Article DOI : https://doi.org/10.37284/eajass.7.1.1966

East African Journal of Arts and Social Sciences
eajass.eanso.org
Volume 7, Issue 1, 2024
Print ISSN: 2707-4277 | Online ISSN: 2707-4285
Title DOI: https://doi.org/10.37284/2707-4285

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics

Dr. Adebiyi Oladipupo Adeboye, PhD[1], Dr. Olajide Rahman Goriola, PhD[2], Christopher Gabriel Falode[3], Prof. Sunday Roberts Ogunduyile, PhD[4] & Prof. Catherine Oluyemisi Eromosele, PhD[1]*

[1] Federal University of Agriculture, Abeokuta, P, M.B. 2240, Abeokuta, Nigeria.
[2] Sikiru Adetona Colleje of Education, Science and Technology, P, M.B. 2240, Abeokuta, Nigeria.
[3] Federal Polytechnic, Ado-Ekiti, P, M.B. 2240, Abeokuta, Nigeria.
[4] Federal University of Technology, Akure, P, M.B. 2240, Abeokuta, Nigeria.
[*] Author for Correspondence ORCID ID: https//orcid.org/0000-0002-5520-484X; Email: adeboyeao@funaab.edu.ng

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Date Published:

04 June 2024

Keywords:

Concentration, Effect, Fabric-Colour, Hypochlorite, Bleaches.

ABSTRACT

Bleaches are known to remove stains from fabric. This study evaluates chlorine-based household bleaches as effective fabric colour removal agents and was conducted in the Chemistry and Textile laboratories of the Federal University of Agriculture, Abeokuta using experimental design. Five common household bleaches were collected from markets in study areas. The concentrations of Sodium hypochlorite in each bleach sample as indicated by the manufacturer were: A (3.85%), B (3.5%), C (not available), D (4.3%) and E (5.3%). To confirm the concentration of sodium hypochlorite in each bleach sample, Redox titration was conducted. One-minute Spot Test was used to determine the time taken for each bleach sample to remove colour (black, brown, navy blue, purple and army-green) from fabrics samples and similar test conducted with pure sodium hypochlorite (7.21% Chlorine) as control. The L*a*b* values for fabric colour change were obtained from images of the fabric samples using Fiji-Image J and Corel Photo-Paint 17. The laboratory analysis and evaluation revealed the concentration of hypochlorite in the bleaches samples as A: 0.36% (3.56 g/dm3), B: 3.5% (34.00g/dm3), C: 1.15% (11.48g/dm3), D: 4.29% (42.92g/dm3), and E: 0.06% (0.57g/dm3); therefore, established the information on bleaches B and D product package. The average time (seconds) to remove colour from fabric samples by bleach samples were A- 80.37; B- 19.60; C- 30.36; D- 20.10; E- no vivid colour change after 120.00 sec while colour change was obtained 7.00 sec by the control. Furthermore, Image J analysis and L*a*b* values show colour changes on fabric samples with Bleach B ($\bar{x}$ = 75.74) and D ($\bar{x}$ = 61.22) most effective in colour removals. In conclusion, Chlorine base household bleaches containing above 1.0% V/v hypochlorite are suitable colour removal agents on coloured fabrics and not stain removals only. Consumers must be careful how to handle Chlorine household bleaches and coloured fabrics.

APA CITATION

Adeboye, A. O., Goriola, O. R., Falode, C. G., Ogunduyile, S. R. & Eromosele, C. O. (2024). Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics. *East African Journal of Arts and Social Sciences, 7*(1), 354-363. https://doi.org/10.37284/eajass.7.1.1966

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

CHICAGO CITATION

Adeboye, Adebiyi Oladipupo, Olajide Rahman Goriola, Christopher Gabriel Falode, Sunday Roberts Ogunduyile, and Catherine Oluyemisi Eromosele. 2024. "Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics". *East African Journal of Arts and Social Sciences* 7 (1), 354-363. https://doi.org/10.37284/eajass.7.1.1966.

HARVARD CITATION

Adeboye, A. O., Goriola, O. R., Falode, C. G., Ogunduyile, S. R. & Eromosele, C. O. (2024) "Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics". *East African Journal of Arts and Social Sciences*, 7(1), pp. 354-363. doi: 10.37284/eajass.7.1.1866.

IEEE CITATION

A. O., Adeboye, O. R., Goriola, C. G., Falode, S. R., Ogunduyile & C. O., Eromosele "Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics". *EAJASS*, vol. 7, no. 1, pp. 354-363, Jun. 2024.

