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Enhancing silk screen printing through potassium dichromate: A path to quality and competitiveness in the printing industry

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ABSTRACT

Silk screen printing, a cornerstone of the printing industry, is often considered one of the oldest printing processes, though debate exists regarding whether block printing predates it. In the face of economic challenges, the printing industry must embrace technological advancements to ensure financial stability and foster quality production. Recognizing its potential economic impact, the need for technological enhancement in this field becomes evident. The quest for global competitiveness necessitates achieving production goals. This study explores the viability of utilizing potassium dichromate as a key agent in photographic silk screen printing. The evaluation of finished products involved twenty-five academic practitioners and twenty professional practitioners from diverse institutions and industries in Region VI, Western Visayas, Philippines. The assessment employed a five-point Likert scale, and statistical analysis relied on a t-test for independent sample means with a significance level of 0.5. The findings affirm the acceptability of potassium dichromate in photographic silk screen printing, with a highly satisfactory rating. Notably, it yields high-quality print legibility on t-shirts. To ensure optimal results, this study recommends the use of quality stencils by academic and professional practitioners, screen entrepreneurs, and enthusiasts engaged in silk screen printing. This research opens new avenues for growth and prosperity within the printing industry.

1. Introduction

It is difficult to establish color constancy when printing using halftone, making halftone printing challenging. The relative densities of the four process colors define the colors produced by the procedure (Gao et al., 2022). These proportions are subject to alteration based on a range of variables, such as those that affect the quantity of ink that flows over a given screen (Gonçalves et al., 2021). The most prevalent reason is an uneven level of the platens, which alters the critical off-contact distance and usually results in a visible color shift (Field, 1998). This is the most typical explanation. It is exceedingly difficult to match the process colors from one run to the next if all relevant elements are not controlled and recorded. The great majority of screen printing processes do not normally use the tools required to handle such a complicated web of interconnected components (Gebhardt and Hötter, 2016). A prospective shirt purchaser will be persuaded to assume that the shop cannot achieve consistency because it lacks devices such as delta scopes, colorimeters, off-contact gauges, and print pressure meters (Chu et al., 2023). Components of the solution include a standardized color-matching system, a high-quality digital scale, and a database of obtainable ink colors (Li et al., 2023). These technologies allow for the accurate matching of colors from one run to the next. An ink-blocking stencil is held in place during the whole process of screen printing by a woven mesh. This printing technique is referred to as "screen printing" (Gholamalizadeh et al., 2022). The permeability of a screen dictates where on the cloth the paste is printed during the process of screen printing (Tipper and Ward, 2022). A squeegee is required for squeegeeing paste through the screen modifying the consistency of the paste to ensure that sufficient paste is transferred to the fabric (Chen and Long, 2018). Silk screen printing is a subfield of the printing industry as a whole. Despite the fact that some people continue to believe that block printing is the earliest form of printing, many historians

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concur that it is the oldest printing method. In the manufacture of a photosensitive lacquer for screen printing in the manufacturing process, polyvinyl alcohol was used as a binder. Ammonium dichromate, iron (III) chloride (FeCl3), and titanium dioxide were used as photosensitive agents in the production process. In the production process, polyester was used as a screen fabric. The procedure was the same as when ammonium dichromate was used. Our use of PVA as our polymer and FeCl3 as our photosensitizer is the only factor that sets us apart from others. After creating the film on the glass, we exposed it to light to observe its reaction.

