MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 6 No. 1 (2025) 119-124
https://publisher.uthm.edu.my/periodicals/index.php/mari

Zinc Oxide as an Active Ingredient in Sensitive Skin Deodorant

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DOI: https://doi.org/10.30880/mari.2025.06.01.017

Article Info

Received: 01 October 2024
Accepted: 30 November 2024
Available online: 15 January 2025

Keywords

Organic deodorant, body odour, sweet almond oil, tea tree oil, essential oil, non-toxic ingredients, skin irritation

Abstract

This study investigates the benefits of Zinc Oxide (ZnO) as an active ingredient in deodorant, replacing aluminium (Al) compounds that usually present in conventional deodorant that caused harmful effects to human skin. The goals of this study are to produce a sensitive skin friendly deodorant using ZnO powder as the main ingredient. Besides, sweet almond oil (SAO), tea tree oil (TTO) and essential oil (EO) were added as an alternative ingredient to help in neutralize body odor and absorbance of sweat. The deodorant was made using heating process and was analysed qualitative and quantitatively. The chemical properties were analysed via Fourier-transform infrared spectroscopy (FTIR) and pH meter. In addition, yellow stain testing was also performed to analyse the quality of the deodorant. At the end of this project, a survey was conducted among Tun Hussein Onn University of Malaysia (UTHM) students to collect their opinion on the deodorant. From the analysis, it is found that the ether compounds are the main compound lies within 3020 cm^{-1} to 2870 cm^{-1} wavelengths based on FTIR analysis. The pH value of ZnO deodorant was measured at pH 7 make it safe to be used on direct skin without any skin irritation. ZnO deodorant was also tested on white cloth within 7 days observation and leaved partially visible white stain on the cloth that is easily removed using cold water. This study concluded that ZnO is a beneficial alternative in deodorant and consumer's feedback shows a positive reception to the new formulation of the deodorant.

1. Introduction

According to research performed by previous researcher, Aluminium (Al) is found in numerous cosmetic products such as deodorants, antiperspirants, lipsticks, and sunscreens [1]. It was frequently utilized as the active deodorant agent in underarm cosmetics and served as a significant route of exposure to the human body, posing a potential source of harm. In vitro research has indicated that Al from deodorants permeated viable human-stripped skin. The evident toxicity of Al has been well-demonstrated, and recent studies strongly suggested its potential involvement in carcinogenic processes. Presently, Al was under suspicion for its potential role in breast cancer. Recent investigations conducted on cultured cells support the hypothesis that this metal accumulate in the

mammary gland, selectively disrupting the biological properties of breast epithelial cells and potentially initiating a sequence of alterations reminiscent of the initial stages of malignant transformation [2].

By using ZnO as the main ingredient to create the skin-safe deodorant, this non-toxic element helped to control the growth of odour-causing bacteria on the skin. This contributed to the deodorant's effectiveness in minimizing or preventing body odour. As the element was non-toxic, there was no evidence of carcinogenicity, genotoxicity, or reproduction toxicity in humans in any report [3] because according to European Union (EU) hazard classification, ZnO was classified as ecotoxic (N; R50-53) [4]. For individuals who had active lifestyles that required long-lasting freshness, ZnO was beneficial due to its ability to provide long-lasting protection against odour. ZnO could give a soothing and mild effect, thus making it gentle for human skin. ZnO was also able to calm irritations and treat itch since it prevented mast cell degranulation as well as lowering histamine secretion that might aggravate itching. For individuals who had sensitive skin, deodorants that used ZnO made it a suitable choice for those who might experience irritation from other deodorant ingredients [5]. Hence, this project was proposed to produce deodorant that uses ZnO as an alternative to Al in order to prevent the rashness of the skin.

2. Materials and Method

Materials that were used in this research are 40 ml of sweet almond oil (SAO), 6 g of ZnO, 8 g of beeswax, 3 g of arrowroot powder, 0.03 g of activated charcoal, 0.6 ml of tree tea oil (TTO) and 1.2 ml of essential oil (EO). Essential oil that is being used is spearmint, vanilla and citrus orange. By adding citrus scent to deodorant, it could help promote a refreshing and fruity smell to the users [6].

