



Published in final edited form as:

*Dermatitis*. 2021 ; 32(5): 327–332. doi:10.1097/DER.0000000000000663.

## Formaldehyde Release From Predispersed Tattoo Inks: Analysis Using the Chromotropic Acid Method

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### Abstract

**Background:** Allergic contact dermatitis to tattoo ink may last from weeks to years. Formaldehyde is a strong sensitizer that may be present in predispersed tattoo inks.

**Objectives:** The aim of this study was to evaluate the presence of formaldehyde in predispersed tattoo inks using the chromotropic acid method.

**Methods:** Tattoo inks from 39 companies were evaluated. Inclusion criteria included availability to purchase inks online through US tattoo product wholesalers or individual Web sites. Brands were grouped based on prevalence of use: common, uncommon, or rare. For common brands, 8 colors (primary colors, secondary colors, black, and white) were purchased. For uncommon and rare brands, 5 colors (primary colors, black, and white) were purchased. Each ink was tested with standard chromotropic acid method procedures; concentration of formaldehyde released was quantified using spectrophotometry.

**Results:** In total, 127 tattoo inks were purchased and tested. Ninety-three (73%) tested positive for formaldehyde release; 34 (27%) tested negative. Formaldehyde release did not correlate with color or brand. At least 1 ink from all brands (except 1) was positive for formaldehyde release.

**Conclusion:** Approximately three-quarters of selected US tattoo inks tested positive for formaldehyde release. Clinicians should be aware of tattoo ink as a potential source of formaldehyde.

A permanent tattoo is formed when ink is forced into the dermis with a needle.<sup>1</sup> In the last century, tattoos have become increasingly popular. It is currently estimated that 30% of adult Americans have at least 1 tattoo.<sup>2</sup> Previously, tattoo artists created their own inks by dissolving pigments in solvents; however, premade or “predispersed” tattoo inks are now commonly used. Predispersed commercially available tattoo inks are color pigments dissolved in a solvent (typically in a water- or alcohol-based carrier).<sup>3</sup>

The rising prevalence of tattoos and permanent makeup has been coupled with a corresponding increase in cutaneous and systemic complications. The most common adverse effects arising from tattoos include blood-borne/cutaneous infections and hypersensitivity reactions.<sup>3</sup> Allergic contact dermatitis (ACD) to tattoo inks has been reported in both tattoo recipients and tattoo artists.

Despite reports of tattoo and permanent makeup-related adverse health problems, the US Food and Drug Administration has yet to formally regulate labeling of tattoo inks; only toxic ingredients in pigments are listed in safety data.<sup>4,5</sup> Most tattoo ACD reports are related to pigments. Contact allergy to tattoo pigments often presents with pruritus, edema, and dermatitis at the site of tattoo placement.<sup>6</sup> These reactions may be chronic and can develop weeks to years after a tattoo is placed.<sup>7</sup> Historically, pigments have contained numerous inorganic metallic compounds known to be strong sensitizers.<sup>8</sup> A recent analysis of 1415 US tattoo inks by Liszewski and Warshaw,<sup>9</sup> however, found that heavy metal pigments are rarely used in modern inks; of the 44 unique pigments identified, 25% have been implicated in ACD. Other reported sensitizers in tattoo inks include paraphenylenediamine, cobalt, balsam of Peru, and nickel sulfate.<sup>10</sup> Furthermore, information is lacking regarding inactive ingredients in US tattoo inks including preservatives, which may potentially be allergenic.<sup>11</sup>

In Europe, there has been increasing concerns about sensitization to preservatives in tattooed individuals. Recently, the German Contact Dermatitis Research Group has developed a screen tattoo series patch that consisted of 82 substances including dyes, preservatives and biocides, and other tattoo ink constituents.<sup>12</sup> Formaldehyde, quaternium-15, DMDM hydantoin, and bronopol were included in this screening series that aim to identify culprit allergens in tattoo inks.

Formaldehyde and formaldehyde-releasing preservatives are used to prevent the growth of microorganisms in various liquid products. These preservatives are well-known contact sensitizers but are relatively underappreciated ingredients in tattoo inks.<sup>13,14</sup> In Switzerland, 55 of 416 tattoo inks were found to contain formaldehyde.<sup>15</sup> Another Korean study discovered that 13 of 16 tattoo inks had formaldehyde concentrations of up to 308.2 ppm, a level that exceeds the concentration (2.5 ppm) needed to worsen existing ACD<sup>16</sup> and the threshold concentration (250 ppm) to elicit a positive patch test reaction.<sup>17,18</sup> Moreover, a patient has previously been reported with tattoo-related dermatitis who had a positive patch test to a formaldehyde-releasing preservative<sup>19</sup>; this finding suggests that the presence of undisclosed formaldehyde in tattoo inks may potentially elicit cutaneous allergic reactions in patients allergic to formaldehyde.