According to Borchers' (1966), application for United States patent number 3246986A, his invention involves a material and a method for screen printing and mimeographing. Particularly, the present invention relates to an improved screen process material that employs organic diazo compounds as sensitizers for the colloid coating, as well as a sensitized emulsion for preparing process screens. These two aspects of the invention fall within the scope of the current invention. A presensitized material for screen printing comprising a highly porous carrier coated with at least one colloid that contains as a sensitizer at least one completely water-soluble condensation product of at least one diazo diphenylamine with at least one aldehyde, condensed in the presence of at least one strong acid. As a result of the fact that screens cannot be coated in advance, numerous manufacturing issues arise. Because it takes several hours to produce a replacement, for instance, if a screen were to become accidentally damaged during the printing process, this would necessitate the creation of an expensive spare screen. In another study, Kaplan and Stulik (2013) provided an overview of the gum bichromate process, as well as a comprehensive guide to this alternative photography technique. Contact printing is the process of printing using gum. A solid negative serves as the basis for a solid print. You will require a negative of the same dimensions as the final print. It may be sufficient to take a digital photograph and invert (and flip) the image using photo editing software so that it appears as a negative before printing it with an inkjet printer on paper or transparency film. Using an imagesetter to create high-quality negatives is an alternative method to consider. Start with negatives that have decent contrast and density, but not necessarily high contrast and density. The so-called bridging effect is an important additional effect in the field of screen printing (Kapur et al., 2013). The deposited film should fill the spaces between the individual strands of the screen at the screen's periphery. When stencils for screen printing are prepared in a conventional manner, they typically have poor bridging properties and do not precisely correspond to the master. This means that a straight line in the master will result in a saw-toothed line following the strands of the screen, especially if the image margin is skewed relative to the screen strands (Abbott, 2008). As a result, the prints created during the printing process are blurry. There are three distinct preparation steps for screen printing. This method employs hand-cut stencils, as well as the tusche, adhesive, and photographic stencil techniques. The photographic method is the newest of these three methods. The 1980s witnessed the introduction of this practice and its subsequent widespread adoption. Silk screen business owners, art students, and printing industry professionals gained new knowledge and skills. Ammonium dichromate is the compound used in the printing industry more frequently than any other substance currently. This chemical is heavily utilized in the photographic silk screening process. On the other hand, a number of business owners reject this strategy outright. The first issue is that printers lack the knowledge and skills required to work with the new technology, which incorporates the most recent industry developments (Li et al., 2022). In addition, the required chemicals for this procedure are in short supply, so they are occasionally unavailable on the local market. Consequently, output was impacted negatively. The investigator who conducted the present study suggested using potassium dichromate as an agent in photographic silk screen printing. Although this chemical is commonly used in photography, the primary objective of this study is to evaluate how well it performs in terms of production quality when used in silk screen printing. This is also an effort to contribute to the creation of a new invention for the silk screen printing technique. The purpose of this research was to determine the optimal proportion of potassium dichromate used as a sensitizer in photographic silk screen printing. This study specifically addressed the following questions: Significant difference in the acceptability of the various potassium dichromate treatments in terms of workability, resiliency, and legibility; substantial variation in the acceptability of the completed stencil in terms of workability and resiliency between academic and professional practitioners; and substantial variation in the acceptability of potassium dichromate as to legibility of prints on t-shirts. At the 0.05 level of significance, the following hypotheses were tested:

1. There is no statistically significant difference in the acceptability of potassium dichromate in the various treatments in terms of stencil workability and resilience, as well as print readability on t-shirts.
2. There is no significant variation in the acceptance of the screen stencil in terms of workability and resilience between school and industry practitioners.
3. There is no significant difference in the perceptions of school and industry practitioners on the acceptability of printing items in terms of print legibility on t-shirts.

The conceptual framework of the study is presented in Fig. 1.