MLA CITATION

Adeboye, Adebiyi Oladipupo, Olajide Rahman Goriola, Christopher Gabriel Falode, Sunday Roberts Ogunduyile, & Catherine Oluyemisi Eromosele. "Evaluation of Hypochlorite Concentration in Household Bleaches as Colour Removal Agent on Coloured Cotton Fabrics". *East African Journal of Arts and Social Sciences*, Vol. 7, no. 1, Jun. 2024, pp. 354-363, doi:10.37284/eajass.7.1.1966.

INTRODUCTION

The method of whitening linen using oxygenated muriatic acid or chlorine was first used by the prehistoric French chemist Berthollet. Malika (2003) draws attention to the ancient practice of bleaching, which required leaving cloth out in the sun for long periods of time. Bleaches using peroxide and chlorine are common household bleaches. Peroxides are a class of chemical compounds that react with hydrogen to decolorize fibre and remove stains; they are most effective on cotton cellulose (Abdel-Halim & Al-Deyab, 2013); (Zeronian & Inglesby, 2003). Sebastian & Sebastian (2024) and Robert (2004) noted that many commercial household bleaches are oxidised (made from sodium hypochlorite, NaOCl) and are effective at decolorizing materials by oxidation, which breaks bonds within chromophores to produce small debris that does not absorb light within the observable section of the electromagnetic field.

Household bleach is a solution of water and sodium hypochlorite, often in a concentration of 3 to 9%, is used to disinfect and destroy germs, fungi, and viruses. It can be used to whiten clothes and other items, but it can destroy a garment colour if wrongfully used, and emit harmful fumes when used with other cleaners or chemicals (Aguirre, 2022). Chlorine-based bleaches, generally referred to as % active chlorine, are utilised in both household items and specialised products for hospitals and public health institutions (Government of Canada, Canadian Centre for Occupational Health and Safety, 2024).

Chlorine-based bleaches are not used to remove stains because they are more strongly oxidising than oxygen-based bleaches, which can chemically remove the dyes in fabrics and even cause damage to the fabrics themselves (Byju's, 2022), (Chris & Candice, 2010) and (Boschetti, 1982). Sodium hypochlorite (NaOCl or NaClO) can be commercially produced through the electrolysis of cooled brine. In a laboratory, hypochlorite is produced when chlorine reacts with cold aqueous sodium hydroxide (Michael & Rosalind, 2001). "The electrolytic preparation of hypochlorite from sodium chloride has taken place since the early nineteenth century" (Jackson, 1983). These days, sodium hypochlorite is mass-produced by soaking chlorine and 21% caustic-soda solution together (Kirk-Othmer, 1979).

Brine is electrolyzed to create hypochlorite solutions, which are commonly used in domestic tasks like disinfection, laundry, and surface cleaning. In the home, sodium hypochlorite has traditionally been used for surface sterilisation, laundry and deodorising toilet bowls, and bleaching fabrics. The use of bleaching agents, particularly as disinfectants in swimming pools, building maintenance and food services, has been explored by Staff (2023), George (2003) and Darlow & Bale (1959). Susan (2011) emphasises the use of bleach—available in a variety of

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

brands—in maintaining the whiteness of white clothing and eliminating stains.

Bleaches are typically used to get rid of stains. According to Karren (2010) and Abdel-Halim & Al-Deyab (2013), chemical colour removers react with cloth colour to progressively remove the colour pigment. According to Gamper & Riggs (1983) and Walter & Schillinger (1975), "These products may damage some synthetic fibres like nylon, and it is not suitable for use with silk or wool." Studies with individuals given treatments containing approximately 5% chlorine or more diluted bleach have strict irritation under intense experimental settings (4-hour patch test), according to a review published by the British Industrial Biological Research Association [BIBRA] (1990).

98% of cases of visual contact with hypochlorite solutions containing 3.6% and 12.5% active chlorine were recovered within 48 hours, according to reports from Chung et-al. (2022), Lavaud et al. (1989) and AISE (1997). In 2 percent of patients, however, the entire recovery took place in 10–30 days. The study found that although 4-5% solutions are most frequently used, household hypochlorite solutions normally contain 2–12.5% accessible chlorine. According to Grant (1986) and Hostynek et al. (1990), consumers are only exposed to the diluted substance through their hands during regular usage, proving that hypochlorite use is safe. This study investigated the extent to which the concentration of the active component in household bleaches could remove colour from fabric rather than acting as a safe stain remover alone. Since commercial household bleaches are the most often used stain removers, the study concentrated on these.