There are several methods used to detect formaldehyde release from products, including the chromotropic acid method (CAM).<sup>20</sup> Briefly, when chromotropic acid is exposed to formaldehyde in a closed container, a color change (clear to purple) occurs in an acidic environment.<sup>20</sup> The CAM can qualitatively detect the presence of formaldehyde in many substances;<sup>16,21,22</sup> the specific concentration of formaldehyde can be further quantified using spectrophotometry.<sup>23</sup>

To our knowledge, there have been no studies evaluating formaldehyde release from predispersed tattoo inks in the United States. This study investigates the presence of formaldehyde in commercially available US tattoo inks using the CAM and spectrophotometric method of formaldehyde detection in an effort to determine whether predispersed tattoo inks represent an additional, undisclosed source of formaldehyde.

## METHODS

### Material Selection

The primary investigator (Y.L.L.) reviewed a list of 39 tattoo ink companies that manufactured and sold tattoo inks in the United States; this list was generated from a previous study of tattoo ink pigments.<sup>9</sup> To minimize counterfeit products, tattoo inks were excluded if they (1) could not be purchased through a US online tattoo product wholesaler or through respective individual Web sites, (2) were available exclusively through [Amazon.com](https://www.amazon.com), or (3) were discontinued.

A dermatologist with expertise in tattoo use (W.L.) categorized the brands of tattoo inks into 3 different groups (common, uncommon, and rare) based on the popularity and prevalence of use by US tattoo artists (Table 1). Five inks of primary colors (including red, yellow, blue, white, and black) were purchased for all brands. Three inks of secondary colors (including orange, green, and purple) were also purchased for common brands. A few brands including “One Ink,” “Kokkai,” and “Cheyenne” had limited colors; in these cases, all colors available were purchased. All tattoo inks used in this study were purchased from online tattoo wholesale/retail vendors or their respective websites.

### Ingredient Review

The label for each tattoo ink was examined for the presence of declared formaldehyde/formaldehyde releasers (eg, bronopol, DMDM hydantoin, diazolidinyl urea). If no ingredients were available on the label, the online Material Safety Data Sheet, if available, was examined and reviewed.

### Chromotropic Acid Method

All chromotropic acid experiments were conducted at room temperature using standard CAM procedures as described in previous studies.<sup>24</sup> Half of a milliliter of tattoo ink sample was used for each experiment. For each chromotropic acid experiment, 0.5 mL of 0.1% formaldehyde solution was used as a positive control, and distilled water was used as a negative control. Each ink sample was tested twice on separate days. Samples that provided conflicting results from the first 2 experiments were tested a third time.

After 48 hours of incubation, each vial of chromotropic acid solution with either tattoo ink samples or control solutions was placed in a Beckman DU 640 UV-VIS spectrophotometer (Fig. 1A). The chromotropic acid solution from the negative control served as blank for each absorbance reading.<sup>24</sup> Absorbances of 570- and 573-nm wavelength of light were used for optimal formaldehyde detection.<sup>25</sup>

### Threshold for Positivity

To identify the limit of detection (LOD) and set the threshold of positivity, a dose-dependent formaldehyde titration curve was performed 3 independent times. Formaldehyde solutions from 2.5 to 80 ppm in concentration with 2-fold dilutions (Fig. 2) were used to form a standard curve. First, an 80-ppm (0.008%) formaldehyde solution was made from a 0.1% formaldehyde solution and then serially diluted to create standard solutions. Each standard formaldehyde solution was incubated with chromotropic acid solution per protocol and then read using the spectrophotometer (Fig. 1B). The LOD for the spectrometer in identifying formaldehyde was determined by 3.3 times the standard deviation of the regression line divided by the slope. Each regression line was generated using data of concentration ranges of 0 to 5 ppm or 0 to 10 ppm, whichever generated a line with the highest  $R^2$ . Data of higher concentrations (20–80 ppm) were excluded because they were outside the linear range for spectrophotometric measurement. The average LOD of 4 standard titration sets was used as the threshold for positivity for all ink samples tested. Absorbance of 2.5-ppm formaldehyde solution was determined as the lowest relevant concentration per previous guidelines.<sup>24</sup>

## RESULTS

### Ingredient Review

Of the 127 inks, 93 inks (73%) had listed ingredients, and 34 inks (27%) did not. Of those with ingredients, 80 tattoo inks did not declare formaldehyde or other formaldehyde-releasing chemicals as ingredients, whereas 13 inks listed DMDM hydantoin. The 13 DMDM-hydantoin-containing tattoo inks were from 2 brands, Millennium Moms Tattoo Ink and World Famous.

