

**Proposed GCMS Analysis of Hair Products Used by Black Women to Detect Endocrine-Disrupting
Chemicals**

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ABSTRACT

Consumer products have been shown to contain endocrine-disrupting chemicals (EDCs), which can pose as hormones and interfere with the endocrine system. This interference can lead to obesity, cancer, and reproductive/fertility issues. In previous studies, researchers have suggested that certain hair care products (e.g. hair relaxers, hair oils) have higher concentrations of EDCs than others, and these specific hair care products are more commonly used by Black women. Therefore, the use of these products may present an increased health risk to Black women. For instance, racial disparities already exist for breast cancer such that a Black woman has a 43.1% chance to die from breast cancer than a white woman. The possibility of higher exposure of Black women and girls to EDCs compounds the systemic issue of inequitable health care experienced by Blacks compared to whites. In this proposed research, we will adopt established methods to measure EDCs using gas chromatography-mass spectrometry (GCMS). Specifically, shampoos and conditioners from the brands OGX, SheaMoisture, Cantu, and Carol's daughter will be analyzed for the presence of methylparabens, diethyl phthalates, and decamethylcyclopentasiloxane. To our knowledge these brands are used by Black women have yet to be tested for EDCs.

INTRODUCTION

Do you really know what chemicals are in your personal care products? Is there a chance that your shampoo can increase your odds of getting cancer? Those are a couple of questions that scientists are asking themselves today. In 2019 the market size in hair care products in the U.S was about \$90.2 billion and is expected to grow to about \$105.1 billion by 2025 (1). There are products for different hair styles, textures, and colors. Studies have shown links between consumer products, like hair dye and straightening products, and negative health effects, such as cancer. (2) These negative health effects are caused by endocrine-disrupting chemicals (3). Unfortunately, it is hard for a consumer to avoid exposure to EDCs from consumer products, because not all chemicals are clearly stated on the label. Due to this it causes those negative health effects to become some people's reality, and when getting treated for their health issues there are indications of racial disparities with a greater rate of disease in people of color (POC) (4) In this proposed study we will focus on a selection of hair products known to be used by Black women and describe an experiment that could be conducted to examine these products for the presence of specific EDCs.

Endocrine-disrupting chemicals (EDCs) and their health effects

Endocrine-disrupting chemicals are substances that affect the endocrine system, typically with the connotation of negative effects. The endocrine system is a series of glands that creates hormones that are used throughout different systems in the body, like respiratory and reproduction. (5) When an EDC enters the body it is mistaken for a hormone, so the body allows the chemical to continue through our blood, but this substance is dangerous to the hormone levels. An EDC may serve to increase or decrease the hormonal levels that are in our blood, like some of the sex hormones estrogen, progesterone, and testosterone. For example an altered estrogen level can cause negative health effects like endometriosis, which is when the tissue from the uterus grows outside of the uterus..(3) Not only do EDCs disrupt hormones, but other consequences are an increase in obesity and are potentially cancer-causing. (6) For instance many consumers are aware of bisphenol A (BPA) and its probable connection to an increased risk of tumors as a result of hormonal issues, infertility, and early menarche. (7). Hence, a variety of plastic products, such as water bottles, are specifically advertised as BPA-free in order to give consumers a chance to avoid the chemicals. Not all consumer items are labeled like this, which causes consumers to come into contact with other products containing EDCs. These EDCs then lead to different negative effects like the ones seen in BPA.

EDCs have been linked to health issues such as menarche and breast cancer. Studies have shown that EDCs not only affect people once they are adults, but using products that contain EDCs at a younger age can cause these health problems in the future. (8) Menarche is the first period that a female experiences, and the average age of menarche in the U.S. is 12.4 years. (9) A period causes the body to

interact with hormones that are produced during the process, but when menarche happens before the body is ready these hormones then lead to the increased chance of developing different negative health effects. In a study conducted by Julie Lee, et al. researchers focused on cardiovascular diseases in females who experience both an early and late menarche.(10) There were other issues mentioned in relation to early menarche like metabolic syndrome, which increases a person's blood sugar and increases the risk of a heart attack or a stroke, and breast cancer.(10)

In 2020 about 1.8 million Americans were diagnosed with cancer and about 606,000 of them have passed due to the condition.(11) Cancer happens when there is an uncontrollable divide in cells that then spread to tissue within the body. (12) With breast cancer one thing that affects these dividing cells is estrogen. Estrogen is what stimulates the breast cells within a woman's body, so when a woman encounters a larger amount of estrogen within her lifetime it increases her risk of getting breast cancer.(13) A specific example that can lead to a result of breast cancer is menarche at an earlier age, because it causes a female to come in contact with estrogen for a longer amount of time than a female who has an average menarche.(10) Estrogen is only introduced by menarche, but some products contain EDCs that are estrogenic.

