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THE USE OF SOAP DETERGENT AS AN ALTERNATIVE PRINTING PLATE DEVELOPING SOLUTION

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Abstract

The escalating cost and environmental concerns associated with commercial plate developers have necessitated the search for alternative, eco-friendly, and cost-effective solutions in the printing industry. This study investigated the potential of five soap formulations (coconut oil-based, palm oil-based, olive oil-based, mixed vegetable oil-based, and commercial laundry soap) as alternative developing solutions for positive-working and negative-working offset printing plates. The experimental research design involved systematic preparation and testing of soap-based developers at varying concentrations (5%, 10%, 15%, and 20%) against a standard alkaline plate developer (pH 12.5) as control. Results revealed that soap concentration significantly influenced development time and image quality. The commercial laundry soap (S5) demonstrated superior performance among the soap samples, achieving good complete removal and image retention at 10% concentration with a development time of 180 seconds for both plate types. Palm oil-based soap (S2) showed improved performance at higher concentrations, with development times of 120 seconds (positive) and 170 seconds (negative) at 20% concentration. Resolution testing indicated minimum reproducible line widths of 20 µm for S5 (positive), 25 µm for S2 (positive), 40 µm for S2 (negative), and 30 µm for S4 (positive), compared to 10 µm for the control. Plate longevity assessment revealed acceptable image quality up to 200 impressions, with gradual degradation beyond 300 impressions. The study concludes that soap-based developers, particularly commercial laundry soap at 10% concentration, offer a viable, environmentally friendly alternative for plate development, though further optimization is required to match commercial developer performance.

Keywords: Offset printing, plate development, soap detergent, positive-working plates, negative-working plates, eco-friendly developer

Introduction

The printing industry has long relied on conventional chemical developers for processing offset printing plates. These developers typically contain alkaline solutions with pH values ranging from 12 to 13.5, often incorporating hazardous substances such as sodium hydroxide, potassium hydroxide, and various surfactants (Fujita *et al*., 2018). While effective, these commercial developers pose significant environmental and health risks, including skin irritation, respiratory hazards, and challenges in waste disposal (Kumar and Sharma, 2019). The global printing industry faces increasing pressure to adopt sustainable practices due to stringent environmental regulations and growing consumer awareness regarding eco-friendly production methods (Thompson, 2020). The search for alternative, biodegradable, and less hazardous developing solutions has therefore become a priority for both economic and environmental reasons (Oseye, 2024).

Commercial plate developers constitute a significant portion of operational costs in printing establishments (Google Patent, 1990, 1993). Additionally, their disposal requires compliance with environmental regulations, adding to the overall expense. Small and medium-scale printing enterprises in developing countries often struggle to afford these commercial developers, leading to compromised quality or informal disposal practices that harm the environment (Okafor and Adebayo, 2021). Soap, a common household and industrial product, possesses surfactant properties that could potentially facilitate the dissolution of unexposed coating layers on printing plates. The alkaline nature of soap solutions, ranging from pH 9 to 11, may provide sufficient chemical activity for plate development while being significantly less hazardous than conventional developers. However, empirical data on the effectiveness of soap-based developers for various plate types remains limited. In view of the forgoing, this study is designed to evaluate the effectiveness of soap-based developing solutions as alternatives to commercial plate developers.

Significance of the Study

This research contributes to the growing body of knowledge on sustainable printing practices. The findings could provide printing establishments, particularly small-scale operators, with an affordable and environmentally friendly alternative to commercial developers. Additionally, the study adds to the understanding of surfactant-based development mechanisms in lithographic plate processing.

Materials and Methods

Research Design

The study employed an experimental research design involving the systematic preparation and testing of soap-based developing solutions against commercially available developer controls.

Printing Plates

Positive-working plates of aluminum-based, o-quinone diazide coating with negative-working plates (aluminum-based, diazonium coating) were used. All plates were of standard commercial grade with identical substrate characteristics

Soap Samples

Five different soap formulations were procured and tested while Standard alkaline plate developer (pH 12.5) as positive control.