### Formaldehyde Detection

The LOD of the spectrophotometer was calculated to be 2.47 ppm. The average absorbance for a 2.5-ppm formaldehyde solution was determined to be 0.014 AU when read with 570-nm light and 0.013 when read with 573-nm light. On the basis of this determined threshold of positivity, 93 of the 127 tested tattoo inks (73%) released greater than or equal to 2.5 ppm of gaseous formaldehyde; 34 of the 127 tested tattoo inks (27%) released less than 2.5 ppm of gaseous formaldehyde (Table 2). All inks with DMDM hydantoin were positive for formaldehyde release using CAM.

## DISCUSSION

This study has several important findings. Approximately three-quarters of study inks released formaldehyde. These positive samples included 13 tattoo inks, which specifically declared DMDM hydantoin—a formaldehyde-releasing preservative commonly used in

personal care products—as well as 80 inks that did not declare any formaldehyde-releasing ingredients. The amount detected in each product was 2.5 ppm or greater, a clinically relevant concentration that has previously been shown to worsen existing dermatitis in formaldehyde-allergic patients.<sup>16</sup> These findings are consistent with several other reports that detected formaldehyde in cosmetic products that did not declare formaldehyde.<sup>22,26,27</sup> Possible explanations may include the following: (1) formaldehyde/formaldehyde-releasing preservative was added for preservation; (2) 1 or more of the individual ink ingredients that manufacturers purchase to produce the ink may contain formaldehyde or a formaldehyde releaser, which may not be listed because they were not added directly; (3) breakdown ingredient(s) that releases formaldehyde; and/or (4) packaging that releases formaldehyde.

We found no correlation between colors or brands and presence of formaldehyde. At least 1 tattoo ink color from almost all brands tested positive for formaldehyde release.

From the colors tested, few brands of tattoo inks had low formaldehyde release (2.5–5 ppm); these included Eternal tattoo ink, Fusion, Intenze, Kokkai Sumi ink, National tattoo ink, and One ink. Cheyenne tattoo inks had the overall highest concentration (20–80 ppm) of formaldehyde release. Empire Ink was the only negative brand, but only 2 colors were tested.

Although we found that most of the tested tattoo inks released formaldehyde, the clinical implications of this study are unclear. Currently, there have not been any reports of ACD explicitly linking formaldehyde patch test reactions to tattoo inks. One reason may be due to difficulty identifying culprit ingredients, as most clients do not know the brand of tattoo ink in their tattoos. Even when tattoo ink brands can be identified, ingredients are often unavailable on packaging or Material Safety Data Sheets. Another reason for the lack of formaldehyde-related ACD tattoo reactions may be that clients often contact the tattooist about adverse tattoo reactions instead of seeing a dermatologist.<sup>28</sup>

In theory, formaldehyde sensitization from tattoo inks is plausible. Cutaneous sensitization develops when an antigen is recognized by dermal dendritic cells.<sup>29,30</sup> Although most tattoo ink is deposited in the dermis,<sup>31</sup> ink also contacts all layers of the epidermis as the needle penetrates the skin. Importantly, sensitization may be enhanced by the intense inflammatory response to the tattoo ink.<sup>32,33</sup>

In addition to tattoo clients, our findings are also relevant to tattoo artists. Regulations of tattoo parlors vary by state, and personal protective equipment is generally required during the needling process but not necessarily when preparing/handling tattoo inks. Given potential exposure to blood-borne pathogens and possible ACD, we recommend that gloves be worn routinely by tattoo artists during all steps of the tattooing process including preparation.

## Limitations

This study has notable limitations. Most importantly, we chose a convenience sample of predispersed tattoo ink brands manufactured and sold in the United States, based on common, uncommon, and rare commercial brands, which spanned a wide variety of tattoo

ink manufacturers. We selectively tested the more commonly used primary and secondary colors. Tattoo inks were excluded from this study to avoid counterfeit inks and to ensure purchase from reliable sources that tattoo parlors would be likely to use for bulk purchases. Testing potentially counterfeit inks from less reliable sources may have yielded additional products containing formaldehyde and may represent a direction for future studies.

## CONCLUSIONS

Tattoos are an increasingly popular aspect of modern skin modification practices. Although pigments are notoriously common causes of tattoo-related contact allergy, additional ingredients such as preservatives may cause ACD. In this study, approximately three-quarters of US predispersed tattoo inks tested positive for formaldehyde release when evaluated with CAM. We found no correlation between colors or brands and presence of formaldehyde. Patients and clinicians should be aware of predispersed tattoo inks as a potential source of formaldehyde.

## Acknowledgments

This work was supported by the use of facilities and resources of the Minneapolis Veterans Affairs Medical Center. The contents do not represent the views of the US Department of Veterans Affairs or the US Government.