Although household bleaches are frequently used as stain removers, users frequently are unaware of the nature and composition of these products, which can cause damage to fabric. While most hypochlorite bleaches can remove stains, they can remove fabric colour also. The purpose of this study is to enlighten customers on the ingredients in household bleaches and how to use them to avoid causing fabric damage when removing stains. It looks into how much hypochlorite is in common household bleaches and how effective they are at removing colour from textiles. The study validates the chemical makeup of common household bleaches and offers a benchmark for gauging the kind and concentration of bleach appropriate for removing colour from textiles.

MATERIALS AND METHODS

The study employed experimental design, which is regarded as the most powerful and rigorous scientific research design (Ezinwa, 2003). Experimental studies are used in explanatory research to look at cause-and-effect relationships. The inquiry may be conducted in the field or in a laboratory, depending on its goals.

Samples of coloured cotton fabric and household bleach are among the materials used in the experimentation processes. Chemical analysis is used to examine the hypochlorite in bleach samples. One-minute spot test was used to evaluate the effect of the hypochlorite in common household bleaches on samples of the dyed cotton fabrics.

Materials

To determine the hypochlorite concentration of household bleaches, the study used metric glassware, chemical reagents, dyed cotton garments, and bleaching solutions. Five fabric samples were chosen at random, and bleach samples were gathered from the study area's major marketplaces. Potassium Iodide (KI) from British Drug House-BDH, Potassium Iodate (KIO_3) from BDH, Tetraoxosulfate (VI) Acid (H_2SO_4), Sodium Carbonate (Na_2CO_3), Sodium Thiosulfate Pentahydrate ($Na_2S_2O_3.5H_2O$), starch solution indicator, Distilled water (BDH), and Pure Sodium Hypochlorite NaOCl (5% chlorine - Analar) from Qualikems Chemical India were among the reagents and chemicals used. Spring and Analytical balances were used to calculate the weight of chemical substances in the study.

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Methods

Analysis of Hypochlorite in Bleach Samples

Volumetric analysis (Re-dox titration) was utilised to assess the presence of sodium hypochlorite in household bleach samples by comparing the ability of the bleaches to oxidize Iodide. The iodide was converted into iodine by the bleach, which was then titrated to determine the iodine content.

A cylinder was used to measure 25 ml of liquid bleach, which was then poured into a clean 250 ml standard volumetric flask. The flask was filled to the calibrated mark with distilled water, sealed, and thoroughly mixed. To acidify the Potassium Iodide (KI) solution, 10 ml of 2 mole H_2SO_4 was added to 40 ml of 10% KI solution in a 150 ml flask. The diluted liquid bleach solution was poured into a burette containing a 0.300 M solution of Sodium Thiosulphate. The diluted bleach solution was run from the burette until a yellow colour was detected as iodine. The 0.300 M Sodium Thiosulphate solution mixed with diluted liquid bleach was used to titrate the acidified Potassium Iodide (KI) solution to a very weak but still detectable yellow colour.

The titration process was delayed achieving a more sensitive endpoint, involving the addition of 2M of a freshly made 1% starch solution. This resulted in a starch-iodine complex with intense blue colouration, making the endpoint more noticeable. The titration was continued until the blue colour faded, and the final burette reading was taken, then repeated in a second and third trial run. The oxidation-reduction equation was

$2H^+ + OCl^- + 2II_2 + Cl^- + H_20$ ------- oxidation

Titrated with

$S_2O_3^{2-} \longrightarrow I_2 + 2S_20_3^{2-} \longrightarrow 2I + S_40_6^{2-}$

Test of Fabric Samples with Bleaches

The One-Minute Spot Test was the technique used to evaluate hypochlorite bleach capacity to remove colour from dyed fabric samples. One part of bleach was added to five parts of water to form a test solution; ratio of bleach to water is 1 : 5. A drop of the solution was applied and soaked into the dyed fabric, and then blotted to verify penetration. The fabric sample was rinsed and blotted dry after a minute, and the final product was inspected for colour alterations.

RESULTS AND DISCUSSION

The following results were derived using the number of moles of reactant to the product, as shown in *Table 1*.