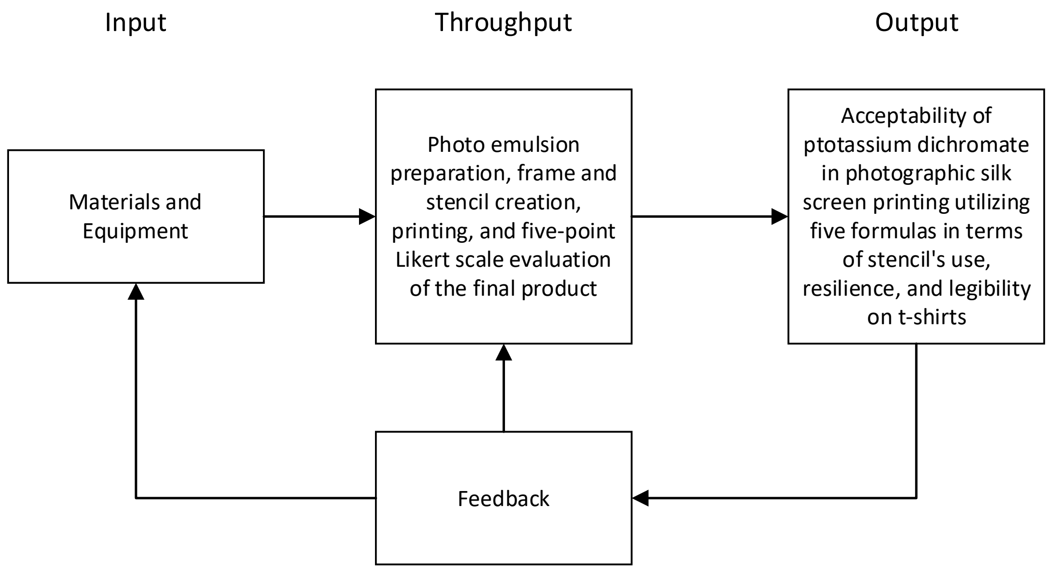

Fig. 1: Schematic diagram outlining the flow of relationship among variables

The paradigm acts as the basis for the structure of the research. It illustrates how the relationships between the variables flow. As can be observed, the researchers believed that the materials and equipment that were used in the investigation had a direct impact on both the procedure and the outcome. The outcome is contingent upon the manner in which the process was modified using scientific principles in order to produce more desirable outcomes. The experiment places a significant emphasis on receiving and considering feedback. The researcher used both the positive and negative aspects of the experiment as the foundation for his interpretation of the data and his proposal for more study. As a consequence of this, the procedure was refined in order to provide better outcomes.

In the first place, the throughput exemplifies how the theories, concepts, and principles of exposure and development of the photo stencil solution were utilized to direct the researcher in the process of preparing the sensitized emulsion, applying the emulsion to the screen, drying it, developing it, and printing it. In order to produce the photo-solution, each of the five different formulations was combined with potassium dichromate and water that had been distilled.

When determining whether or not potassium dichromate should be used in photographic silk screen printing, a scorecard that was based on an adapted version of the Likert scale with five points was used. The output shows the outcomes of the completed photographic stencil and the product of the printing process.

2. Methodology

The experimental study technique was used to determine what proportion of potassium dichromate as a sensitizing agent in photographic silk screen printing produces better quality, specifically: To determine the level of acceptability of Potassium Dichromate in terms of workability, resiliency, and legibility; a significant difference in the acceptability of the various potassium dichromate treatments in terms of workability, resiliency, and legibility. Using potassium dichromate (powder) and distilled water, five formulations of combination were produced. Each mixture was put in a brown container to prevent light from reaching it. The formulations were labeled in accordance with the allocated percentage. In order to combine the sensitizer (potassium dichromate) and emulsion (Tulco brand), seven parts of the emulsion and one part of diluted potassium dichromate were placed into a mixing cup.

The raw materials preparation includes potassium dichromate (powder) and distilled water.

All the formulations were stored in dark brown bottles to prevent any damage from sunlight. Each formula was labeled with its allocated percentage. Seven parts of the Tulco brand emulsion were put into a mixing cup, and one part of diluted potassium dichromate was added to create a sensitizer. A stirring stick was used to ensure that the solution was well combined. Using a coater, the solution was applied to one side of the screen, and the excess was scraped off. After coating a screen with photo-solution, it must be dried in the dark before being exposed to light. An electric fan is employed for this purpose. The positive artwork or design was fastened upside down at the top of the screen and a transparent glass was put over it before being exposed to light and developed in a chemical bath. The photo-solution on the screen was made more sensitive with the help of a 250-watt light bulb. Three minutes was all it took to expose the film, and then the hand sprayer was used to wash away the water from the exposed areas. After washing, the screen was dried using an electric fan or a clean towel before being packed away. Part of the emulsified sides of the screen holes and the wooden components of the screen were covered with masking tape. Phase two of the procedure involves printing the results of the experiment. At this point, the area to be printed was protected by inserting a piece of paper or board inside the t-shirt to cover the back. The squeegee blade was loaded with enough Tulco textile paint for printing.