This report is the result of work supported by the American Contact Dermatitis Society Clinical Research Award.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (NIOSH/CDC). Mention of any company or product does not constitute endorsement by NIOSH/CDC.

## REFERENCES

1. Engel E, Santarelli F, Vasold R, et al. Modern tattoos cause high concentrations of hazardous pigments in skin. *Contact Dermatitis* 2008;58(4):228–233. [PubMed: 18353031]
2. Shannon-Missal L Tattoo takeover: three in ten Americans have a tattoo, and most don't stop at one. The Harris Poll. Available at: [https://www.prnewswire.com/news-releases/tattoo-takeover-three-in-ten-americans-have-tattoos-and-most-dont-stop-at-just-one-300217862.html#:~:targetText=TheHarrisPoll&targetText=Butone thing's for sure,%25\) have two or more. Accessed March 20, 2020.](https://www.prnewswire.com/news-releases/tattoo-takeover-three-in-ten-americans-have-tattoos-and-most-dont-stop-at-just-one-300217862.html#:~:targetText=TheHarrisPoll&targetText=Butone thing's for sure,%25) have two or more. Accessed March 20, 2020.)
3. Gonçalo M Tattoo artists. In: Kanerva's Occupational Dermatology. 2nd ed. vol. 3. Berlin, Germany: Springer Verlag; 2012:1709–1710.
4. LeBlanc PM, Hollinger KA, Klontz KC. Tattoo ink-related infections—awareness, diagnosis, reporting, and prevention. *N Engl J Med* 2012;367(11): 985–987. [PubMed: 22913662]
5. Haugh IM, Laumann SL, Laumann AE. Regulation of tattoo ink production and the tattoo business in the US. *Curr Probl Dermatol* 2015;48:248–252. [PubMed: 25833652]
6. Ruby Kaur R, Kirby W, Maibach H. Cutaneous allergic reactions to tattoo ink. *J Cosmet Dermatol* 2009;8(4):295–300. [PubMed: 19958434]
7. Serup J, Hutton Carlsen K, Sepehri M. Tattoo complaints and complications: diagnosis and clinical spectrum. *Curr Probl Dermatol* 2015;48:48–60. [PubMed: 25833625]
8. Forbat E, Al-Niaimi F. Patterns of reactions to red pigment tattoo and treatment methods. *Dermatol Ther (Heidelb)* 2016;6(1):13–23. [PubMed: 26972808]
9. Liszewski W, Warshaw EM. Pigments in American tattoo inks and their propensity to elicit allergic contact dermatitis. *J Am Acad Dermatol* 2019;81(2): 379–385. [PubMed: 30731175]