Table 1: Analysis of bleach

Bleach Sample	Ave. Titre(cm^3)	Conc. (g/dm^3)	% Conc. Analysed	% Conc. on product Pack
Bleach A	0.78	3.537	0.36	3.85 m/v
Bleach B	7.40	33.966	3.40	3.5
Bleach C	2.50	11.475	1.15	Missing
Bleach D	9.35	42.917	4.30	4.2
Bleach E	0.13	0.574	0.06	5.3v/v
Pure hypochlorite	15.70	72.060	7.21	5% Chlorine

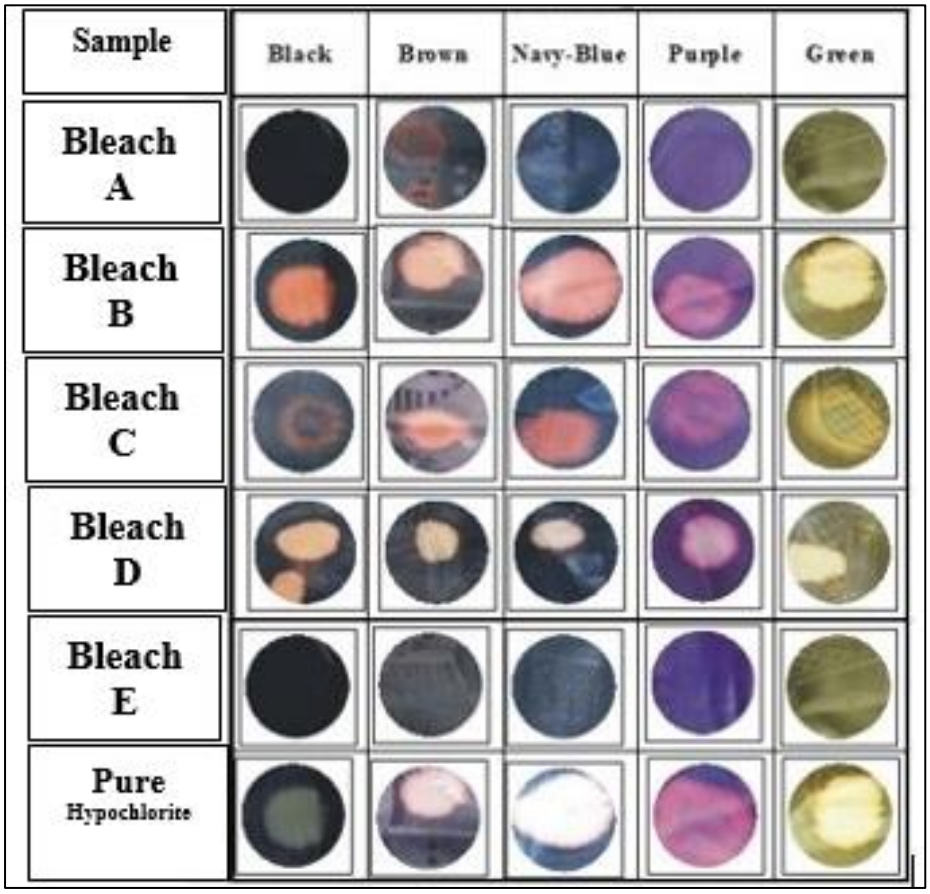
Based on the results shown in Table 1, the percentage concentration of Bleach D is 4.3% v/v and that of Bleach B is 3.40% v/v. Although the concentration of Bleach D grew by 0.1%, the concentration of Bleach B decreased by 0.1%, which could be the result of shelf-life deterioration. Bleach C was analysed to be 1.15%, but the manufacturers did not indicate the concentration of hypochlorite used on the pack. The concentration analysed for the other two bleaches is not what is on their packs, indicating that the information provided by manufacturers may not be reliable. The pure Sodium Hypochlorite concentration indicated on the pack was 5% chlorine, equivalent to 7.25% hypochlorite when packed, while the analysed concentration is 7.21%.

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Effects of Bleach Samples on Dyed Cotton Fabrics

Fabric samples were subjected to the One-Minute Spot Test in order to evaluate how well different household bleaches removed colour while tracking colour changes over time.

Figure 1: Fabrics colour removal by bleach samples



Furthermore, the study measured the time it takes for colour loss (colour change) from five fabric samples affected by various household bleaches and displayed the results in *Table 2*.

Table 2: Concentration of bleach and time to remove colour from fabrics

BLEACH SAMPLES	CONC. (g/dm^3)	MEAN TIME (S)
Bleach A	3.56	80.37
Bleach B	34.00	19.60
Bleach C	11.48	30.36
Bleach D	42.92	20.10
Bleach E	0.57	No colour change
Pure Hypochlorite	72.1	7.00

The colour change of bleach samples on dyed cotton fabric was observed to be visually different. Bleach B and Bleach D took approximately 20 seconds to produce a change, while Bleach C and Bleach A took 30 and 80 seconds respectively. The coloured cotton fabrics took only 7 seconds to change colour when exposed to pure sodium hypochlorite as a control. The colour removal impact of various household bleaches on dyed cotton fabric samples differed visually.

