QUALITATIVE ANALYSIS OF FORMALDEHYDE CONTENT IN NAIL POLISH PRODUCTS SOLD AT COSMETIC CLINIC X

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Abstract

Nail polish is a cosmetic product used to color and beautify nails, composed of pigments dispersed in volatile solvents that coat the natural nail surface. One of the additional ingredients sometimes found in nail polish is formalin (formaldehyde), which functions as a nail hardener. According to the Regulation of the Head of the Indonesian Food and Drug Authority (BPOM) No. 18 of 2015, the use of formalin in nail polish is permitted only if it is clearly stated on the product label with the warning "Contains Formalin," and the concentration does not exceed 5%. This study aimed to qualitatively analyze the presence of formaldehyde in nail polish products sold at Cosmetic Clinic X. The tests included organoleptic observation, packaging label inspection, and chemical identification using the chromotropic acid method and Tollens' test. The results showed that six nail polish samples tested positive for formaldehyde but did not include proper labeling as required by BPOM regulations. These findings indicate the need for stricter quality control and supervision of cosmetic products to ensure consumer safety.

Keywords: *Formaldehyde, Nail polish, Cosmetic.*

INTRODUCTION

The excessive use of formalin in nail polish formulations may cause various adverse health effects, including irritation of the eyes, nose, and throat, headaches, and skin rashes. In this study, a preliminary qualitative analysis was conducted to determine the presence of formaldehyde in nail polish products using two analytical methods: the chromotropic acid reagent combined with concentrated sulfuric acid and the Tollens precipitation test. The primary objective of this study was to determine whether nail polish products sold in cosmetic stores in Cimahi City contain formaldehyde within the concentration permitted for use as a nail-hardening agent. In addition, this study aimed to verify the conformity of the product registration numbers displayed on the packaging labels with the official database of the Indonesian Food and Drug Authority (BPOM), identify the presence of excessive formaldehyde, and evaluate product labeling

compliance with BPOM regulations.

Qualitative analysis is an analytical approach used to identify the presence of chemical elements or compounds in a sample based on their physical and chemical properties (Anonymous, 2007). According to the Regulation of the Indonesian Minister of Health No. 1175 of 2016, cosmetics are defined as substances or preparations intended for application to the external parts of the human body, including the skin, hair, nails, lips, external genital organs, teeth, and oral mucous membranes, with the purpose of cleaning, perfuming, enhancing appearance, protecting, or maintaining the body in good condition.

Nail cosmetics represent one of the most widely used categories of cosmetic products. Nails serve both physiological and aesthetic functions, acting as protective structures for the fingertips while contributing to personal appearance. Healthy nails are characterized by a proportional shape, a smooth and glossy surface, a translucent appearance that reveals the underlying nail bed, and intact periungual tissues, including the cuticle, proximal nail fold, and hyponychium. Currently, a wide range of nail care procedures is available, such as manicures, pedicures, and artificial nail applications. However, the rapid development of nail cosmetic products has been accompanied by an increasing number of reports describing adverse effects, including allergic reactions, skin irritation, infections, and even systemic toxicity resulting from exposure to chemical ingredients present in these products.

One of the most common methods of enhancing nail appearance is the application of nail polish (Ariesta, 2016). Nail polish was first introduced in the 1920s as a clear liquid coating, and in the 1930s, Charles Revson incorporated pigments to produce colored nail polish. Nail polish generally consists of pigments dispersed in volatile solvents that form a coating over the natural nail surface (Harjanti et al., 1990). This coating covers the entire nail plate and remains relatively impermeable to air for several days before being removed using organic solvents with degreasing properties (Latifah & Tranggono, 2007).

Formalin, or formaldehyde (CH_2O), is a chemical compound composed of hydrogen, oxygen, and carbon atoms (ACC, 2011). It is also known by several alternative names, including methanal, methylene oxide, methylaldehyde, and formic aldehyde. At low concentrations (<1%), formalin is commonly used as a preservative in various non-food products, such as household cleaners, fabric softeners, waxes, and carpets (Yuliarti, 2011). At higher concentrations, it serves as an effective biocidal agent against viruses, bacteria, fungi, and parasites (Whindolz et al., cited in Cahyadi, 2012). In pharmaceutical applications, formalin is used as a detoxifying agent for toxins during vaccine production and as an active ingredient in wart removal medications because of

its protein-denaturing properties (Angka, cited in Cahyadi, 2012). Therefore, investigating the presence of formaldehyde in commercially available nail polish products is essential to ensure consumer safety, particularly because excessive or inappropriate use of formaldehyde may pose significant health risks and violate applicable regulatory standards.