2.1 Concentration of ZnO, TTO and EO

Despite all the benefits and antimicrobial properties of EO, high concentration of EO that directly being applied onto skin can cause toxicity to humans. According to a previous study, the safe volume-to-volume percentage (v/v) concentration of EO that is safe to be applied on human skin needs to be 1-3% v/v to the carrier oil, which in this study, is SAO. In this study, 2%v/v of EO and 1% v/v of TTO were used in deodorant formulation [7].

The accurate data on the ratio and concentration of ingredients in various types of deodorants could vary depending on the desired formulation and texture. In typical deodorants, active ingredients usually contained about 10%w/v to 25%w/v [8]. The FDA also determined that ZnO was safe for use in cosmetic products in concentrations up to 25%. Since powdered ZnO was the active ingredient in the deodorant that was prepared.

2.2 ZnO Deodorant Preparation

40 ml of SAO was poured into a beaker and placed into a hot magnetic stirrer. After the SAO has achieved temperature of 35℃, approximately 6 g of ZnO was poured into the beaker. The mixture was stirred until all the powder of ZnO homogenously blended with SAO. Afterwards, 3 g of arrowroot powder was poured into the homogenous mixture and stirred thoroughly. Next, approximately 0.03 g of activated charcoal was added into the mixture that caused the sample to change colour from cream white to off-white. While in stirring mode, about 8 g of beeswax was added into the mixture until all the wax melted and homogeneously blended. Finally, approximately 0.6 ml of TTO and 1.2 ml of EO (vanilla, spearmint, and orange) was poured into the mixture and stirred continuously for 1 minute.

The mixture was allowed to cool for 5 minutes before being transferred into a grinder. The sample was grinded until there was no powder from ZnO, arrowroot and charcoal to ensure the sample was in a creamy texture as shown in Fig. 1 (a). After achieving the thick and creamy texture, the prepared sample was carefully transferred into a deodorant tube using a syringe to ensure the absence of any air bubbles on the tube as shown in Fig. 1 (b). The deodorant sample was then tested for pH, the functional group via Fourier-transform infrared (FTIR) spectroscopy, stain testing and questionnaire survey.

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(a) (b)

Fig. 1 *Creamy texture of ZnO deodorant*

3. Results and Discussion

3.1 pH

By using a pH strip, it was observed that the pH of ZnO deodorant is pH 7. The suitable pH for deodorant is mostly cited to be in the range 4 to 7. This is called 'pH-balanced' deodorant as it helps to maintain good skin, reduce odor-causing bacteria, and effectively prevent bacterial growth [5].

3.2 FTIR Analysis

The chemical analysis of ZnO deodorant via FTIR spectroscopy is shown in Fig. 2 and the functional groups are tabulated in Table 1.

Table 1 *Matching Functional Group from FTIR sample result*

Functional Group	Wavelength range (cm^{-1})
Ether	3020-2870
Aromatic amide	1480-1435
Aromatic Sulfonic acid	1420-1360
Carboxylic acid	1315-1220
Amino acid	3600-3200