10. Warshaw EM, Schlarbaum JP, Taylor JS, et al. Allergic reactions to tattoos: retrospective analysis of North American Contact Dermatitis Group data, 2001–2016. *J Am Acad Dermatol* 2020;82(2):e61–e62. [PubMed: 31604096]
11. Laux P, Tralau T, Tentschert J, et al. A medical-toxicological view of tattooing. *Lancet* 2016;387(10016):395–402. [PubMed: 26211826]
12. Schubert S Patch test panel for epidemiological surveillance of tattoo allergens in tattoo products. Paper presented at: 4th European Congress on Tattoo and Pigment Research; Bern, Switzerland; 2019:66.
13. Hauksson I, Pontén A, Isaksson M, et al. Formaldehyde in cosmetics in patch tested dermatitis patients with and without contact allergy to formaldehyde. *Contact Dermatitis* 2016;74(3):145–151. [PubMed: 26696132]
14. Aalto-Korte K, Kuuliala O, Suuronen K, et al. Occupational contact allergy to formaldehyde and formaldehyde releasers. *Contact Dermatitis* 2008;59(5): 280–289. [PubMed: 18976378]
15. Hauri U Pigments, Preservatives and Impurities in Tattoo Ink. 2014:1–14.
16. Hauksson I, Pontén A, Gruvberger B, et al. Skincare products containing low concentrations of formaldehyde detected by the chromotropic acid method cannot be safely used in formaldehyde-allergic patients. *Br J Dermatol* 2016;174(2):371–379. [PubMed: 26480304]
17. Lim H-H, Shin H-S. Sensitive determination of volatile organic compounds and aldehydes in tattoo inks. *J Chromatogr Sci* 2017;55(2):109–116. [PubMed: 27799251]
18. Flyvholm MA, Hall BM, Agner T, et al. Threshold for occluded formaldehyde patch test in formaldehyde-sensitive patients. Relationship to repeated open application test with a product containing formaldehyde releaser. *Contact Dermatitis* 1997;36(1):26–33. [PubMed: 9034684]
19. Serup J, Katrina HC. Patch test study of 90 patients with tattoo reactions: negative outcome of allergy patch test to baseline batteries and culprit inks suggests allergen(s) are generated in the skin through haptization. *Contact Dermatitis* 2014;71(5):255–263. [PubMed: 25040844]
20. Fregert S, Dahlquist I, Gruvberger B. A simple method for the detection of formaldehyde. *Contact Dermatitis* 1984;10(3):132–134. [PubMed: 6713848]
21. Nikle AB, Liou YL, Ericson ME, et al. Formaldehyde release from clothing and upholstery fabrics using the chromotropic acid method. *Dermatitis* 2019;30(4):255–258. [PubMed: 31136352]
22. Liou YL, Ericson ME, Warshaw EM. Formaldehyde release from baby wipes: analysis using the chromotropic acid method. *Dermatitis* 2019;30(3): 207–212. [PubMed: 31045936]
23. Bricker CF, Johnson HR. Spectrophotometric method for determining formaldehyde. *Ind Eng Chem Anal Ed* 1945;17(6):400–402.
24. Flyvholm MA, Tiedemann E, Menné T. Comparison of 2 tests for clinical assessment of formaldehyde exposure. *Contact Dermatitis* 1996;34(1):35–38. [PubMed: 8789223]
25. Sawicki E, Hauser TR, McPherson S. Spectrophotometric determination of formaldehyde and formaldehyde-releasing compounds with chromotropic acid, 6-amino-1-naphthol-3-sulfonic acid (J acid), and 6-anilino-1-naphthol-3-sulfonic acid (phenyl J acid). *Anal Chem* 1962;34(11):1460–1464.
26. Nikle A, Ericson M, Warshaw E. Formaldehyde release from US personal care products: chromotropic acid method analysis. *Dermatitis* 2019;30(1):67–73. [PubMed: 30570583]
27. Ham JE, Siegel P, Maibach H. Undeclared formaldehyde levels in patient consumer products: formaldehyde test kit utility. *Cutan Ocul Toxicol* 2019;38(2):112–117. [PubMed: 29719992]
28. Rosenbaum BE, Milam EC, Seo L, et al. Skin care in the tattoo parlor: a survey of tattoo artists in New York City. *Dermatology* 2016;232(4):484–489. [PubMed: 27287431]
29. Honda T, Egawa G, Grabbe S, et al. Update of immune events in the murine contact hypersensitivity model: toward the understanding of allergic contact dermatitis. *J Invest Dermatol* 2013;133(2):303–315. [PubMed: 22931926]
30. Silvestre MC, dos Reis VMS, Sato MN. Innate immunity and effector and regulatory mechanisms involved in allergic contact dermatitis. *An Bras Dermatol* 2018;93(2):242–250. [PubMed: 29723367]
31. Sperry K Tattoos and tattooing II: gross pathology, histopathology, medical complications, and applications. *Am J Forensic Med Pathol* 1992;13(1):7–17. [PubMed: 1585890]

32. Bendsoe N, Hansson C, Sterner O. Inflammatory reactions from organic pigments in red tattoos. *Acta Derm Venereol* 1991;71:70–73. [PubMed: 1676223]
33. Bil W, van der Bent SAS, Spiekstra SW, et al. Comparison of the skin sensitization potential of 3 red and 2 black tattoo inks using interleukin-18 as a biomarker in a reconstructed human skin model. *Contact Dermatitis* 2018; 79(6):336–345. [PubMed: 30136287]