METHOD

This study employed a **descriptive research design**, which aims to describe the research object based on observable facts without manipulating any variables. The study focused on the qualitative analysis of formaldehyde in nail polish products sold in cosmetic stores throughout Cimahi City. Two qualitative analytical methods were used: a **visual spectrophotometric color reaction test** (color change observation using the chromotropic acid reagent) and the **Tollens test**, which detects the formation of a silver or black precipitate indicative of formaldehyde.

Population and Sample

The study population consisted of all nail polish products available in cosmetic stores across Cimahi City, Indonesia. Samples were selected using a **random sampling** technique from several cosmetic stores within the study area. A total of **10 nail polish samples** were collected. Each sample was assigned two identification codes: **1a–10a** for the chromotropic acid color test and **1b–10b** for the Tollens precipitation test.

Materials and Reagents

The laboratory equipment used in this study included **test tubes, Pasteur pipettes, a 25-mL volumetric flask, beakers, an analytical balance, glass stirring rods, and spatulas**.

The chemicals and reagents used were:

- Nail polish samples,
- **0.5% chromotropic acid solution**,
- Concentrated sulfuric acid (H_2SO_4),
- Silver nitrate ($AgNO_3$),
- Sodium hydroxide (NaOH),
- Ammonium hydroxide (NH_4OH), and
- Ethyl acetate.

Experimental Procedure

1. Sample Preparation

All laboratory equipment and reagents were prepared prior to analysis. Ten nail polish samples were collected and labeled according to the requirements of each analytical method.

2. Organoleptic Examination

Each sample was visually examined to evaluate its physical characteristics, including **appearance, color, and odor**.

3. Packaging Label Inspection

Each product label was examined to verify the completeness of mandatory information, including the **product name, manufacturer, ingredient list, registration number, expiration date, and batch number**. The registration number was subsequently verified through the official website of the **Indonesian Food and Drug Authority (BPOM)** to confirm the product's regulatory status.

4. Preparation of Reagents

Chromotropic Acid Reagent (0.5%)

A 0.5% chromotropic acid solution was prepared by dissolving **125 mg of chromotropic acid** in concentrated sulfuric acid and adjusting the final volume to **25 mL**.

Tollens Reagent

The Tollens reagent was prepared by dissolving **2.5 g of sodium hydroxide (NaOH)** in **25 mL of distilled water** and **2.5 g of silver nitrate ($AgNO_3$)** in another **25 mL of distilled water**. The two solutions were mixed, followed by the gradual addition of **25 mL of ammonium hydroxide (NH_4OH)** until a clear solution was obtained.

5. Identification of Formaldehyde Using the Chromotropic Acid Method (Color Test)

Each nail polish sample was placed in a test tube, followed by the addition of the chromotropic acid reagent previously mixed with concentrated sulfuric acid. The appearance of a **purple to reddish-purple coloration** was interpreted as a positive indication of formaldehyde.

6. Identification of Formaldehyde Using the Tollens Test (Precipitation Test)

Silver nitrate solution was mixed with sodium hydroxide solution until a precipitate formed. Ammonium hydroxide was then added dropwise until the precipitate completely dissolved, producing the Tollens reagent. Nail polish samples previously dissolved in **5–10 drops of ethyl acetate** were subsequently added to the reagent. The formation of a **silver or black precipitate within 10 minutes** was interpreted as a positive result for formaldehyde.

Data Analysis

The experimental data were analyzed descriptively based on the observed **color changes** in the chromotropic acid test and the **formation of silver or black precipitates** in the Tollens test. In addition, product labels were evaluated for compliance with **BPOM cosmetic labeling regulations**. The findings were summarized in tabular form, indicating whether each nail polish sample tested **positive or negative** for formaldehyde.