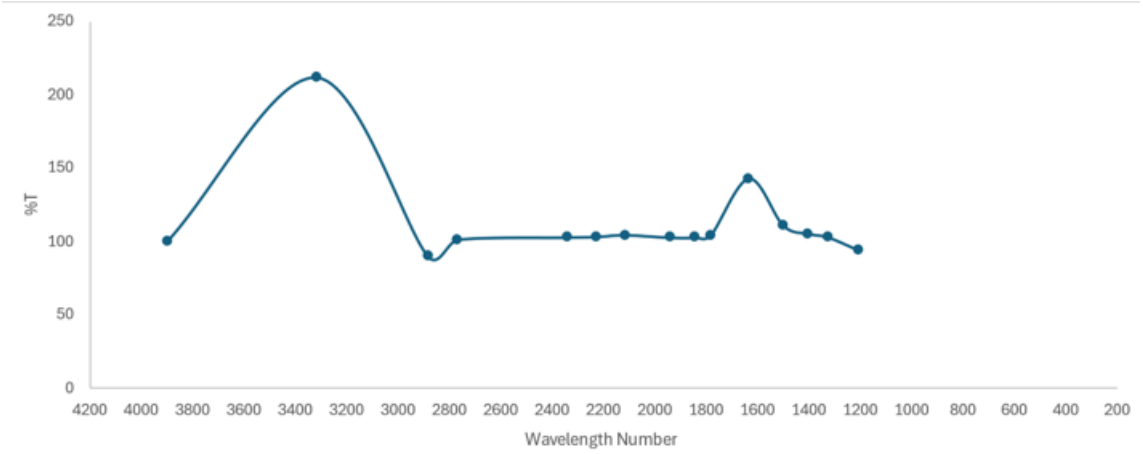

Fig. 2 *Functional group analysis of ZnO deodorant via FTIR analysis*

Ether works as skin conditioning as it can give hydration to the underarm skin. The main ingredient that focuses on moisturizing the skin is SAO. Aromatic amide works as stabilizer in the deodorant sample coming from the beeswax used to mix ZnO powder and SAO together. Aromatic sulfonic acid is a buffering ingredient which makes the pH of the deodorant to be neutral, pH 7. The ingredients used to make the pH of the sample become neutral are activated charcoal. Moreover, sulfonic acid can ensure the smoothness of the skin while preventing acne, itchiness and dryness of the skin. Carboxylic acid works as an antioxidant which can prevent the skin from aging while improving the retention of moisture inside the skin cells. Amino acid can heal damaged skin, maintain the normal biological function of the under am skin cells and protects from sun ultraviolet light. These functional groups come from the oils used during the preparation of deodorant, which is SAO, TTO and EO.

3.3 Yellow Stain

ZnO deodorant was tested on white cloth by applying it every day for seven days to see if it would leave any stain on the white cloth. Fig. 3 shows the stain of the deodorant sample of white cloth after day seven. From the observation, the deodorant samples leave white stain on the cloth as the pigment of the ZnO and arrowroot powder is white. However, the stain can be easily removed using cold water. For comparison, the same test was performed using commercial deodorant. Unfortunately, a similar stain was observed but difficult to remove using the same approach. This is due to the Al-based compounds contained in the deodorant that are effective in reducing sweat by temporarily blocking sweat ducts. A chemical reaction will occur when Al compounds mix with the salts and proteins held in sweat. This reaction can lead to the formation of yellowish compounds that deposit on the fabric, creating stains [5].

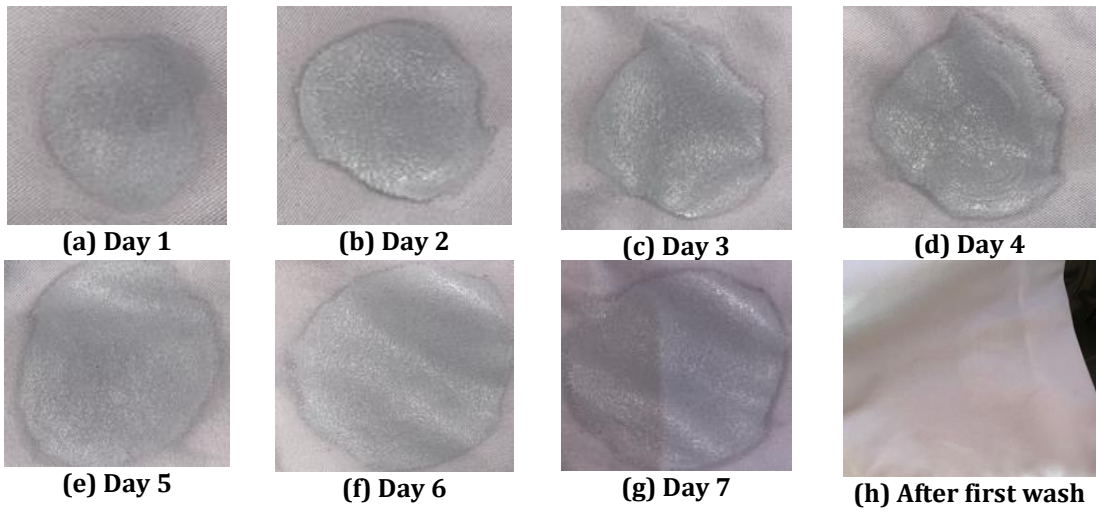

Fig. 3 *Stain on white cloth was observed after seven days of application of the ZnO deodorant*

The stain can be removed after being washed using a washing machine. This indicates the ingredients used for ZnO deodorant will not cause a permanent dirt on cloth.