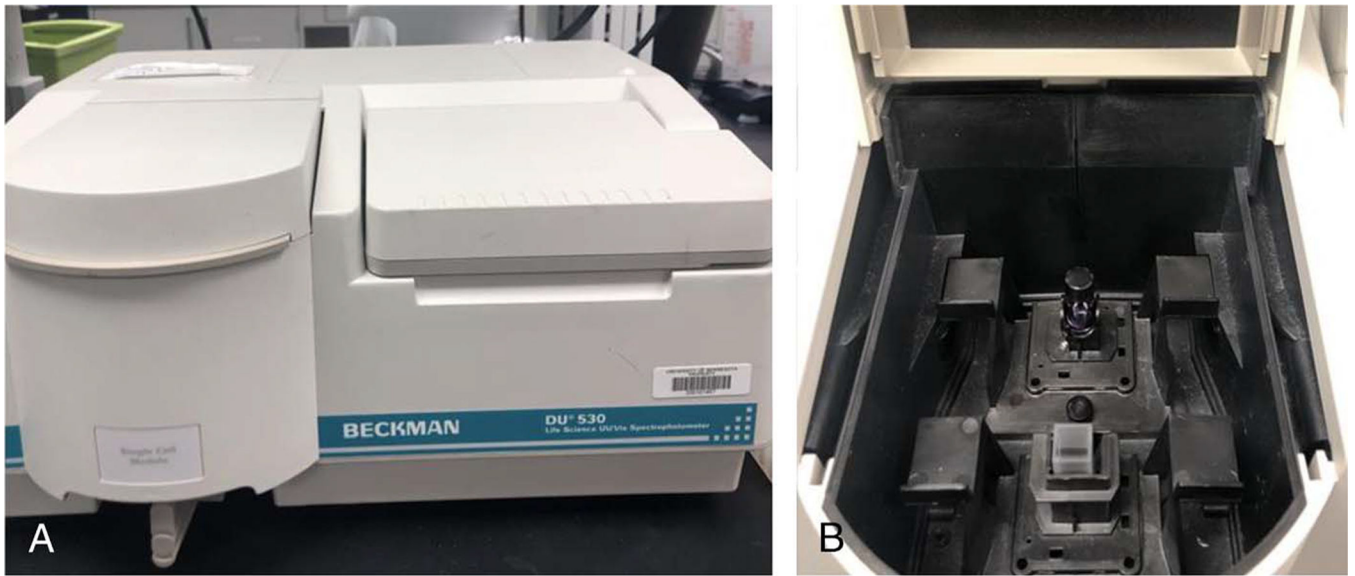
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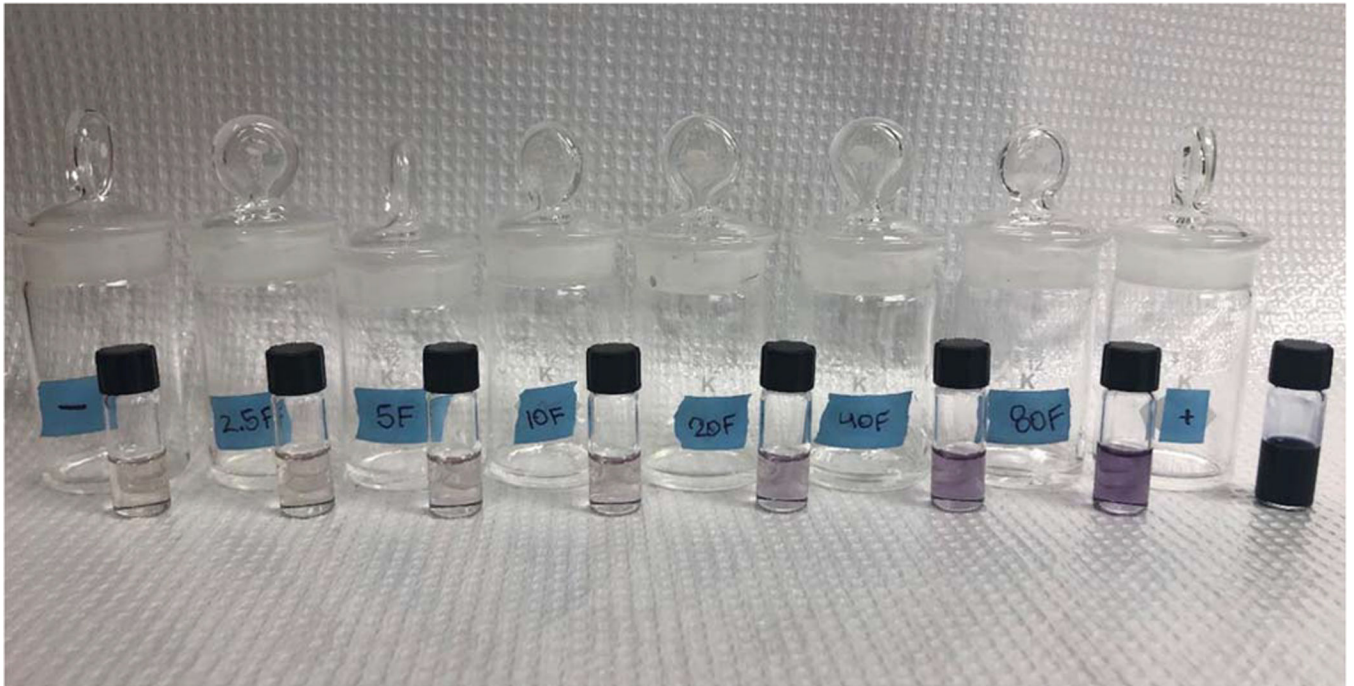
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**Figure 1.**  
A, Beckman DU 640 UV-VIS spectrophotometer. B, Each glass vial containing chromotropic acid solution is placed in the reading chamber of the spectrophotometer.