Routes of Exposure to EDCs

Avoiding EDCs is an extremely hard thing to do, because EDCs are contained in everyday items. Some examples are foods, toys, plastic tupperware, detergents, metal can liners, cosmetic, and pesticides.(14) A study held by the Silent Spring Institute has included these products in order to pursue their connection with EDCs In a study conducted by Dodson, et al. in 2012, different everyday products were tested with GCMS in order to observe the EDCs and asthma-associated chemicals in the products. There were 213 products that were observed, and those product types included personal care items, cleaners, and household goods like diapers and cat litter. The major classes of chemicals that were investigated were parabens, phthalates, ethanolamines, alkylphenols, fragrances, glycol ethers, cyclosiloxanes, and ultraviolet filters (UV). They also tested these products for bisphenol A and triclosan, both of which have since been banned in certain consumer products. The result of this experiment was 55 of these compounds were detected in the tested products. Each product had at least two detected EDCs, with sunscreen having the most detected with 22 chemicals. When examining the labeling of the products not all of the ingredients were accurately disclosed when comparing the detected EDCs to the label on the products. For example antimicrobials and parabens were more likely to be accurately listed on the ingredient list, while phthalates and BPA weren't listed at all regardless of their presence in hair care products.(15)

More recently, Dodson and collaborators conducted another experiment in 2018, highlighting Black hair care products as a potential route of exposure to EDCs. The EDCs included in this study are

parabens, phthalates, UV filters, cyclosiloxanes, fragrances, glycol ethers, and alkylphenols. (16) This research team focused on eighteen different hair products and continued to use the same methods that were reported in the earlier 2012 paper. These eighteen products could be sorted into six different categories: hair oil treatment, anti-frizz, leave-in conditioner, root stimulator, hair lotion, and relaxers. After performing GCMS analysis, the results were compared to the ingredients listed on the product's label to confirm the accurate disclosure of the presence of EDCs. Each of the products had at least a minimum of four detected EDCs, and hair relaxer 1 had the most detected EDCs, which was 30 chemicals. Like the previous study Dodson and collaborators saw that there was not accurate labeling when looking for EDCs in the ingredients list. (16)

Racial disparities in the healthcare system

The prevalence of EDCs in Black hair care products, and the lack of proper labeling to disclose the presence of those EDCs so that conscious consumers can avoid them, is one more factor leading to racial disparities in healthcare. Even in our current pandemic, Black Americans are disproportionately affected. As of May 5, 2021 there have been 32.6 million COVID-19 cases in the U.S. with 584,116,000 deaths attributed to the disease.(17) On April 9, 2020 it was recognized that 51.5% of Covid positive cases were made up of African American. 67.3% of the COVID deaths in the U.S. are made up of African Americans. The case numbers have drastically increased from a year ago, so it is expected that the stats for African Americans and Covid has too. In general, the quality of medical care that a patient receives is often varied by the patient's race. Jemal, et al. observed that people of color (POC) are most likely unable to receive good or any healthcare at all in the United States. (4) These racial disparities cause many obstacles when trying to receive proper care for different health issues, and result in higher death rates of POC. The lack of good or any healthcare for POC has contributed to 37.0% of the deaths in POC with breast cancer. (4) Racial disparities have been seen in the health system for a long period of time, but recently there have been studies that have linked racial disparities and the health problems caused by EDCs in hair products.

Statistics between white and Black breast cancer patients receiving treatment show the Black woman has a higher death rate than a white woman. Between the 2010 and 2014 time period it was 43.1% more likely for a Black woman to die from breast cancer than a white woman. (18) Some products used by POC have been studied and researchers have recognized that some of these products can increase a POC chance of getting breast cancer. Products including estrogenic EDCs in hair products like hair oils and relaxers, have increased a person's chance of getting breast cancer. (8) These products are more likely used by Black women, which increase the number of breast cancer cases seen. Estrogenic products are used on Black younger girls, which impacts their bodies by causing her to encounter early onset menarche, like stated earlier in the paper. There are many EDCs that exist and should be observed to try

and prevent these negative effects, but the specific EDCs that I'll be observing throughout my experiment are parabens, phthalates, and cyclosiloxanes.