Information was collected from the ratings provided by the two groups of raters for each product and each treatment. Twenty (20) were employed by businesses, whereas twenty-five (25) worked in educational institutions. The samples were selected with intent. Drawing, drafting, and industrial arts instructors at Western Visayas's chosen technical vocational schools were the practitioners. The business owners and professionals that participated were drawn from a variety of sectors within Iloilo, Philippines. These responses were deemed sufficient since they represent a large proportion of local educators and business professionals. Because these are the people who were accessible for testing, the sample sizes for the two groups are different.

The data was gathered using a scoring sheet using a five-point Likert scale. Five printing industry professionals validated the form's appearance and content. Participants were polled on whether or not they thought each element was required to draw conclusions about potassium dichromate's viability in photographic silk screen printing, both in terms of the stencil's use and durability and the prints' intelligibility on tees. The instrument's legitimacy was established by the proportion of signatories who agreed with its terms. Every single jury agreed that the results of the test were appropriate. Reliability was determined by administering the same survey twice, one week apart, to different subsets of respondents. Results from the test-retest showed high levels of responder consistency (r=.95) (Canals, 2017).

Potassium dichromate's acceptability in photographic silk screening was evaluated using the instruments once their validity and reliability had been established. The completed goods were graded based on how well they met the following criteria: (1) the stencil was easy to use and (2) the prints on the t-shirts were clear and legible. Evaluators assigned scores of 5 (strongly agree) to the best quality samples, 4 (agree), 3 (neither agree nor disagree), 2 (disagree), and 1 (strongly disagree) to the lowest quality samples.

The procedure was divided into three phases. The preparation phase, the printing phase, and the evaluation phase.

2.1. Preparation

The first phase of the research was the preparation of a photographic stencil, as shown in Fig. 2. The equipment and substances to be used in the experiment were set up and readied for the subsequent steps of combining photo solution, drying it, exposing it, and developing it. The final stencils for the various sensitizer formulas were then created. The following items and equipment were required for this experiment: Potassium dichromate (powder), five (5) brown empty bottles, one (1) liter distilled water, photo emulsion (Tulco brand), two (2) meters #100 silk screen, five (5) sets 6" x 9" frame (outside dimension), stapler, staple wire, one (1) piece spreader (wide), one (1) piece 10" x 12" acetate model, glass jar to receive diluted potassium dichromate, mixing cup, stirring. Materials: 30 square meters of transparent glass, 1 piece of backing (illustration board), bottom support for the screen frame, 1 piece of 250-watt light bulb with shade, 1 hand sprayer, 1 electric fan, 1 basin with water, 1 clean cloth, 1 longnose pliers, cotton, and masking tape.

Fig. 2: Preparation of photographic stencil

These processes were observed when potassium dichromate was diluted. The office is a gloomy, shadowy room with no windows. The five variations were prepared by combining potassium dichromate and distilled water in a glass container, as shown in Fig. 3.

Fig. 3: Preparation of sensitizer

A mixture of 1 ounce of potassium dichromate powder and 2 ounces of distilled water was used in Formulation A, whereas Formulation B utilized 1 ounce of potassium dichromate powder and 3 ounces of distilled water. Formulation using four ounces of distilled water and one ounce of potassium dichromate topically: To make formula D, one ounce of potassium dichromate was combined with five ounces of distilled water, and to make formula E, one ounce of potassium dichromate was combined with six ounces of distilled water.

After diluting potassium dichromate in a glass jar, the resulting solution was placed in a brown bottle for storage. This procedure was carried out again until a complete set of formulations was attained.

The following procedures were used to combine the sensitizer (potassium dichromate) with the Emulsion: To one part potassium dichromate (sensitizer), seven parts Tulco photo-emulsion were added to a mixing cup. After mixing the solution well, it was put into the screen's printing side, as presented in Fig. 4. The coater was then used to uniformly distribute the solution on the screen. On the opposite side of the monitor, the excess solution was scraped off.

Fig. 4: Applying the solution to the screen

To speed up the drying process of the photo-stencil solution, an electric fan was used, but the coated screen was kept in the dark. In order to keep the fluid from drying out, the screen was kept out of direct sunlight. The screen remained in its hiding spot until it was ready to be exposed to light.