Table 1: Five different soap formulations used for the research

Sample code	Soap type	Primary fatty acid composition	PH (1% SOL.)
S1	Coconut oil based	Lauric acid (C12:0) - 48%	9.8
S2	Palm oil based	Palmatic acid (C16:0) -44%	10.0
S3	Olive oil based	Oleic acid (C18:1) -75%	9.5
S4	Mixed vegetable oil	Palmatic +oleic (approx. 40:35)	10.0
S5	Commercial laundry soap	Mixed fatty acid	10.5

Each soap bar was grated and dissolved in distilled water at concentrations of 5%, 10%, 15%, and 20% (w/v). The solutions were heated to 40°C to aid dissolution, then cooled to room temperature (25°C) before use. The pH value was measured for each concentration.

Plate Preparation and Exposure

All sample plates were cut into 10×10 cm test pieces. Plates were exposed through a negative or positive test target using a Ultra Violet exposure unit. Exposure times were optimized for each plate type according to manufacturer specifications as follows: Positive plates were given 120 seconds while 60 seconds was assigned to negative plates.

Development Procedure

Exposed plates were immersed in the developing solution at 25°C ± 1°C. Later, development was carried out with gentle agitation manually by hand shaking. Development time was recorded for each sample and optimized for each solution. Plates were rinsed with distilled water and dried under the shade.

Development Quality

Complete removal was observed by the absence of coating in non-image areas and Image retention for sharpness and integrity of image areas were observed. For image quality assessment, resolution Ability to reproduce fine lines using resolution test target. Dot integrity Quality of halftone dots (5-95% range). For background cleanliness, Absence of scum or residual coating in non-image areas. Plate Longevity was assessed by mounting plates on a small offset press and run for 500 impressions while image quality was reassessed at intervals of 100 impressions

Data Analysis

Results were analyzed using descriptive statistics. A scoring system was developed to evaluate performance.

Table 2: A scoring system for Development performance

Score	Development quality	Image resolution	Plate longevity
5	Excellent	<10Um lines	>500 impressions
4	Good	20 um lines	400-500 impression
3	Fair	50 um lines	300-400 impression
2	Poor	100 um lines	200-300 impression
1	Very poor	>100um lines	<200 impression

Preparation of Soap Solutions

Soap solutions were prepared at concentrations of 5%, 10%, 15%, and 20% (w/v) by dissolving the appropriate weight of soap in distilled water. The solutions were stirred continuously until complete dissolution and then filtered to remove any undissolved particles. Fresh solutions were prepared for each experimental session to ensure consistency.

pH and Stability Measurements

The pH of each soap solution was measured using a calibrated digital pH meter. Measurements were taken at 25°C immediately after preparation and at 24-hour intervals over a seven-day period to assess stability.

Plate Development Procedure

Printing plates were exposed using a standard vacuum frame exposure unit with a UV light source. Following exposure, plates were developed by immersing them in the respective soap solutions at room temperature (25°C ± 2°C) with gentle agitation. Development time was recorded from immersion until complete removal of the unexposed coating was visually observed. The control plates were developed using the standard alkaline developer according to the manufacturer's specifications.

Evaluation Criteria

Development timewas recorded in seconds from immersion to complete removal of unexposed coating and complete removal was carried outby assessing visually and rated as: Excellent (5), Good (4), Fair (3), Poor (2), Very Poor (1.5). Image retention was evaluated based on the fidelity of the image after development. Resolution was assessed by measuring the minimum reproducible line width (in micrometers) using a calibrated microscope as reported by Okafor and Adebayo (2021). Plate Longevity was assessed by running the developed plates on an offset press and evaluating image quality and background cleanliness at 100-impression intervals.

Data Analysis

Data were analyzed using descriptive statistics, including means and standard deviations. Comparative analysis was performed to evaluate the performance of soap-based developers against the control.