3.4 Quantitative Survey

The survey was conducted among 20 respondents from the second-year students of Diploma in Engineering Technology (2DAK). From the value, it is calculated that about 33% of the population of 2DAK was involved during this survey, which 61.9% are females while the other 38.1% are male. This survey might help in providing initial insights into the end users' preferences and suggestions for product improvement in future. During the survey session, there were two samples which are Deodorant A (commercial deodorant) and Deodorant B (ZnO deodorant). Deodorant A and Deodorant B were filled in separated tubes and the respondents were tested blindly. There were three general questions about deodorant usage habits which included the frequency of using deodorant, type of deodorant and their skin sensitivity from the usage of deodorant. From the analysis, 90.5% of respondents used deodorant daily. Besides, almost 47.6% of the respondents are having a sensitive skin problem towards a cosmetic product. Table 2 tabulated the findings from the survey.

Deodorant B was favoured by 61.9% of respondents, while only 38.1% prefer Deodorant A in terms of scent and pleasant smell. From the product label, Deodorant A, which is a commercial deodorant has vanilla essence that gives a sweet smell. In other hand, Deodorant B contain spearmint scent that is refreshing, as per claimed by most respondent during the interview. to be scent instead of sweet scent. This data suggests that Deodorant B has a significantly higher appeal among the respondents.

Table 2 *Percentage of respondents that chose Deodorant A and Deodorant B based on variable*

Variable	Deodorant A (%)	Deodorant B (%)
Scent	38.1	61.9
Texture	14.3	85.7
Absorption	23.8	76.2
Moisture	4.8	95.2

For preferable texture, 85.7% of respondents prefer the creamier texture of Deodorant B that is similar to hand lotion texture. Meanwhile, only 14.3% preferred the texture of Deodorant A that is thicker and viscous. Deodorant B has a higher absorption period compared to Deodorant A where 78.2% of the respondents chose Deodorant B and the rest of 23.8% respondents chose Deodorant A.

Finally, 95.2% of the respondents chose Deodorant B over Deodorant A in terms of moisture effect after applied on the skin. This is most probably caused by the soothing ingredients that are added during the preparation of the sample. They also agreed that Deodorant A makes the skin feel tight and dry after each application.

4. Conclusion

ZnO helps to provide a natural antibacterial property. This can help in reducing the body odor smell that is produced by bacteria growth on the skin. The duality of ZnO helps in promoting odor control and skin protection that most people looking for solutions for hygienic and skin problems. Other than that, ZnO also is suitable for most skin types, even those with sensitive skin, which makes it a flexible component for products that target a wide range of customers. Through chemical analysis, the study clarified the deodorant's composition, discovering important components like zinc oxide and other elements that support both its safety and effectiveness. This study aids in comprehending the interactions between these components and how they affect the product's overall performance. Other than that, the usage of pH paper and Fourier Transform Infrared Spectroscopy (FTIR) has been used to make sure the product fulfils customer expectations for application ease and overall experience in addition to operating as intended. The research assessed the deodorant's physical characteristics, including its texture, colour, and sensory elements by doing quantitative testing. The texture of ZnO deodorant is like any other conventional deodorant but giving more moisture into skin and the odour last longer than conventional deodorant. From the quantitative survey that collected data of scent, texture, absorption and moisture, majority of the respondents satisfied with the ZnO deodorant. For future research, it is suggested that the ZnO deodorant must be undergo dermatological tests to ensure the effectiveness and safety of the ingredients in the ZnO deodorant.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Fatin Khadijah Roslan, Clijster Taib, Siti Noraiza Ab Razak* ***data collection:*** *Alif Aiman Azhar, Clijster Anak Taib, Fatin Khadijah Roslan;* ***analysis and interpretation of results:*** *Fatin Khadijah Roslan, Clijster Taib, Siti Noraiza Ab Razak;* ***draft manuscript preparation:*** *Siti Noraiza Ab Razak, Clijster Taib. All authors reviewed the results and approved the final version of the manuscript.*

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