Parabens

Parabens act as preservatives in hair products, and all parabens contain the basic structure given in Figure 1, in which the "R" represents an organic substituent. For instance, methyl paraben has a -CH₃ group attached at that location. (Figure 2) This preservative prevents dangerous bacteria and fungi from growing within the products. Parabens are linked to some health issues like a compromised reproductive system, due to this chemical being hormonally disruptive, in both males and females and a higher risk of getting cancer. (19) The regulations when using parabens in consumer products are different for different countries. The European Union (EU), Southeast Asian nations, and Japan have set maximum limits on the concentration of parabens used in products. These countries also have regulations on parabens that are seen in products that are sold in the U.S.(20) The paraben that will be observed throughout the experiment is methylparaben because it was the most common paraben found in the hair products tested in the 2018 Dodson and collaborator study.

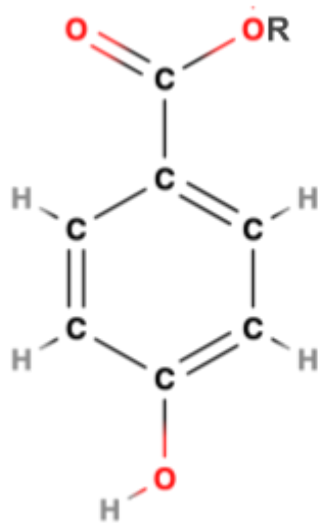


Figure 1. Structure of paraben

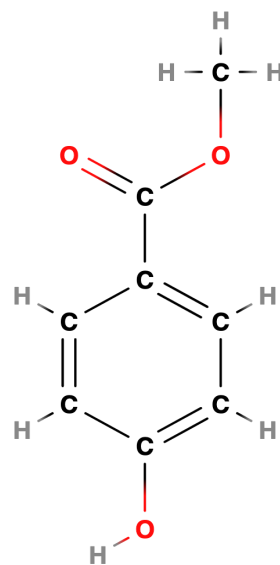


Figure 2. Structure of methyl paraben

Phthalates

Like parabens, phthalates are also based on a substituted benzene ring (Figure 3) and these chemicals are used as dispersants that reduce the stiffness and brittleness of hair. Phthalates are used in hair products as they are also found within the fragrances that are used in the products.(21) Phthalates have been linked to the damage of the reproductive system, lungs, liver, kidney, and neurodevelopmental issues.(22) There are different types of phthalates that are identified in hair products like dioctyl, dipropyl,

benzyl butyl, and diethyl phthalates.(16) The type that will be observed throughout the experiment is diethyl phthalates(DEP) due to the high concentrations of it found in the 2018 Dodson study. (Figure 4) .

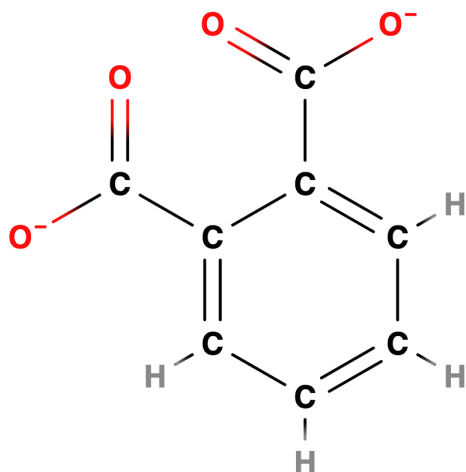


Figure 3. Structure of a phthalate

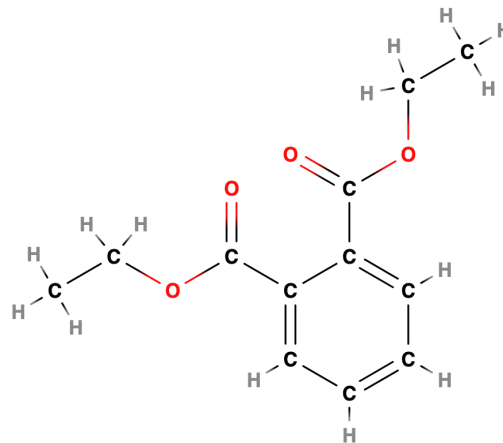


Figure 4. Structure of a diethyl phthalate (C₁₂H₁₄O₄)