While the photo stencil was being exposed and developed, the backing board was positioned on top, with the back side of the board facing the screen. The artwork or design, which was originally positive, was affixed upside-down to the top of the screen, and a sheet of clear glass was then placed over it. The film was exposed for three minutes with the 250-watt, diffused light placed underneath the transparent glass. After three minutes, the backing, support board, and positive artwork or design were taken away. After the screen was taken down, it was soaked in a bucket of water, and the uncovered areas of the film were sprayed with a hand sprayer.

To get the screen dry and ready for shipping, a clean towel and an electric fan were used, as shown in Fig. 5. The screen was repaired by touching up the damaged or closed areas with clear lacquer. After the touch-ups were complete, the emulsified sides of the screen holes were covered with masking tape, and the stencils were not hardened so that the screen's durability could be evaluated. However, a photo-hardener should be applied to all photographic stencils to increase their durability.

Fig. 5: Drying of screen

2.2. Phase 1: Experimental layout

A total of five different methods were used to manufacture potassium dichromate. Potassium dichromate becomes a diluted chemical, often known as a stock solution after being mixed with distilled water. The diluted chemical was kept in a dark brown container until it came time to utilize it. Five different formulations were obtained by repeating the processes, and each was given a name that indicated the relative amount of each ingredient. To get a true CRD, we performed three sets of the same five treatments. Table 1 presents the treatments and the replications. CRD for five treatments shows that there are five treatments with three replications.

Table 1: Shows the treatments and replications

Treatments and reflections		
1	2	3
A_3	A_1	A_2
B_2	B_3	B_1
C_3	C_2	C_1
D_1	D_3	D_2
E_2	E_1	E_3

2.3. Phase II: The printing phase

In the second phase of the study, which focuses on T-shirt printing, all of the necessary equipment and supplies were assembled: Photo stencils, brown Tulco textile paint, a squeegee, a backing board or paper, some t-shirts, and a work table were all required for this investigation.

During the printing process, these phases were observed: In order to prevent the paint from seeping through the back of the t-shirt, a piece of paper or board was inserted to cover the area to be printed. The photograph stencil was placed on top of the stretched t-shirt on the work table. The squeegee was loaded with enough Tulco textile paint to cover the screen completely, as shown in Fig. 6.

Fig. 6: Applying textile paint to screen

After the t-shirts were printed, the paper backing was peeled off and they were hung up to dry. White t-shirt runs of fifteen (15) were produced, with three (3) sets for each treatment, as presented in Fig. 7.

Fig. 7: Finished products

2.4. Phase III: Evaluation

Completed items (photographic stencils and printed t-shirts) were sent to the group of evaluators and distributed in a manner consistent with the Completely Randomized Design.

The researcher briefed the assessors on the assessment criteria and process. They utilized a 5-point Likert scale.

The product's viability was assessed by polling experts on which of five possible formulations had the greatest chance of yielding desirable results in practice. In addition, testers considered how simple it was to apply photo solution to the screen, how uniformly the solution was spread throughout the screen, and how well the photo solution and emulsion blended. Screen stencils' durability was measured by testing their ability to endure repeated printing and washing, as well as the persistence of photo solution's insolubility with textile paints and the absence of pinholes and rips in the stencil. However, readability was assessed by considering the print's clarity, the accuracy of the model's reproduction, and the overall quality of the prints.

The Development of Potassium Dichromate as an Agent in Photographic Silk Screen printing was evaluated by actual testing and for its level of acceptability. A self-made questionnaire in terms of its workability, resiliency, and legibility was used for the level of acceptability. The data gathered was tabulated for all treatments (Assmann et al., 2000).

3. Results and discussion

Means (X) are presented for how respondents rated the agents' workability, resiliency, and legibility; t-tests for independent samples mean differences are presented for how respondents rated the stencil's workability and resiliency; and one-way analyses of variance are presented for how significantly respondents rated the stencil's legibility. The Scheffé a posteriori test is used to assess the significance of significant findings. In Table 2, the two groups of responders both gave Treatment A the highest mean ratings (4.53). Treatment E had the lowest average scores (3.76 and 3.72) among the available treatments. The five methods were deemed helpful in creating a functioning stencil by both academic and professional practitioners in the area.

