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Determination of formol in samples of hair-straightening products

Determinação de formol em amostras de produtos de alisamento capilar

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Abstract

The objective of the present work was to determine the contents of formol (formaldehyde) in hair-straightening products used in various beauty salons. Formol can cause damages to hair, it is also toxic and carcinogenic in the medium term. Despite being banned by the Brazilian Health Surveillance Agency (ANVISA) it is frequently utilized, being disguised with flavorings, and its presence is not noted on product labels. Therefore, the study was intended to evaluate levels of formol in samples taken in the city of Rolandia (Paraná State, Brazil), where the surveillance does not always take place. The determined values ranged from 5.37 to 10.65 %.
Keywords: Formol (formaldehyde). Hair straightening. Progressive brush.

Resumo

O objetivo deste trabalho foi determinar o conteúdo de formol (formaldeído) em produtos de alisamento capilar usado em vários salões de beleza. O formol pode causar danos aos cabelos e é tóxico e carcinogênico em doses moderadas .Apesar de ser proibido pela Agência Nacional de Vigilância Sanitária (ANVISA) é freqüentemente utilizado, sendo disfarçado com aromas, e sua presença não é notada nos rótulos dos produtos. Portanto, o estudo teve como objetivo avaliar os níveis de formol em amostras colhidas na cidade de Rolândia (Paraná, Brasil), onde a vigilância nem sempre acontecem. Os valores determinados variaram de 5,37-10,65%.
Palavras-chave: Formol (formaldeído). Alisamento capilar. Escova progressiva.

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Introduction

To follow the standards of beauty imposed by the contemporary society, men undergo treatments and use trendy products that promise miraculous results, being unaware of the consequences.

Hair has become indispensable in the construction of a personal identity, and it can be loosely modified with discoloring, painting and straightening.

Hair straightening consists in the permanent breakage of disulfide bonds that maintain the dimensional structure of the keratin molecule in its original rigid form. It can be achieved by using either sodium, lithium, potassium and guanidine (calcium hydroxide and guanidine carbonate) hydroxides, or ammonium and ethanolamine bisulfites and thioglycolates, or formol (AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA – ANVISA, 2009; DRAELOS, 2008).

Progressive brush, containing formol as main ingredient, appears to be the best-known hair-straightening method. Its effect lasts for one to four months. Besides, it has a more affordable price on the market, and it is easy to use.

Formol is a 37% formaldehyde solution, the sales of which are prohibited at pharmacies. This solution is empirically mixed with liquid keratin, consisting of positively charged amino acids, and with a cream conditioner. The final product is applied to the hair and spread by using a comb. Then, the hair is dried and flat-ironed. Formaldehyde binds to cuticle proteins and hydrolyzed keratin amino acids to form stiff films on the hair, thus making it water-repellent, hard and straight (LEWIS; TATKEN, 1989).

Formol as preservative was allowed on the cosmetic market at concentrations up to 0.2%, but since 2009 it has been considered toxic, and its use has been forbidden by the Brazilian Health Surveillance Agency (ANVISA). Exposure to formol can cause damages to those consuming cosmetic products that contain this ingredient.

Since formol is highly volatile when heated, it may lead to the most common symptoms if inhaled: severe headaches, coughs, shortness of breath (dyspnea), dizziness and pulmonary edema. The contact with vapor or a solution can leave the superficial skin white and rough, causing strong sensations of anesthesia and necrosis on it. According to the World Health Organization (WHO), formol is associated with the risk for mouth, nose, lung, blood and head cancers (ROBBINS, 2002).

Hair straighteners are cosmetics that have been already registered with the ANVISA as Risk 2 products or require registration for their commercialization. However, the practice, now considered illegal and prohibited, suggests the addition of formol to these products in order to expand the straightening capacity (SÁ DIAS et al., 2007).

Therefore, taking into consideration the unauthorized use of formol in hair-straightening products, the present research aimed to determine its levels in several cosmetic samples.

Experimental Procedure

The method employed to analyze formol in cosmetic samples was proposed by the AOAC International and validated by Scarabelot and Michels (2008). It is based on a titration procedure using a bromothymol blue reagent (SOLOMONS, 1983).

Five samples of hair-straightening products donated by beauty salons located in the city of Rolândia (Paraná State, Brazil) were tested.

The following standard solutions were prepared: 1 mol L^{-1} sodium hydroxide (NaOH), 0.5 mol L^{-1} sulfuric acid (H_2SO_4) and 3% hydrogen peroxide (H_2O_2). All solutions were previous standardized.

A 3 g aliquot of each sample was dissolved in 50 ml of H_2O_2 and poured into a 500 mL flask containing 50 mL of NaOH. In this reaction, H_2O_2 functioned as catalyst. The mixture was heated in a water bath for 5 min and stirred occasionally.

After cooling, five drops of bromothymol blue were added to the solution.

In the flask, formol (formaldehyde), converted to formic acid, reacted with NaOH, leaving an excess of base, which was then titrated with H_2SO_4.

All tests were performed in triplicate.

Results and Discussion

The samples were taken from the salons on October 9, 2012. They were placed into plastic vials and kept under refrigeration until their analysis.