Cyclosiloxanes

Cyclosiloxanes are siloxanes made up of a closed cyclic loop that contains the elements silicon and oxygen. (Figure 5)(23) This chemical is used as an anti-frizz, softening, and thickening component in hair products. When cyclosiloxanes were tested on animals it showed that the chemicals caused irritation to skin, neurotoxicity, organ toxicity and tumor after absorbing in skin. (24) Another thing that was shown was that these siloxanes have had a negative effect on the creation of hormones, which can lead to the fertility levels of a woman to decrease. (25) Different types of cyclosiloxanes that are seen at higher levels in hair products are octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6). Decamethylcyclopentasiloxane will be measured in the hair products in this experiment. (Figure 6)

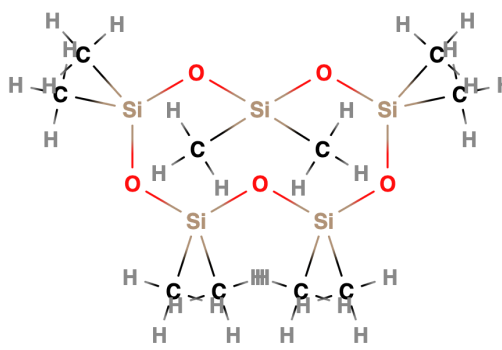
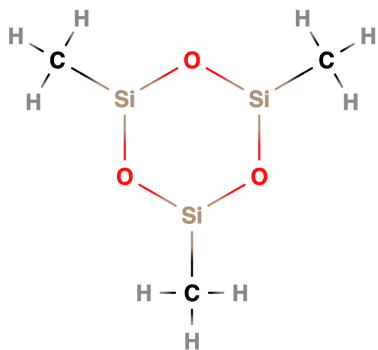


Figure 5. Structure of cyclosiloxanes **Figure 6.** Structure of decamethylcyclopentasiloxane

Proposed Study

As noted earlier, the 2018 paper “Measurement of endocrine disrupting and asthma-associated chemicals in hair products used by Black women” discussed sixty-six chemicals in eighteen different hair products. Those hair products included root stimulators, hair lotions, relaxers, and anti-frizz products. (Dodson 2) The experiment that I will be conducting will follow the same methods as the one described by Author, et al. The products that I will be examining are shampoo and conditioners used by Black women that were not already studied in that paper. Those products include Cantu, SheaMoisture, TreSemme, and OGX shampoos and conditioners. These brands were chosen because of my personal experience with all of them and their relevance within the Black community. I have used each brand sometime in my lifetime when washing and conditioning my hair. When looking at the labeling there was no indication that any of the EDCs that will be observed are contained within the products (Figure 7).

EXPERIMENTAL

Chemicals & Equipment

Cantu, SheaMoisture, TreSemme, and OGX shampoos and conditioners will be purchased from a local retailer. Methyl paraben, diethyl phthalate, and decamethylcyclopentasiloxane will be purchased from Fisher Scientific. Analysis of hair products will be conducted using a GCMS-QP2010 Shimadzu Gas Chromatograph Mass Spectrometer that contains an AOC-5000 Auto Injector and a SH RXI-5MS column (25mm thickness, 30m length, and 25mm diameter). This instrument is housed at Robert Morris University.

Preparation of Samples with standard addition of EDCs

Samples will be prepared according to Robin Dodson’s 2018 paper. Specifically, 0.25 mL of the hair care products will be diluted with 50 mL of 3:1 dichloromethane:methanol. (Dodson 1) In Dodson’s paper the products were mixed using a shaker table, but due to limited resources the products will have to be mixed thoroughly without it to form a homogeneous solution. We hope to use the method of standard addition, such that methyl paraben, diethyl phthalate, and decamethylcyclopentasiloxane with concentrations ranging between 0.15-25 µg/mL, will be added to hair product samples (Dodson 2)

CONCLUSION

In conclusion, this proposed study would use GCMS to analyze eight hair products known to be used by black women for the presence of methyl paraben, diethyl phthalate, and decamethylcyclopentasiloxane. The results would then be compared to the ingredients listed on the product labels. These products would be compared due to the fact the distributors of the hair product

neglect to state all of the chemicals present in the product. This causes educated consumers to have a harder time avoiding them and making it easier for them to be exposed to different EDCs. The motivation for studying this is to identify known EDCs in personal care products that could be related to negative health issues and racial disparities.

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