Table 2: Workability of the stencil as perceived by the respondents

Treatments	Academic practitioners (N=25)	Professional practitioners (N-20)	t-lest		df
			OV	TV (.05)	
A	4.53	4.75	2.22*	2.02	43
B	4.20	4.23	0.15^{ns}	2.02	43
C	3.94	3.96	0.13^{ns}	2.02	43
D	4.00	3.83	1.06^{ns}	2.02	43
E	3.76	3.72	0.26^{ns}	2.02	43

*: 5% confidence level; ns: Not significant

The actual and expected values for Treatment A were 2.22 and 2.02, respectively. Academics and professionals agree that a sizable gap exists between the means since the observed value is greater than the computed value. In other words, there was a significant divide in how academics and professional practitioners evaluated the usefulness of stencil A (1:2 ratio). Professionals and academics will not find a statistically significant difference between the means if the observed values for treatments B, C, D, and E are less than the tabulated values. This means that the ratings of Stencil B, C, D, and E by the various groups of respondents were not significantly different from one another. Researchers concluded that potassium dichromate was Very Satisfactory for its intended use in both academic and industrial settings.

In Table 3, you can see how both academics and professionals in the field rate the stencil's durability. Treatment A had the highest mean scores (4.33 and 4.60) from both groups of responders. Treatment E had the lowest average scores (3.49 and 3.25) and hence was chosen. Practitioners in academia were in agreement on the five treatments, while those in industry were in agreement regarding the three treatments' stencils' resilience and were split down the middle regarding the two treatments' resilience. The Observer and Table 3 values for Treatment A were 2.37 and 2.02, respectively. Given that the observed value exceeds the tabulated value, there is a large discrepancy between the means, as judged by academics and professionals. That is to say, there was a large discrepancy between what academics and professionals thought of the stencil A's practicality (1:2 ratio).

Table 3: Resiliency of the stencil as perceived by the respondents

Treatments	Academic practitioners (N=25)	Professional practitioners (N-20)	t-test		df
			OV	TV (.05)	
A	4.33	4.60	2.37	2.02	43
B	3.96	4.05	0.69*	2.02	43
C	3.70	3.61	0.58	2.02	43
D	3.49	3.43	0.06	2.02	43
E	3.49	3.25	1.98	2.02	43

*: 5% confidence level

In light of the observed values pertaining to treatments B, C, D, and E, which consistently fail to align with the tabulated reference values, it becomes evident that a significant disparity exists between the perspectives held by academic and professional stakeholders regarding the definition of an acceptable mean. This divergence in appraisal implies a conspicuous absence of notable distinction in how each distinct group of respondents evaluated the resilience attributes of Stencil variants B, C, D, and E. It is worth noting that the assessments of product durability yielded ambivalent responses: while academics conveyed a tepid endorsement, professionals operating within the private sector voiced a more moderate degree of approval. Notably, the evaluation of the durability of a locally-manufactured photo stencil solution culminated in a verdict of satisfaction, based on the collective judgments of academics and industry professionals. This verdict substantiates the robust resilience associated with potassium dichromate, as revealed in the findings of the present inquiry. As depicted in Table 4, the data pertaining to t-shirt legibility are detailed therein. An in-depth perusal of Table 4 divulges that treatment A garnered the highest mean ratings, an impressive 4.42 and 4.52, signifying unanimous acclaim from both respondent cohorts. Conversely, treatment E languished at the nadir of the spectrum, registering the lowest mean score, resting at an average of 3.53 stars. It is noteworthy that across all five procedural approaches to t-shirt printing, a unanimous consensus was established among the respondents, confirming the unequivocal legibility of the resulting prints. Table 4 data reveals that there is a large disparity between how academics and professionals rate the readability of printed materials. Analysis of Variance was performed to discover whether there were statistically significant differences between the derived means. Researchers found that most practitioners were neutral to positive on print legibility. To achieve Very Satisfactory print readability, potassium dichromate was used in this investigation.

