 2016). However, there have been reports of these products not being as effective as their ammonium-based counterparts.

- **Formaldehyde and Glyoxylic Acid**

Formaldehyde is used in keratin based straightening and curling products. Once the keratin breaks bonds in the hair, formaldehyde "locks-in" the new texture. The health risks associated with formaldehyde exposure are severe. Many products have begun to use Glyoxylic Acid and similar chemicals as alternatives (McConnell, 2017). However, while relative toxicity may be lower, glyoxylic acid has been shown to release formaldehyde when heated, which is the usual protocol for most keratin hair treatments.

- **Propylene Glycol and Phenoxyethanol**

Propylene glycol and Phenoxyethanol are not used as relaxing agents. They appear in many relaxing "kits" in the products used pre or post hair relaxing. Phenoxyethanol is used as a preservative in many cosmetic products ("Phenoxyethanol"), while Propylene glycol is used as a conditioning agent ("Propylene Glycol"). They are included here as they appear in numerous "alternative" products and may be of concern.

**Inputting information into the matrix**

Information about each chemical was retrieved from Material Safety Data Sheets. Due to differences in the MSDS formats, sometimes multiple were referenced for each chemical. A full list of all MSDS' referenced is included at the end.

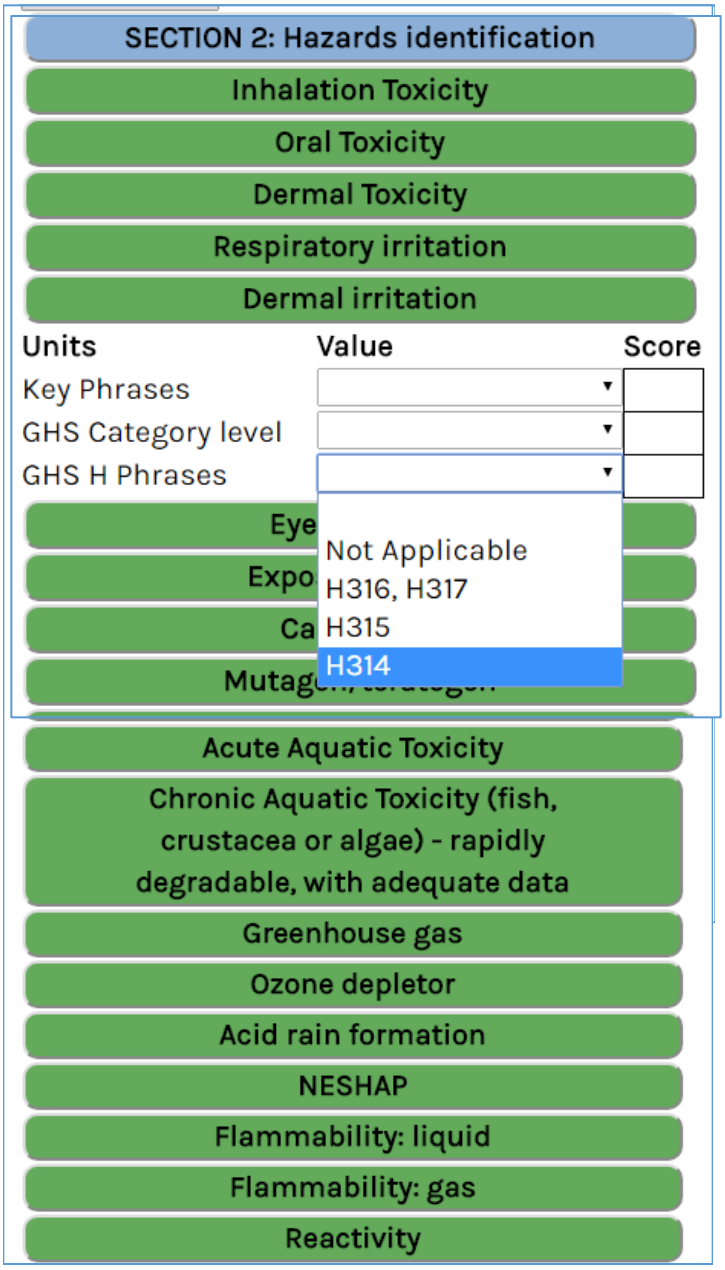
Image 1 is of the format to input information for each chemical. Once a new chemical assessment is created (in this case sodium hydroxide is being used as an example) and an MSDS or other source of information is found, the sections can be expanded and information can be input into each subsection. In this case, the categories match sections on a standard MSDS. Image 2 is of the expanded "Hazards Identification" section which shows what chemical characteristics are included. Information does not have to be input into every single subsection. Subsections that don't have information input are not counted in the total score for the chemical.