The process that occurred during the experiment can be described by the Cannizaro reaction:

$$(1)\quad HCOH + NaOH \rightarrow HCOOH + CH_3OH$$

This auto-redox reaction involves aldehyde molecules that do not have the proton bonded to the alpha carbon atom. When aldehyde is mixed with a NaOH solution, 50% of its molecules is oxidized to form carboxylic acid salts, and the other 50% is reduced to form alcohols (WICKETT, 1987).

Apart from reacting with formaldehyde to form formic acid, NaOH added to the flask also reacted with formic acid, as shown below:

$$(2)\quad HCOOH + NaOH \rightarrow HCOONa^{+} + H_2O$$

The stoichiometry of this reaction is 1:1; *i.e.*, one mole of formic acid reacts with one mole of base. Formic acid reacted with the excess of NaOH to form the corresponding salt and water. This excess was titrated with H_2SO_4, and the following reaction took place:

$$(3)\quad 2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$$

As can be seen, the stoichiometry of this reaction is 2:1, and thus, two moles of acid are required to neutralize one mole of base. The burette volumes of spent H_2SO_4 were recorded, and the percentage of formol in each sample was calculated using the following steps:

• The number of moles of formic acid:

$$(4)\quad 2(M_{H2SO4} \times V_{H2SO4}) = n_{NaOH}\ (in\ excess)$$

$$(5)\quad n_{NaOH}\ initial - n_{NaOH}\ titrated = n_{NaOH}\ that\ reacted\ with\ formic\ acid.$$

Since n_{NaOH} that reacted is equal to number of moles of formic acid in the samples, the number of moles of formic acid equal to the number of moles of formaldehyde.

• The percentage of formic acid:

The molar mass (mm) of formaldehyde is 30 g mol^{-1}. Thus, according to the equation given below:

$$(6)\quad n_{HCOH} \times mm_{HCOH} = Xg\ formol$$

In this experiment, 3 g of each sample were used; this amount is equivalent to 100%, thus the percentage of formol can be estimated as follows:

$$1 - \frac{100 \text{ x } Xg\ formol}{3g\ sample}$$

The analysis results showed very high levels of formol in all the samples. It should be observed that for Sample 4 (Table 1) the vial contained no information on formol present in the product.

However, the highest percentage value was obtained for this sample. One possible explanation is that another component having similar characteristics, such as glutaraldehyde, may have been used in place of formol.

Glutaraldehyde is a saturated dialdehyde that has been used as hair straightener since the prohibition of formol. It is commonly available as a clear aqueous solution at concentrations up to 50% (w/w). Compared to formol, this component is six to eight times more active in producing DNA-protein cross-links and about ten times more intense in causing damages to the nasal tissue after inhalation (SWAIN et al., 1979).

The table below shows the percentage and deviation values for formol present in the samples.

Table 1 – Experimental results.

Sample	% (average)
1	6.30±0.55
2	5.37±0,10
3	10.53±0,23
4	10.65±0,46
5	8.76±0,06

Fonte: Statistica, 2009

Conclusion

The percentage values obtained herein were compared with the allowable level of 0.2%, which was canceled after banning the use of formol by the ANVISA in 2009, and it can be concluded that the concentrations of formol in the samples of hair-straightening products are very high.

Since formol is toxic and causes serious damages to health, its commercialization is strictly prohibited, but products containing this component are still sold. The persons intending to straighten their hair should seek to inform themselves beforehand on cosmetic products used in salons. In turn, the beauty salons should look for other techniques involving less aggressive components.

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References

AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA – ANVISA. *Resolução – RDC nº 36, de 17 de junho de 2009.*

DRAELOS, Z. D. Hair Cosmetics. In: BLUME-PEYTAV, U.; WHITING, D. A.; TRÜEB, R. M. *Hair growth and disorders.* London: Springer, 2008. p. 499-512.

LEWIS, R. J.; TATKEN, R. L. *Registry of toxic effects of chemical substances.* Cincinnati, OH: Online Ed. National Institute for Occupational Safety and Health, 1989.

ROBBINS, C. R. *Chemical and physical behavior of human hair.* 4. ed. London: Springer. 2002.

Statistica V 9.1. For Windows: Statsoft Inc. Sofware, Tulsa, 2009

SÁ DIAS, T. C.; BABY, A. R.; KANKO, T. M.; ROBLES VELASCO M. V. Relaxing/straightenig of Afro-ethinic hair: historical overview. *Journal of cosmetic dermatology,* Oxford, v. 6, n. 1, p. 2-5, 2007.

SOLOMONS, T. W. G. *Química orgânica.* Rio de Janeiro: Livros Técnicos e Científicos, 1983. v. 3, p. 736 – 737.

WICKETT, R. R. Permanent waving and straightening of hair. *Cutis,* New York, v. 39, n. 6, p. 496-497, 1987.

SWAIN, C. G.; ARNET, L.; POWELL, A. L.; SHEPPARD, W. A.; CHARLES, R.; MORGAN, C. R. Mechanism of the Cannizzaro reaction. *Journal of the American Chemical Society*, Easton, v. 101, n. 13, p. 3576-3583, 1979.

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