The rate of a chemical reaction is influenced by concentration and surface area. To determine the effect of differences in hypochlorite concentration on the colour removal strength of each bleaching

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

product, the molar concentrations of the bleaches were determined by volumetric analysis. The values obtained were used to calculate the amount of hypochlorite in each bleach sample (g/dm3) and compare it with their average time to affect the first colour change on dyed cotton fabrics.

The concentration of hypochlorite affects the colour change in a dyed fabric treated with bleach sample; bleach D has the maximum concentration at 42.92 g/dm3, bleach B at 33.996 g/dm3, and bleach E at 0.574 g/dm3. The quantity of hypochlorite in the sample directly correlates with the time it takes for the first colour shift to occur. The length of time and degree of colour change are greatly influenced by the hypochlorite concentration, which also affects how strong each bleaching product is at removing colour.

Fabric Samples colour Change in Numbers

Colour changes were calculated using the L* a* b* colour space. There are three channels in the L*a*b* colour space, and each channel has two hues. Black and white make up the L*-Lightness Channel, green and red make up a*-Channel, and blue and yellow make up the b*-Channel. While the values of a* and b* channels range from -128 to 127, the values of L* range from -128 to 127 or 0 to 100.

Table 3: Weighted Mean of L*a*b* value of colour Change obtained using Image J

Samples	Black			Brown			Navy-Blue			Purple			Green		
	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
Bleach-A	8.53	0.06	-1.57	58.45	5.17	5.17	49.57	1.53	-17.51	35.13	21.73	-30.46	47.03	-6.10	24.06
Bleach-B	66.69	2.34	1.33	78.63	12.49	14.17	36.68	9.28	-7.36	34.75	27.04	-27.77	89.35	-3.82	30.03
Bleach-C	53.93	1.25	-4.75	44.52	9.46	-0.76	55.67	12.44	-8.94	31.80	18.68	-26.21	82.03	-4.25	34.78
Bleach-D	76.91	11.64	23.04	77.09	4.39	17.17	75.18	5.40	5.45	63.28	25.96	-9.65	86.25	-3.03	19.10
Bleach-E	8.96	0.06	-1.56	56.29	0.04	-1.21	52.96	0.78	-11.19	37.24	25.78	-35.00	47.25	-5.56	23.35
Bleach-F	23.67	-1.33	-0.19	35.61	7.02	-7.98	37.12	5.71	-19.67	35.06	31.22	-25.51	62.40	-4.45	35.18

Following the introduction of each bleach sample, digital cameras were used to take pictures of the colours seen in the fabric samples. The L*a*b* values of each colour image and the images of the colour differences on fabric samples were produced and displayed in *Figure 2* and *Tables 3* respectively, after each image was duplicated to Fiji-Image J.

Table 3 and the line charts presented in *Figure 3* shows the effect of hypochlorite bleaches on coloured cotton fabric samples. There were colour changes on the fabric as indicated in *Figure 3*, where the values of the Lighteners channel tends towards white or off white with bleach B ($\bar{x}$ = 75.74) been the most effective colour removal on all fabric samples, followed by Bleach D ($\bar{x}$ = 61.22) and bleaches A and E, the least with means ($\bar{x}$ = 39.74) and ($\bar{x}$ = 40.54) respectively. Furthermore, the a* and b* channels for all the bleaches tend towards zero as shown in *Figure 4*, an indication of colour change in fabric samples.

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Figure 3: Images of colour difference on fabric samples obtained from Image J