Table 4: Legibility of prints on t-shirts as perceived by the academic and professional practitioners

Treatments	Academic practitioners	Professional practitioners
A	4.42	4.52
B	3.91	4.09
C	3.75	3.90
D	3.76	3.83
E	3.53	3.53
Total	19.37	19.87
Average	3.87	3.97

The results of a One-Way ANOVA on the perceived readability of t-shirt prints, as reported by teachers and administrators, are summarized in Table 5. Table 5 data shows that the observed value was 55, and the tabulated value was 3.48. At the 5% significance level, the observed value is higher than the expected value. This just demonstrates how vastly different the resources are. There is one distinct group that stands out from the others. According to the results, ammonium bichromate and water should be mixed at a 1:4 ratio. This research found that no matter the method used, photographic silk screen printing turned out well. The readability of Procedures B, C, D, and E was judged to be Very Satisfactory. A superior therapy, however, was discovered to be treatment A.

Table 5: Summary of one-way ANOVA as perceived by school practitioners as to legibility

Source of variation	df	Sum of squares	Mean sum of squares	Obtained F-value	
				OV	TV
Between groups/treatment BSS	4	1.33	0.33	55*	3.48
Within groups/replications WSS	10	0.06	0.006		

*: 5% confidence level

Table 6 shows the result of the Scheffé Test conducted on academic practitioners as to the legibility of prints on t-shirts. Scheffé's main points are outlined in Table 7. If the value of F_{A-B}=65, then the F_{A-C}=112.5, F_{A-D}=110, F_{A-E}=197.5, the F_{B-C}=7.5, the F_{B-D}=5.5, the F_{B-E}=35, the F_{C-D}=.025, the F_{C-E}=12.5 and the F_{D-E}=12.5. Treatment E is inferior to options A, B, C, and D according to Scheffé. In contrast, therapy A is superior to any alternatives.

Table 6: Scheffé test results for school practitioners as to legibility

Pair of means	F value	
	OV	TV (1,10)
A vs B	65.00*	4.96
A vs C	112.50*	4.96
A vs D	110.00*	4.96
A vs E	197.50*	4.96
B vs C	7.50*	4.96
B vs D	5.50*	4.96
B vs E	35.00*	4.96
C vs D	.025^{ns}	4.96
C vs E	12.50*	4.96
D vs E	12.50*	4.96

*: 5% confidence level; ns: Not significant

Table 7 shows the observed F-value was 4.14, while the calculated F-value was 3.48. At the 5% confidence level, the observed value is higher than the expected value from the Table 7. This just demonstrates how vastly different the resources are. There is one distinct group that stands out from the others. Since the F-value is significant, a posteriori test (Scheffé) must be conducted.

Scheffé findings for academic practitioners on the readability of t-shirt designs are shown in Table 7. As shown in Table 8, a summary of Scheffè where the significance of F_{A-B}=8.79 is high: F_{A-C}=5.82 means significant: F_{A-D}=7.3 means significant; F_{A-E}=14.85 means significant: F_{B-C}=.30 for F_{B-D}=.06, for F_{B-E}=.76, F_{C-D}=.06, F_{C-E}=2.12 and F_{D-E}=1.36 all indicates non-significant. According to Scheffé, therapy A is superior to all others. The similarities and advantages of treatments B, C, and D over treatment E are greatest. Utilizing ammonium bichromate as a sensitizer revealed that the concentrated mixture of chemicals used in photo stencil solution improved the ability of the solution to spread evenly and smoothly on the screen, requiring less coatings to produce a reasonable and considerable stencil. A study by Adams et al. (1982) supported this idea, finding that the more concentrated the photo solution, the better the results.

Table 7: Summary of one-way ANOVA as perceived by industry practitioners as to legibility

Source of variation	df	Sum of squares	Mean Sum of squares	Obtained F-value	
				OV	TV
Between groups/treatment BSS	4	1.65	0.41	4.14*	3.48
Within groups/ replications WSS	10	0.99	0.099		

*: 5% confidence level

Table 8: Scheffe test results for industry practitioners as to legibility

Pair of means	F value	
	OV	TV (1,10)
A vs B	8.79*	4.96
A vs C	5.82*	4.96
A vs D	7.3*	4.96
A vs E	14.85*	4.96
B vs C	0.30^{ns}	4.96
B vs D	0.06^{ns}	4.96
B vs E	0.76^{ns}	4.96
C vs D	0.06^{ns}	4.96
C vs E	2.12*	4.96
D vs E	1.36*	4.96

*: 5% confidence level; ns: Not significant

The results of this investigation, which used potassium dichromate as the agent in photographic silk screen printing, were consistent with those of an earlier study using ammonium bichromate as the agent, which showed that the recommended composition of the two was 1:4, or 1-part ammonium bichromate to 4 parts water.