**Figure 2.** Standard formaldehyde titrations. Concentration ranged from 2.5 to 80 ppm. Distilled water and 0.1% formaldehyde as negative and positive controls, respectively.

TABLE 1.

inks

|         | Common             |                    |         |                      |                            |                      |              |              |                     |                     | Uncommon |            |        |        |           |                           |           |                    |         |  | Rare |  |  |
|---------|--------------------|--------------------|---------|----------------------|----------------------------|----------------------|--------------|--------------|---------------------|---------------------|----------|------------|--------|--------|-----------|---------------------------|-----------|--------------------|---------|--|------|--|--|
|         | Element Tattoo Ink | Eternal Tattoo Ink | Intenze | Kuro Sumi Tattoo Ink | Millennium Moms Tattoo Ink | Starbrite Tattoo Ink | World Famous | Cheyenne Ink | Fantasia Art Supply | National Tattoo Ink | One Ink* | Scream Ink | Empire | Fusion | Inksanity | Kokkai Sumi Ink (B Only)* | Solid Ink | Victory Tattoo Ink | Waverly |  |      |  |  |
| Dynamic | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |
| ◆       | ◆                  | ◆                  | ◆       | ◆                    | ◆                          | ◆                    | ◆            | ◆            | ◆                   | ◆                   | ◆        | ◆          | ◆      | ◆      | ◆         | ◆                         | ◆         | ◆                  | ◆       |  |      |  |  |

◆ produced black tattoo ink.

◆ Bl, blue; G, green; O, orange; P, purple; R, red; Y, yellow; W, white.

◆ available in PMC 2021 October 08.

*Dermatitis.* Author manuscript; available in PMC 2021 October 08.

**TABLE 2.**

## Formaldehyde Release of Tattoo Inks by Brand and Color

| Brand               | Formaldehyde Negative Ink Color (<2.5 ppm) | Formaldehyde Positive Ink Color | Estimated Formaldehyde Released (ppm) |
|---------------------|--|---------------------------------|---------------------------------------|
| Alla Prima Ink      | Titan white                                | Ruby red                        | 2.5–5                                 |
|                     |  | Brilliant yellow                | 20–40                                 |
|                     |  | Krishna blue                    | 2.5–5                                 |
|                     |  | Tangerine                       | 20–40                                 |
|                     |  | Forest green                    | 20–40                                 |
|                     |  | Violet                          | 20–40                                 |
|                     |  | Ash                             | 20–40                                 |
| Cheyenne ink        | N/A  | Chili red                       | 40–80                                 |
|                     |  | Lemon cream                     | 40–80                                 |
|                     |  | Pure blue                       | 40–80                                 |
|                     |  | Lining black                    | 20–40                                 |
| Dynamic             | N/A  | Chinese red                     | 5–10                                  |
|                     |  | Canary yellow                   | 10–20                                 |
|                     |  | BD1 (blue)                      | 10–20                                 |
|                     |  | OD-5                            | 10–20                                 |
|                     |  | Leaf green                      | 10–20                                 |
|                     |  | Lavender                        | 10–20                                 |
|                     |  | BLK (black)                     | 10–20                                 |
|                     |  | White                           | 10–20                                 |
| Electra Pro         | Fire engine red                            | Orchid                          | 5–10                                  |
|                     | Dandelion yellow                           | Solid black                     | 2.5–5                                 |
|                     | Deep blue sea                              | Mixing white                    | 2.5–5                                 |
|                     | Bright orange                              |                                 |                                       |
|                     | Forest green                               |                                 |                                       |
| Element Tattoo Ink  | Blue                                       | Red                             | 20–40                                 |
|                     | Burnt orange                               | Yellow                          | 2.5–5                                 |
|                     | Green                                      | Black                           | 2.5–5                                 |
|                     | Purple                                     |                                 |                                       |
|                     | White                                      |                                 |                                       |
| Empire              | White                                      | N/A                             |                                       |
|                     | Black                                      |                                 |                                       |
| Eternal Tattoo Ink  | Lightning yellow                           | Dark red                        | 2.5–5                                 |
|                     | True blue                                  | White                           | 2.5–5                                 |
|                     | Bright orange                              |                                 |                                       |
|                     | Jungle green                               |                                 |                                       |
|                     | Light magenta                              |                                 |                                       |
| Fantasia Art Supply | N/A  | Triple black                    |                                       |
|                     |  | Dark red                        | 10–20                                 |
|                     |  | Lite yellow                     | 10–20                                 |