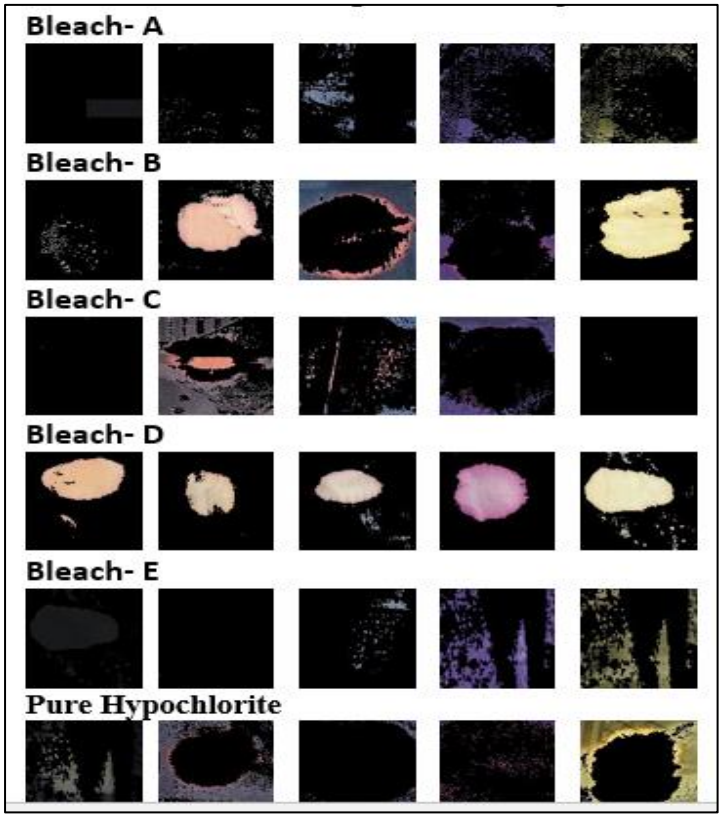


Figure 4: Line Chart of L* a*b* Colour Change on fabric samples (L* -128 to 127)

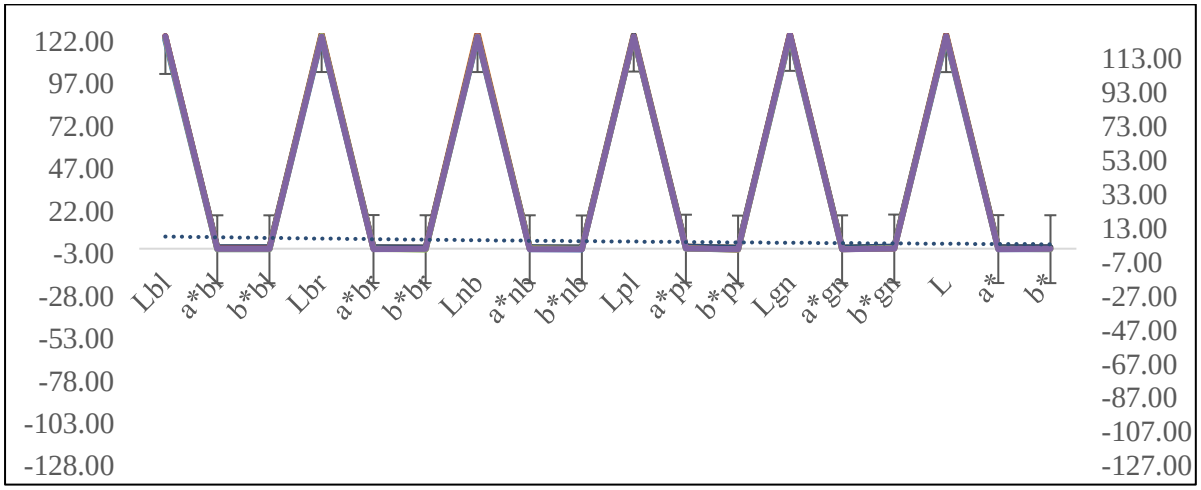
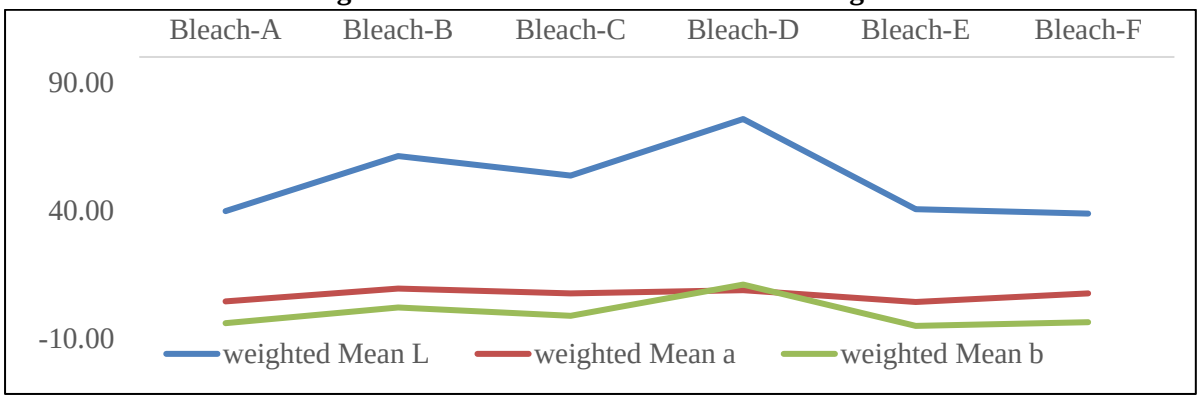