RESULTS

The qualitative analysis of formaldehyde in nail polish products obtained from cosmetic stores in Cimahi City generated data from organoleptic evaluation, packaging label inspection, BPOM registration verification, and formaldehyde identification using the **0.5% chromotropic acid method** and the **Tollens test**.

3.1 Organoleptic Evaluation

The organoleptic evaluation was performed to observe the physical appearance, color, and odor of each nail polish sample. Visual inspection showed that all samples were in liquid form with different color variations and exhibited the characteristic odor commonly associated with nail polish formulations.

Table 1. Organoleptic Characteristics of Nail Polish Samples

Sample	Physical Form	Color	Odor
1	Liquid	Clear	Characteristic
2	Liquid	Clear	Characteristic
3	Liquid	Metallic Salmon	Characteristic
4	Liquid	White	Characteristic
5	Liquid	Dark Pink	Characteristic
6	Liquid	Clear	Characteristic
7	Liquid	Yellow	Characteristic
8	Liquid	Metallic Pink	Characteristic
9	Liquid	Clear	Characteristic
10	Liquid	White	Characteristic

These findings indicate that all samples exhibited the normal physical characteristics expected for commercial nail polish products, including the typical odor of volatile solvents and resin components commonly used in cosmetic formulations.

3.2 Packaging Label Inspection

Packaging labels were examined to evaluate the completeness of mandatory product information, including the product name, manufacturer's name, ingredient list, registration number, expiration date, and batch number.

Table 2. Packaging Label Inspection Results

Sample	Product Name	Manufacturer	Ingredients	Registration No.	Expiration Date	Batch No.
1	Present	Present	Present	Present	Absent	Absent
2	Present	Present	Present	Present	Present	Present
3	Present	Present	Present	Present	Present	Present
4	Present	Present	Present	Present	Present	Present
5	Present	Present	Present	Present	Absent	Absent
6	Present	Present	Present	Present	Present	Present
7	Present	Absent	Absent	Absent	Absent	Absent
8	Present	Present	Present	Present	Present	Present
9	Present	Present	Present	Present	Present	Present
10	Present	Absent	Absent	Absent	Absent	Absent

The inspection revealed that several products lacked mandatory information, including the manufacturer's name, expiration date, and batch number. These omissions do not comply with the requirements stipulated in **BPOM Regulation No. 23 of 2019 on Technical Requirements for Cosmetic Products**.

3.3 Verification of BPOM Registration Numbers

The registration numbers displayed on each product label were verified through the official website of the Indonesian Food and Drug Authority (BPOM).

Table 3. Verification of BPOM Registration Numbers

Sample	Registration Number	BPOM Status
1	Available	Registered
2	Available	Registered
3	Available	Registered
4	Available	Registered
5	Available	Registered
6	Available	Registered
7	Not Available	—
8	Available	Registered
9	Available	Registered
10	Not Available	—

The verification results showed that **eight of the ten samples possessed valid BPOM registration numbers**, whereas **Samples 7 and 10 lacked registration numbers**, suggesting that these products were not officially registered with BPOM.

3.4 Identification of Formaldehyde

Formaldehyde identification was performed using the **0.5% chromotropic acid reagent** mixed with concentrated sulfuric acid. A **purple to reddish-purple color change** was interpreted as a positive indication of formaldehyde.

The qualitative analysis revealed that **six of the ten nail polish samples tested positive for formaldehyde**. However, **none of the positive samples displayed the mandatory warning statement, "Contains Formalin," on their product labels**, as required by **BPOM Regulation No. 18 of 2015 concerning Cosmetic Ingredients**.

These findings indicate that although several nail polish products contained formaldehyde, they failed to comply with the mandatory labeling requirements established by the Indonesian Food and Drug Authority. Such non-compliance may expose consumers to potential health risks due to inadequate disclosure of hazardous ingredients.