Results and Discussion

Table 3: pH and Stability of Soap Solution

Sample	5%	10%	15%	20%
S1	9.2	9.8	10.1	10.3
S2	9.5	10.2	10.5	10.7
S3	9.0	9.5	9.8	10.0
S4	9.3	10.0	10.3	10.5
S5	9.8	10.5	10.8	11.0

The pH of all soap solutions increased with concentration, ranging from 9.0 (S3 at 5%) to 11.0 (S5 at 20%). This concentration-dependent alkalinity is attributed to the increased concentration of fatty acid salts, which hydrolyze to produce alkaline solutions (McBain, 2019). The commercial laundry soap (S5) exhibited the highest pH values across all concentrations, likely due to additives such as sodium carbonate or sodium silicate commonly

incorporated in laundry soap formulations (Warner, 2020). The pH range of 9.0–11.0 is significantly lower than that of the commercial developer (pH 12.5), which has important implications for development mechanism and plate compatibility. The lower alkalinity may reduce the risk of over-development and substrate attack, potentially extending plate life (Fujita et al., 2018).

Table 4: Development Performance on Positive-Working Plates

Sample	Concentration	Development time (sec)	Complete removal	Image retention	Score
S1	10%	180	Poor	Poor	2
S2	10%	150	Good	Good	4
S3	10%	200	Fair	Fair	3
S4	10%	160	Good	Good	4
S5	10%	120	Excellent	Good	4.5
Control	-	45	Excellent	Excellent	5

The development performance of soap-based solutions on positive-working plates varied significantly among samples. The commercial laundry soap (S5) demonstrated the best performance, with a development time of 180 seconds and good complete removal and image retention (score 4). Palm oil-based soap (S2) and mixed vegetable oil soap (S4) showed fair performance (score 3), while coconut oil-based (S1) and olive oil-based (S3) soaps exhibited poor to very poor performance. The superior performance of S5 can be attributed to its higher pH and the presence of additives that enhance surfactant properties. Laundry soaps typically contain builders such as sodium carbonate and zeolites that improve dirt removal, which may similarly enhance the removal of unexposed plate coating (Warner, 2020). The development time for soap-based solutions was 3.6 to 5.2 times longer than the control (50 seconds). This extended development time reflects the lower alkalinity and different surfactant chemistry compared to commercial developers. The o-quinone diazide coating on positive plates undergoes a solubility switch upon exposure, converting from a hydrophobic to a hydrophilic state through indene carboxylic acid formation (Thompson, 2020). Complete removal requires sufficient alkaline activity to dissolve the unexposed resin, which is more efficiently achieved at higher pH.

Table 5: Development Performance on Negative-Working Plates

Sample	concentration	Development time (sec)	Complete Removal	Image Retention	score
S1	10%	240	Very poor	Poor	1.5
S2	10%	200	Fair	Fair	3
S3	10%	260	Poor	Poor	2
S4	10%	210	Fair	Fair	3
S5	10%	180	Good	Good	4
Control	-	50	Excellent	Excellent	5

The performance pattern on negative-working plates closely mirrored that of positive-working plates, with S5 demonstrating superior performance (score 4) and S1 and S3 showing poor results. This consistency suggests that the development mechanism is primarily dependent on the surfactant and alkaline properties of the soap solution rather than the specific coating chemistry. Diazonium-based negative plates undergo photodecomposition upon exposure, with the exposed areas becoming insoluble while unexposed areas remain

soluble as reported by Kumar and Sharma (2019). The development process requires dissolution of the unexposed diazonium resin, which is facilitated by surfactant action and alkaline hydrolysis.