(Image 1: P2oASys data entry, SDS format)

(Image 2: P2oASys data entry, SDS format, expanded Hazards identification category)

In the case of our example, Sodium Hydroxide has a GHS H phrase 314 (found on its SDS) for dermal irritation. The subsection includes a drop down menu to select from the different categories and H phrases (image 3). Different subsections have various formats for inputting information that match standard SDSs.

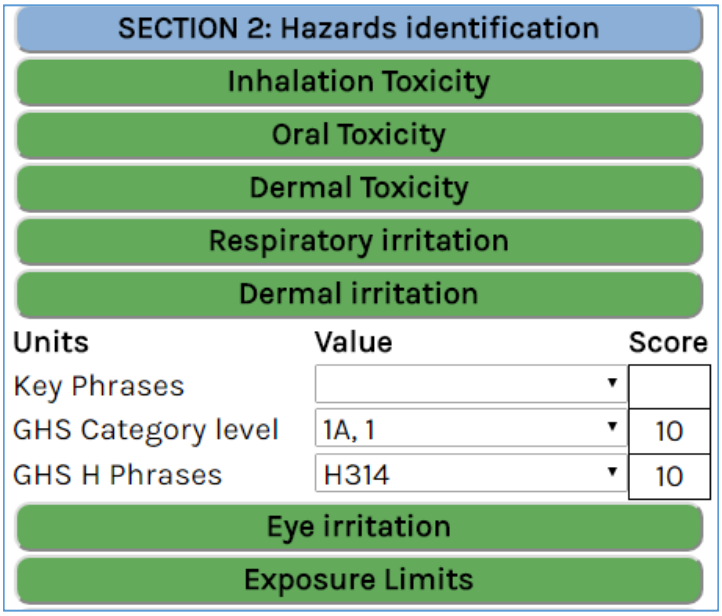
Once information is input, the matrix assigns a score from 1 to 10, 10 being the highest. This subsection score is then used in the final calculation of scores for chemicals (image 4).




(Image 3: P2oASys sample format for data entry for subsection)

(Image 4: P2oASys sample data entry and scores for subsection)

**Results and Discussion**




**Matrix Results**

For each set of chemicals, the final matrix scores are shown as well as the expanded "Acute Human Effects" category that shows the subsection scores. The full matrixes for each set of chemicals are included at the end of the report as excel files.

- **Sodium Hydroxide and Calcium Hydroxide**

(Image 5: P2oASys total matrix scores, Sodium Hydroxide, Calcium Hydroxide)

Sodium hydroxide received a score of 8.7, while calcium hydroxide received a score of 8.3. The overall score for calcium hydroxide is only slightly lower than that of sodium hydroxide, and although some of the scores for acute human effects were lower for calcium hydroxide, other scores (dermal irritation, eye irritation), were sufficiently high as to be of concern. This indicates calcium hydroxide is not significantly lower in terms of toxicity than sodium hydroxide, and should not be considered a safer alternative.

- **Ammonium Hydroxide, Ammonium Thioglycolate, and Cysteamine**

(Image 6: P2oASys total matrix scores, Ammonium Hydroxide, Ammonium Thioglycolate, Cysteamine)

| Categories | Ammonium Hydroxide | Ammonium Thioglycolate | Cysteamine |
|---|---|---|---|
| Acute Human Effects | 9 | 9 | 8 |
| Sub Category | Ammonium Hydroxide | Ammonium Thioglycolate | Cysteamine |
| Inhalation Toxicity | 4 | | |
| Oral Toxicity | 8 | 8 | 8 |
| Dermal Toxicity | | | |
| Respiratory Irritation | | | 4 |
| Dermal Irritation | 8 | 10 | 8 |
| Eye Irritation | 10 | | 8 |
| Exposure Limits | 6 | | |
| IDLH | | | |
| Health | | | |
| Chronic Human Effects | | | |
| Ecological Hazards | 10 | | |
| Environmental Fate & Transport | | | |
| Atmospheric Hazard | | | |
| Physical Properties | 10 | 10 | |
| Process Factors | | | |
| Life Cycle Factors | | | |
| Product Score | 9.7 | 9.5 | 8 |
| Final Score | 9.7 | 9.5 | 8 |

Cysteamine has a much lower overall score compared to both Ammonium Hydroxide and Ammonium Thioglycolate. The scores for the acute human effects for Cysteamine are also lower. Notwithstanding its effectiveness as a straightener, Cysteamine may be a viable safer alternative to ammonium-based products.