Table 4. Qualitative Identification of Formaldehyde Using the Chromotropic Acid Method

Sample	Before Reaction	After Reaction	Result
1a	Clear	Yellow	Negative (−)
2a	Clear	Red	Positive (+)
3a	Metallic Salmon	Yellowish Brown	Negative (−)
4a	White	Cloudy Yellow	Negative (−)
5a	Dark Pink	Purplish Red	Positive (+)
6a	Clear	Deep Red	Positive (+)
7a	Yellow	Deep Red	Positive (+)
8a	Metallic Pink	Red	Positive (+)
9a	Clear	Red	Positive (+)
10a	White	Deep Red	Positive (+)

The chromotropic acid assay demonstrated that Samples 2a, 5a, 6a, 7a, 8a, 9a, and 10a exhibited a distinct red to deep reddish-purple coloration, indicating a positive reaction for formaldehyde. In contrast, Samples 1a, 3a, and 4a showed only yellow or yellowish-brown color changes and were therefore classified as negative for formaldehyde. The variation in color intensity among the positive samples may be attributed to differences in the formulation and chemical composition of the individual nail polish products, which can influence the chromotropic acid reaction. This qualitative method effectively distinguished between samples containing formaldehyde and those without detectable levels of the compound.

Table 5. Qualitative Identification of Formaldehyde Using the Tollens Test

Sample	Before Reaction	After Reaction	Result
1b	Clear	No precipitate	Negative (−)
2b	Clear	Brown precipitate with slight black coloration	Positive (+)
3b	Metallic Salmon	No precipitate	Negative (−)
4b	White	Black precipitate formed	Positive (+)
5b	Dark Pink	Black precipitate formed	Positive (+)
6b	Clear	Dark brown precipitate formed	Positive (+)
7b	Yellow	No precipitate	Negative

			(−)
8b	Metallic Pink	Black precipitate formed	Positive (+)
9b	White	Blackish-silver precipitate formed	Positive (+)
10b	White	Blackish-silver precipitate formed	Positive (+)

The presence of formaldehyde was further evaluated using the **Tollens test**, in which a positive reaction was indicated by the formation of a **silver or black precipitate**. As presented in **Table 5**, **Samples 2b, 4b, 5b, 6b, 8b, 9b, and 10b** produced brown, black, or blackish-silver precipitates and were therefore classified as **positive for formaldehyde**. Conversely, **Samples 1b, 3b, and 7b** showed **no precipitate formation**, indicating negative results.

Table 6. Labeling Compliance of Nail Polish Samples

Sample	Chromotropic Acid Test	Tollens Test	Labeling ("Contains Formalin")
1	Yellow (−)	No precipitate (−)	Not Applicable
2	Red (+)	Brown precipitate with slight black coloration (+)	Absent
3	Yellowish Brown (−)	No precipitate (−)	Not Applicable
4	Cloudy Yellow (−)	Black precipitate (+)	Absent
5	Purplish Red (+)	Black precipitate (+)	Absent
6	Deep Red (+)	Dark brown precipitate (+)	Absent
7	Deep Red (+)	No precipitate (−)	Absent
8	Red (+)	Black precipitate (+)	Absent
9	Red (+)	Blackish-silver precipitate (+)	Absent
10	Deep Red (+)	Blackish-silver precipitate (+)	Absent

Discussion

Nail polish is one of the most widely used cosmetic products for enhancing the appearance of natural nails. It is available in various colors and formulations and is popular among consumers because of its affordability, accessibility, and widespread availability in cosmetic stores. In the present study, ten commercially available nail polish samples representing different colors were collected from cosmetic stores in Cimahi City. One of the additives commonly incorporated into nail polish formulations is **formalin (formaldehyde)**, which functions as a nail-hardening agent and as a cross-linking resin that improves adhesion of the polish to the nail surface. However, prolonged exposure to formaldehyde may result in toxic effects because the compound can penetrate the nail plate and be absorbed through the surrounding skin. Exposure through inhalation, dermal contact, or accidental ingestion has been associated with adverse health effects,

including skin irritation, allergic reactions, dermatitis, respiratory irritation, and systemic toxicity following repeated exposure. Since nail polish is often applied repeatedly over extended periods, the presence of formaldehyde in these products may pose a significant health risk to consumers.

The qualitative analysis began with an **organoleptic examination**, including observations of physical appearance, color, and odor. All ten samples were found to be liquid formulations with varying colors and the characteristic odor typically associated with nail polish products. Nevertheless, the characteristic odor of formaldehyde could not be distinguished because it was likely masked by the volatile solvents, fragrances, and other formulation ingredients. Consequently, organoleptic examination alone was considered insufficient for detecting formaldehyde, highlighting the necessity of subsequent chemical analyses.