Table 4: Line Chart of weighted Mean of Lab value for colour change



Article DOI : https://doi.org/10.37284/eajass.7.1.1966

The study findings show that not all household bleaches are colour removers, but rather stain removers, as three of the five samples used in the study confirm Robert's (2004) claim that bleach or bleaching agents are frequently combined with optical brighteners and are quite different from bleaches. Robert (2004) goes on to state that they are capable of absorbing ultraviolet light wavelengths and converting them to blue-green light. The colour of the fabric is not destroyed, but it appears whiter, brighter, and more noticeable in light when viewed with the naked eye.

This study also supports Zubir, *et -al*. (2020), George (2003) and Benzoni & Hatcher. (2023). findings in a study on the use of bleaching agents, which found that most bleaching agents are utilized largely as disinfectants in areas such as swimming pools, house upkeep, health care, and food. The test for colour removal ability showed that different household bleaches have diverse impacts on samples of coloured cotton fabric in terms of colour removal. An additional conclusion of the study was that the bleach's hypochlorite content affects how well bleaching chemicals remove colour.

Samples D and B, which were collected and subjected to titrimetric evaluation, had hypochlorite concentrations of 42.917 and 33.996 g/dm3, respectively. Compared to the other three bleach samples, which had less than 12 g/dm3 of hypochlorite (the kind of hypochlorite found in most household bleaches), these two bleach samples destroyed the most colour from clothing the fastest.

The results of the study showed that the bleaching product's ability to break down dye varied depending on how concentrated the active ingredient was in household bleaches. This variation in hypochlorite concentration was the cause of these differences. The finding also demonstrates that, unless the bleaching product is a stain removal product that also contains a bleach activator, like ethylenediamine tetra-acetyl (EDTA), hypochlorite can remove the colour from cellulosic fabric regardless of the concentration of hypochlorite in any household bleaching product. It should be noted that not all colours will be eliminated from materials when bleach is used with a sample that contains 3.5% to 5.5% v of hypochlorite.

CONCLUSION

Many people think bleach is safe to use and help them feel secure because they can get it at a supermarket or other retailer. While bleaches work at room temperature in a pH range of 5 to 9, they react with cellulose more quickly at pH 7 than they do with the colour of the cloth. The pack of every bleach sample used in the study indicated that hypochlorite is the bleaching agent most frequently found in home bleaches in Lagos and Ogun State. The laboratory volumetric measurement used to determine the concentration of hypochlorite in commercial bleaches also showed that certain manufacturers use the chemical sparingly.

Recommendation

Manufacturers of household products are required to give accurate information about their products to consumers; law enforcement agencies such as the Nigerian Standard Organisation would punish them for providing misleading information. In order to guarantee family members' safety and the safety of household products, consumers should read the directions on product packaging.

ACKNOWLEDGMENTS

I wish to appreciate the co-authors for their immersed contribution to the success of the study and also going through the original manuscript. The publication of this article was funded by authors

REFERENCES

Abdel-Halim, E., & Al-Deyab, S. S. (2013). One-step bleaching process for cotton fabrics using activated hydrogen peroxide. *Carbohydrate Polymers*, *92*(2), 1844–1849. https://doi.org/10.1016/j.carbpol.2012.11.045

Aguirre, S. (2022). *The types of bleach and where to use them*. The Spruce. https://www.thespruce.com/types-of-bleach-1900685

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Association Internationale de la Savonnerie, de la Détergenceet des Produits d'Entretien A.I.S.E. (1997 March). *Benefits and Safety Aspects of Hypochlorite Formulated in Domestic Products*, Brussels; AISE Technical Task Force – Hypochlorite Scientific Dossier, pp. 11-48.

Benzoni, T., & Hatcher, J. D. (2023). *Bleach toxicity*. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK441921/

Boschetti, M. (1982). *Carpet Care, cleaning and Stain removal,* Retrieved March 12, 2012, from Iowa State University,

British Industrial Biological Research Association- BIBRA (1990), *Toxicity Profile of Sodium Hypochlorite.* ___www.bibra-information.co.uk/ profile.