In the current investigation, it was observed that potassium dichromate has the same properties as ammonium bichromate. Potassium dichromate's acceptance, on the other hand, was Very Satisfactory. In a test using ammonium bichromate, the efficacy of a locally produced photo solution was found to be only satisfactory. The researcher had sought to use comparable resources pertinent to the current investigation but studies made accessible employed just ammonium bichromate instead of potassium dichromate. In the printing sector, it is anticipated that this research will be thoroughly investigated by interested parties.

4. Conclusion

The following inferences may be made in light of the results of the investigation, which were as follows: Treatment A, which consists of a 1:2 ratio of potassium dichromate and distilled water, performs superiorly to the other treatments in terms of the stencil's workability as well as its resilience. Treatments B and C are quite similar to one another, and the same can be said for treatments D and E. In photographic silk screen printing, Treatment E is still permissible. When compared to treatment E, treatments A, B, C, and D produced outcomes that were superior in terms of the readability of the printing on the t-shirts. Treatment A, with its 1:2 ratio, produced the highest quality printed output when compared to the other treatments. According to Adams et al. (1982), the results are better when the photo solution is more concentrated. As a result, treatments A, B, and C achieved the greatest results in this investigation as a direct consequence of the concentrated formulation of potassium dichromate and distilled water. The capacity of the photo stencil solution to spread uniformly and smoothly on the screen is improved when the ingredients employed in the solution have a higher concentration. This results in the need for fewer coats to make a decent and substantial stencil. According to the findings of this investigation, the properties of potassium dichromate are identical to those of ammonium bichromate. However, the efficacy of potassium dichromate was shown to be highly good in terms of the workability and resilience of the stencil as well as the readability of the prints. The use of potassium dichromate as a sensitizer in photographic silk screen printing is a lucrative business that may produce additional revenue for those working in the industry, as well as opportunities for business ventures for hobbyists, entrepreneurs, and those working in the sector.

5. Recommendation

In accordance with the findings derived from the analysis, the ensuing recommendations merit contemplation at an elevated scholarly level. It is unequivocally advised that practitioners within academic and professional spheres, as well as screenprinting enthusiasts and entrepreneurs, should prioritize the utilization of premium-quality stencils and high-grade printed t-shirts. This recommendation is underscored by the demonstrated superiority of treatment A, with its 1:2 ratio, as manifested in enhanced stencil workability, resilience, and legibility of prints upon t-shirts. Furthermore, it is prudent to acknowledge that although stencils may endure repeated printing and washing, prudent hardening through the application of photo hardener is strongly advocated to augment their longevity. This fortification process is to be executed in strict accordance with the guidelines provided by the manufacturer of the photo hardener product.

In the quest for the attainment of optimal outcomes, meticulous adherence to the prescribed procedures for creating the photo solution, as well as for the subsequent stages of drying and development, is imperative. Additionally, it is imperative to recognize that potassium dichromate holds intrinsic value in the realm of photographic silk screen techniques and should be embraced without reservation by practitioners within both academic and professional domains.

It is incumbent upon academic instructors in disciplines such as drawing, drafting, graphic arts, and industrial arts to actively promote the adoption of potassium dichromate as a vital component in the practice of photographic silk screen printing. Furthermore, in the quest for an expanded body of knowledge, the formulation of the photo solution utilizing potassium dichromate should be subjected to comprehensive exploration across a spectrum of diverse emulsion brands as the primary constituent. The resulting insights garnered from this research endeavor ought to be disseminated not only within the classroom settings where instruction on silk screen process printing is imparted but also within the domain of workshops and seminars.

Lastly, it is imperative to highlight that a parallel investigation, characterized by distinct substrate designs and alternative paint types, is slated for implementation in the foreseeable future.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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