Table 6: Effect of Concentration on Development of Palm Oil-Based Soap

Sample	Concentration	Development time (positive)	Development time (Negative)
S2	5%	>300 (incomplete)	>300 (incomplete)
S2	10%	150 sec	200 sec
S2	15%	130 sec	180 sec
S2	20%	120 sec	170 secs

The concentration study using S2 (palm oil-based soap) revealed a clear inverse relationship between concentration and development time. At 5% concentration, development was incomplete even after 300 seconds, indicating insufficient surfactant and alkaline activity for effective coating removal.Increasing concentration to 10% dramatically improved performance, reducing development time to 150 seconds for positive plates and 200 seconds for negative plates. Further increases to 15% and 20% yielded diminishing returns, with development times decreasing only marginally (130 and 120 seconds for positive plates, respectively). This suggests that optimal development efficiency is achieved at approximately 10–15% concentration, beyond which additional soap provides limited benefit. This finding is consistent with critical micelle concentration (CMC) theory, where surfactant effectiveness plateaus once micelle formation is complete (McBain, 2019). The difference in development time between positive and negative plates at equivalent concentrations reflects the different dissolution characteristics of the respective coating chemistries as reported by Okafor and Adebayo (2021).

Table 7: Resolution Analysis

Sample	Minimum Reproducible line (um)
S2(positive)	25
S2(Negative)	40
S4(positive)	30
S5(positive)	20
Control	10

Resolution testing revealed that soap-based developers produced minimum reproducible line widths ranging from 20 µm (S5, positive) to 40 µm (S2, negative), compared to 10 µm for the control. The superior resolution of S5 (20 µm) approaches the control performance and may be acceptable for many printing applications, particularly those not requiring the highest resolution as reported by Free Patent Online (1998). The poorer resolution of negative plates (40 µm for S2) compared to positive plates (25 µm for S2) may be attributed to the different development mechanisms and the tendency of diazonium coatings to swell during development, potentially causing image distortion (Fujita *et al*., 2018).

Table 8: Plate Longevity

Impression	Image	Background cleanliness
100	Good	Cleane
200	Good	Cleane
300	Fair	Slight degradation
400	Poor	Visible degradation
500	Very poor	Unacceptable

Plate longevity testing on S2-developed positive plates (10% concentration) showed that commercial control maintained acceptable quality through 500 impressions. Plate longevity testing revealed acceptable performance up to 200 impressions, with good image quality and clean backgrounds (Schmid, 2002). Beyond 200 impressions, gradual degradation occurred, with fair image quality and slight background degradation at 300 impressions, poor quality at 400 impressions, and unacceptable performance at 500 impressions.The limited plate longevity compared to commercial developers may result from incomplete removal of unexposed coating, leaving residues that affect ink-water balance during printing as depicted by Eureka/Patsnap (2019). Additionally, the lower pH of soap solutions may not fully desensitize the non-image areas, leading to scumming and background contamination over extended print runs (Okafor and Adebayo, 2021).

Conclusion

This study demonstrated the potential of soap-based developing solutions as alternatives to commercial plate developers for offset printing plates. Among the five soap formulations tested, commercial laundry soap (S5) at 10% concentration emerged as the most effective, achieving good complete removal and image retention with a development time of 180 seconds for both positive-working and negative-working plates. Palm oil-based soap (S2) showed concentration-dependent performance, with development time decreasing from >300 seconds at 5% to 120 seconds (positive) and 170 seconds (negative) at 20% concentration. Resolution testing revealed that S5 achieved a minimum reproducible line width of 20 µm, approaching the control performance of 10 µm. Plate longevity was acceptable up to 200 impressions, with degradation observed beyond 300 impressions. The study concludes that soap-based developers, particularly commercial laundry soap, offer a viable, environmentally friendly, and cost-effective alternative for plate development in applications not requiring the highest resolution or extended print runs. However, further optimization is required to match the performance of commercial developers in terms of development speed, resolution, and plate longevity.

Recommendations

Based on the findings of thepresent study, the following recommendations are made:

1. Further research should be conducted for optimization of soap-baseach Life cycle analysis comparing soap-based developers with commercial developers should be conducted to quantify environmental benefits.
2. Commercial laundry soap at 10–15% concentration should be adopted as an alternative developer for short-run printing applications\
3. Pilot-scale trials in actual printing production environments should be conducted to validate laboratory findings under operational conditions

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