| Brand                      | Formaldehyde Negative Ink Color (<2.5 ppm) | Formaldehyde Positive Ink Color | Estimated Formaldehyde Released (ppm) |
|----------------------------|--|---------------------------------|---------------------------------------|
|                            |  | Medium blue                     | 10–20                                 |
|                            |  | White                           | 10–20                                 |
|                            |  | Tribal black                    | 10–20                                 |
| Fusion                     | Golden yellow                              | Really red                      | 2.5–5                                 |
|                            | Periwinkle                                 | Power black                     | 2.5–5                                 |
|                            | Mixing white                               |                                 |                                       |
| Inksanity                  | Super white                                | Blood red                       | 20–40                                 |
|                            |  | Banana                          | 2.5–5                                 |
|                            |  | Electric blue                   | 20–40                                 |
|                            |  | Tribal black                    | 2.5–5                                 |
| Intenze                    | Bright red                                 | Lemon yellow                    | 2.5–5                                 |
|                            | Bright orange                              | Mario's blue                    | 2.5–5                                 |
|                            | Grasshopper green                          | Grape                           | 2.5–5                                 |
|                            | True black                                 |                                 |                                       |
|                            | Snow white opaque                          |                                 |                                       |
| Kokkai Sumi Ink            | N/A  | Black                           | 2.5–5                                 |
| Kuro Sumi Tattoo Ink       | N/A  | Dragon's breath red             | 5–10                                  |
|                            |  | Koi yellow                      | 2.5–5                                 |
|                            |  | Tsunami blue                    | 5–10                                  |
|                            |  | Rising sun orange               | 2.5–5                                 |
|                            |  | Oochi Momma green               | 5–10                                  |
|                            |  | Double Sumi                     | 5–10                                  |
|                            |  | White rice mixing               | 5–10                                  |
| Millennium Moms Tattoo Ink | N/A  | Monthly red *                   | 5–10                                  |
|                            |  | Hello yellow *                  | 5–10                                  |
|                            |  | Pretty boy blue *               | 2.5–5                                 |
|                            |  | Danger zone *                   | 20–40                                 |
|                            |  | Mean green *                    | 2.5–5                                 |
|                            |  | Marvelous magenta *             | 20–40                                 |
|                            |  | Black onyx *                    | 2.5–5                                 |
|                            |  | Power white opaque *            | 5–10                                  |
| National Tattoo Ink        | Red velvet                                 | Buttercup yellow                | 2.5–5                                 |
|                            | Electric blue White on white               | Triple black                    | 2.5–5                                 |
| One Ink                    | N/A  | Black                           | 2.5–5                                 |
| Scream Ink                 | N/A  | Super red                       | 10–20                                 |
|                            |  | Electric yellow                 | 10–20                                 |
|                            |  | Dodger blue                     | 10–20                                 |
|                            |  | Pitch black                     | 10–20                                 |
|                            |  | Silk white                      | 10–20                                 |
| Solid Ink                  | N/A  | Red                             | 10–20                                 |

| Brand                | Formaldehyde Negative Ink Color (<2.5 ppm) | Formaldehyde Positive Ink Color | Estimated Formaldehyde Released (ppm) |
|----------------------|--|---------------------------------|---------------------------------------|
| Starbrite Tattoo Ink | Lime green                                 | Yellow                          | 2.5–5                                 |
|                      |  | Dark blue                       | 5–10                                  |
|                      |  | Lining black                    | 2.5–5                                 |
|                      |  | White                           | 5–10                                  |
|                      |  | Crimson red                     | 2.5–5                                 |
|                      |  | Canary yellow                   | 5–10                                  |
|                      |  | Royal blue                      | 2.5–5                                 |
|                      |  | Brite orange                    | 2.5–5                                 |
|                      |  | Lavender                        | 2.5–5                                 |
|                      |  | Black outliner                  | 10–20                                 |
| Victory Tattoo Ink   | American red<br>Lemon sailfin              | Brite white                     | 10–20                                 |
|                      |  | Victoriana                      | 2.5–5                                 |
|                      |  | Snack black                     | 2.5–5                                 |
| Waverly              | N/A  | White caps                      | 20–40                                 |
|                      |  | Red                             | 20–40                                 |
| World Famous         | N/A  | Yellow                          | 40–80                                 |
|                      |  | Blue                            | 20–40                                 |
|                      |  | Black                           | 20–40                                 |
|                      |  | White                           | 10–20                                 |
|                      |  | Samuel O'Reilly red*            | 5–10                                  |
|                      |  | Canary yellow*                  | 2.5–5                                 |
|                      |  | Bangkok blue*                   | 5–10                                  |
|                      |  | Everest orange                  | 20–40                                 |
|                      |  | Ireland green*                  | 2.5–5                                 |
|                      |  | Galaxy purple                   | 5–10                                  |
| Pitch black*         | 5–10                                       |                                 |                                       |
|                      |  | Fuji Mt mixing white            | 5–10                                  |

\* Declared DMDM hydantoin.