Packaging label inspection was then conducted to assess compliance with regulatory labeling requirements, including the presence of the product name, manufacturer's name, ingredient list, BPOM registration number, expiration date, and batch number. This evaluation is essential because cosmetic products marketed in Indonesia are required to comply with BPOM regulations to ensure product quality and consumer safety. The inspection revealed that **Samples 7 and 10** lacked critical information, including the manufacturer's identity, batch number, and BPOM registration number, indicating that these products did not meet the minimum regulatory requirements and could therefore be considered unregistered cosmetic products. Furthermore, **Samples 1, 5, 7, and 10** did not display expiration dates. Verification through the official BPOM database confirmed that all products bearing registration numbers were officially registered, whereas the two products without registration numbers were not listed in the BPOM database.

Chemical identification of formaldehyde was subsequently performed using the **0.5% chromotropic acid method** and the **Tollens test**. In the chromotropic acid assay, a positive reaction was indicated by the appearance of a **purple to reddish-purple coloration**, whereas a positive Tollens reaction was characterized by the formation of a **silver or black precipitate**. The chromotropic acid test demonstrated that **Samples 1a, 3a, and 4a** remained yellow or yellowish-brown and were therefore classified as negative for formaldehyde. Conversely, **Samples 2a, 5a, 6a, 7a, 8a, 9a, and 10a** exhibited reddish-purple color changes, indicating the presence of formaldehyde. Differences in color intensity among positive samples may be attributed to variations in the chemical composition and additives present in individual nail polish formulations, which can influence the chromotropic acid reaction.

The Tollens test produced results generally consistent with those of the chromotropic acid assay. **Samples 1b, 3b, and 7b** showed no precipitate formation and were interpreted as negative, whereas **Samples 2b, 4b, 5b, 6b, 8b, 9b, and 10b** produced brown, black, or blackish-silver precipitates, indicating the presence of formaldehyde. The slight discrepancy observed for **Sample 7**, which tested positive using the

chromotropic acid method but negative in the Tollens test, may be attributed to differences in the sensitivity and specificity of the two qualitative analytical methods or to interference from other chemical constituents present in the sample.

According to **BPOM Regulation No. 18 of 2015 concerning Cosmetic Ingredients**, formaldehyde is permitted in nail polish formulations only within the prescribed concentration limits and must be accompanied by the mandatory warning statement **"Contains Formalin"** on the product label. However, none of the formaldehyde-positive samples identified in this study displayed the required warning statement. These findings demonstrate that all positive samples failed to comply with the applicable BPOM labeling requirements. Furthermore, the results indicate that the presence of a valid BPOM registration number does not necessarily guarantee that a product is free from formaldehyde or fully compliant with labeling regulations. Several registered products tested positive for formaldehyde, whereas one unregistered product yielded negative results. These findings highlight the need for continuous post-market surveillance and stricter regulatory enforcement to ensure cosmetic product safety. They also emphasize the importance of increasing consumer awareness regarding the selection of cosmetic products that are legally registered, appropriately labeled, and manufactured in accordance with established safety standards.

CONCLUSION

Based on the qualitative analysis of ten nail polish samples collected from cosmetic stores in Cimahi City, the following conclusions can be drawn:

1. Two of the ten nail polish samples (Samples 7 and 10) did not display BPOM registration numbers and were not listed in the official database of the Indonesian Food and Drug Authority (BPOM), indicating that these products were not officially registered.
2. Two samples (Samples 1 and 3) consistently tested negative for formaldehyde in both the chromotropic acid color test and the Tollens precipitation test, indicating the absence of detectable formaldehyde.
3. Six samples (Samples 2, 5, 6, 8, 9, and 10) were consistently identified as positive for formaldehyde by both qualitative analytical methods. Among these six confirmed positive samples, only Sample 10 was not registered in the official BPOM database.
4. None of the six formaldehyde-positive samples displayed the mandatory warning statement, “Contains Formalin,” on their product labels, as required by BPOM Regulation No. 18 of 2015 concerning Cosmetic Ingredients. These findings demonstrate non-compliance with the applicable labeling regulations and indicate the need for improved regulatory oversight of cosmetic products marketed in Indonesia.

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