- **Formaldehyde and Glyoxylic Acid**

(Image 7: P2oASys total matrix scores, Formaldehyde, Glyoxylic Acid)

Glyoxylic Acid and Formaldehyde have the same overall score, though the category scores for the chemicals are slightly different. Glyoxylic acid has significantly high scores for certain subsections under acute human effects, which makes it a nonviable alternative to

| Categories | Formaldehyde | Glyoxylic Acid |
|---|---|---|
| Acute Human Effects | 10 | 10 |
| Sub Category | Formaldehyde | Glyoxylic Acid |
| Inhalation Toxicity | 8 | |
| Oral Toxicity | 6 | 4 |
| Dermal Toxicity | | |
| Respiratory Irritation | | |
| Dermal Irritation | 10 | 10 |
| Eye Irritation | 10 | 10 |
| Exposure Limits | 8 | |
| IDLH | | |
| Health | | |
| Chronic Human Effects | 8 | |
| Ecological Hazards | 8 | 6 |
| Environmental Fate & Transport | | |
| Atmospheric Hazard | | |
| Physical Properties | | 10 |
| Process Factors | | |
| Life Cycle Factors | | |
| Product Score | 8.7 | 8.7 |
| Final Score | 8.7 | 8.7 |

formaldehyde, even when disregarding the potential for secondary formaldehyde production.

- **Propylene Glycol and Phenoxyethanol**

(Image 8: P2oASys total matrix scores, Propylene glycol, Phenoxyethanol)

Propylene Glycol has a relatively low score, which means it may be prudent to dismiss as a chemical of concern when it appears in products. Phenoxyethanol has a higher score, both overall and in certain categories of acute human effects. There may be cause to be concerned if and when this chemical appears in products.

| Categories | Propylene Glycol | Phenoxyethanol |
|---|---|---|
| Acute Human Effects | 3 | 7 |
| Sub Category | Propylene Glycol | Phenoxyethanol |
| Inhalation Toxicity | | |
| Oral Toxicity | 2 | 6 |
| Dermal Toxicity | 2 | 2 |
| Respiratory Irritation | | |
| Dermal Irritation | 4 | |
| Eye Irritation | | 8 |
| Exposure Limits | 2 | |
| IDLH | | |
| Health | | |
| Chronic Human Effects | | |
| Ecological Hazards | | |
| Environmental Fate & Transport | | |
| Atmospheric Hazard | | |
| Physical Properties | | |
| Process Factors | | |
| Life Cycle Factors | | |
| Product Score | 3 | 7 |
| Final Score | 3 | 7 |

**Conclusion**

There are a number of limitations to the analysis conducted. The scoring in the matrix is limited to what information is available about each chemical and what is input into the matrix. The information available for each chemical is not uniform; some have much more specific hazards listed in their SDS' than others, and some hazard metrics may be more relevant to assessment of human health impact than others. In order to combat this limitation, multiple sources can be consulted for information on each chemical, as was done for many of the chemicals in this assessment. Current use of the P2oASys tool is also made difficult as assessments cannot be saved and returned to at a later time. Each time the tool is used, a new assessment must be created and the information about each chemical inputted again. This can limit the number of chemicals that can be put into a single matrix and compared to one another, as all the chemical information would have to be inputted in a single session, which poses a challenge for the user.

As mentioned previously, P2oASys is currently in beta so it is not possible to compare mixtures of chemicals or concentrations of chemicals. This is of particular concern as the concentrations of the chemicals vary greatly from product to product. Future research could use these aspects of the tool as they become fully functional to do more thorough comparisons effects of chemical mixtures on overall toxicity.

Overall, two potential replacement chemicals, calcium hydroxide and glyoxylic acid, were dismissed as viable alternatives for their more common counterparts. Cysteamine was identified as a potentially less toxic alternative that warrants further investigation into its more specific human health and exposure impacts as well as its effectiveness in products.

This paper also demonstrates one application of the P2oASys tool as a method of preliminary comparison of chemical hazards in products, particularly in narrowing down and identifying which chemicals should be researched as viable alternatives. This paper provides a guideline for how this kind of comparison can be conducted, not only for chemicals in hair relaxers, but also for any kind of consumer product.

**References**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**Material Safety Data Sheets Referenced**

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  -
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