Byju's. (2022). *Give the reason for bleaching action of Cl 2-*. https://byjus.com/question-answer/give-the-reason-for-bleaching-action-of-cl2-1/

Chung, I., Ryu, H., Yoon, S., & Ha, J. C. (2022). Health effects of sodium hypochlorite: review of published case reports. *Environmental Analysis, Health and Toxicology*, *37*(1), e2022006. https://doi.org/10.5620/eaht.2022006

Chris, J., & Candice, T., (2010).*Cillit Bang – Chemistry in your Cupboard*. United Kingdom: The Royal Society of Chemistry. www.vanish.co.uk./pdf

Darlow, H.K., & Bale, W.R. (1959). Infective Hazards of Water Closets. *The Lancet 1*, 1196-1200. www.aise.EU/downloads/AISE-hypo-int.

Ezinwa, B.A. (2003). *Research Techniques in Business and Education*. Oko; Data word Publication

Gamper, G., & Riggs, C.L. (1983). The Effect of Disinfection Concentrations of Chlorine Bleach in Chlorine-Sensitive Fabrics. *JAAFCC. 15.* 29- 44 www.aise.eu/downloads /AISE- hypo- int.69.94.102.27/members/docs/dep/NaOCl.

George, I. (2003). *Oxidizing and Bleaching Agents.* Norwalk: Business Communicating Company, Inc. www.beeresearch.com.

Government of Canada, Canadian Centre for Occupational Health and Safety. (2024, May 10). *Bleach (Household chlorine) - Working Safely*. https://www.ccohs.ca/oshanswers/chemicals/bleach.html

Grant, W. M. (1986). *Toxicology of the Eye*. Springfield, Illinois, USA, C.C. Thomas Publishers.

Hostynek, J. J., Wilhelm, K. P., Cua, A.B. and Maibach, H.I. (1990). Irritation Factors of Sodium Hypochlorite Solutions in Human Skin. *contact dermatitis 23*, 316-324 www.ncbl.nih.gov/pubmed/ 1965715

Jackson, C. (1983). *Modern Chlor-Alkali Technology*. Vol 2, Edited by C. Jackson, Pub. Ellis Horwood Ltd. www.aise.eu/downloads/AISE-hypo-int-scientific.pdf.

Karren, K. B. (2010). Honourable Colour removal: Decolourization of Natural Fabrics. www.google.com/colour removal with bleach.

Kirk-Othmer (1979). *Encyclopedia of Chemical Technology*, Third Edition, Vol 5. Mark, H.F., Othmer, D. F, Overberger, C.G. & Seaborg, G.T., Eds. John Wiley & Sons Inc, USA

Malika, R. (2003). U.S. Consumption of Oxidizing and Bleaching Agents, through 2007. Norwalk: Business Communication Company, Inc.

Michael, C., & Rosalind, F. (2001).*Advanced Chemistry*. United Kingdom: Oxford University Press.

Robert, A. (2004). *Bleaching Agents;* Leeward Community College, Naio; November 12, 2010, Educational Media Centre University of Hawaii.

Article DOI : https://doi.org/10.37284/eajass.7.1.1966

Sebastian, A., & Sebastian, A. (2024). How to bleach clothes for white brightness: An ultimate guide. *Seam Apparel Blogs*. https://seamapparel.com/blog/how-to-bleach-clothes/

Staff, C. (2023). Bleaching agents and stain removal. *Cleanfax*. https://cleanfax.com/bleaching-agents-and-stain-removal/

Susan, W. (2011). *Getting Clothes Clean.* Retrieved March 12, 2012, from New Mexico State University, College of Agricultural, Consumer and Environmental Sciences, Board of Regents.www.aces.nmsu.edu/pubs.

Walter, W.C., & Schillinger, J.E. (1975). Bacterial survival in laundered fabrics, *Journal of Applied Microbiology 29,* 368-373

Zeronian, S.A., & Ingleby, M.K. (2003). *Bleaching of Cellulose by Hydrogen Peroxide.* U.S.A: the University of California, Division of Textiles and Clothing.

Zubir, M., Darmana, A., Damanik, M., Nasution, H. I., G, O. A., Siregar, V. C. R. U., & Silitonga, Y. S. (2020). Bleach effectively removes stubborn stains. *Indonesian Journal of Chemical Science and Technology*, *3*(1), 20. https://doi.org/10.24114/ijcst.v3i1.18312

