

To Study Print Density on Uncoated Paper Using Natural Extracts Based Ink

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Abstract:

Petroleum derived pigments, synthetic dyes and heavy metal driers commonly used in commercial ink formulation pose risks to worker health and contribute to environmental pollution. So, the growing environmental concerns associated with printing inks have encouraged researchers to explore sustainable and ecofriendly alternatives. Natural extract inks derived from plant and flower sources offer a promising solution due to their renewable origin, biodegradability and reduces environmental impact. However, the successful application of these inks in printing depends not only on their formulation but also on their formulation but also on their interaction with printing substrate. So, understanding the print quality performance of natural extract inks such as print density on uncoated paper for their practical use in the printing industry. The present study focuses on print density on uncoated paper using natural extracts-based ink. Natural pigments extracted from plant-based sources were formulated into printing inks and applied onto selected paper substrate under controlled printing condition. Uncoated papers exhibit higher porosity and ink absorption properties. To evaluate the effectiveness of natural extract inks on uncoated paper this study analysed print quality parameters such as print density. Solid ink density was measured to determine colour strength and ink coverage on the substrate surface. The printed samples obtained on uncoated papers were analysed to identify the influence of substrate characteristics on print performance. The findings are intended to contribute to the growing body of knowledge on sustainable printing technologies and to inform practical decisions for industries.

Keywords: Natural extract ink, Lake pigment, Screen printing, Uncoated substrate, Sustainable printing, Floral Pigment, Eco friendly

I. Introduction

Naturally produced inks are recognised as environmentally friendly inks because their ingredients come from natural resources such as leaves, the roots, fruit and flowers. They deal with several concerns with synthetic inks by making them less expensive and simpler to create as well as environmentally friendly and secure. The majority of materials are flowers, leaves, roots, fruits and seeds are perfectly coloured and their natural extracts may be turned into inks that are also recyclable, environmentally friendly, inexpensive, safe in everyday use and simple to process with widely available local resources [1]. The pigments used in natural inks come

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from natural sources. Good colour, taste, aroma, brightness, fast drying times and non clogging are characteristics of the herbal inks. Maximum inks are discovered to be stable, safe, edible and simple to put together [2].

Lake pigments- a class of dye based pigment in which organic colorants are precipitated onto an inorganic substrate typically aluminium hydroxide offer a compelling platform for developing natural ink systems [3]. Unlike conventional dye solutions, lake pigments exhibit improved lightfastness, reduced water solubility and enhanced particle stability making them more suitable for ink formulation [4]. Floral sources are particularly attractive owing to their high anthocyanin, carotenoid and flavonoid content which are responsible for a broad and vibrant colour gamut [5].

The word serigraphy has been derived from a combination of two separate such as latin words 'Seri' which means silk and 'graphein' which means to write or to draw, are combined to get the word serigraphy. Reproducing visual images, specifically text and pictures on a range of substrates and three-dimensional objects. The ink is squeezed, pumped or forced through the stencil's openings onto the printing substrate and printing objects in the screen printing process. The stencil's open sections are referred to as image areas and the other portions are known as non- image areas. Only the image part of the stencil are able to pass ink and print because the non-image areas prevent ink from getting on the stencil surface [6].

Print quality in screen printing is commonly characterised primary parameters such as solid ink density. SID measured by x-rite spectrophotometer and reflects the optical density of a solid printed patch and is strongly influenced by ink film thickness, pigment concentration and substrate absorption.

Paper substrates are broadly classified into coated and uncoated grades based on their surface finish and ink absorption characteristics. Coated papers are manufactured by applying a mineral based coating typically comprising kaolin clay, calcium carbonate and latex binder onto the base sheet by which it resulting in a smooth, low porosity surface that promotes ink holdout and superior optical density [7]. Uncoated papers possess an open fibrous surface with higher porosity and roughness that causing greater ink penetration and dot gain during printing [8]. The surface smoothness and absorbency are the two most critical substrate parameters governing print quality in screen and offset printing [9].

This study addresses this gap by conducting a rigorous analysis of SID on 90 gsm uncoated paper substrate using a solvent based lake pigment ink derived from floral species such as Hibiscus rose, Marigold, Butterfly pea and Black rose applied via screen printing.

The objective is to study print density on uncoated paper using natural extracts based ink.

II. Literature Review

S. B. Gokhale, A. U. Tatiya, S. R. Bakliwal and R. A. Fursule (2004) carried out the research entitled 'Natural dye yielding plants in India' documented numerous plant derived colourants and highlighted their application in inks, textile and related industries. The study demonstrated the potential of natural dyes as sustainable and environmentally alternatives to synthetic colouring materials. [10]

Vikas Jangra and Abhishek Saini and Sunil Sharma (2013) ‘Solid ink density in relation with dot gain in sheet-fed offset printing’ studied the effect of coated and uncoated paper substrates on print quality through the evaluation of solid ink density and dot gain. The findings indicated that substrate characteristics and ink film thickness significantly influence print reproduction and overall print quality. [11]

Nikil Kapur, Steven J. Abbott, Elisabeth D. Dolden, and Philip H. Gaskell (2013) carried out the research entitled ‘Predicting the Behavior of Screen Printing’ reported that screen mesh characteristics play a crucial role in controlling ink transfer and printed film thickness. The authors observed that finer mesh structures and appropriate mesh geometry contribute to more consistent ink deposition which directly influences print quality on the substrate. [12]

Vikas Jangra and Abhishek Saini (2014) ‘Dot Gain comparison on coated and uncoated paper in Sheet-fed Offset and Digital Printing’ evaluated a dot gain on coated and uncoated papers and reported that substrate properties play a crucial role in determining tonal value increase during printing. The authors emphasized that controlling dot gain is essential for achieving accurate colour reproduction and consistent print quality across different paper grades. [13]

Nisha Sharma, Dr. Anuja Agarwal, Dr. Y.S. Negi, Hemant Bhardwaj and Jatin Jaiswal (2014) carried out the research entitled ‘History and chemistry of ink- a review’ discussed the evolution of ink chemistry and highlighted the use of plant extracts, natural gums and vegetable based material in ink production. The review demonstrated that naturally derived colourants have long been used as sustainable alternatives to synthetic ink components. [14]

Arif Karademir, Cem Aydemir, Semiha Yenidogan, Emine Arman Kandirmaz and Rukiye G. Kıter (2020) carried out the research entitled ‘The use of natural (Pinus pinaster) resin in the production of printing ink and the printability’ studied the application of natural pinus pinaster resin in printing ink production and found that it improved several print quality attributes including gloss, rub resistant and light fastness. The findings demonstrated that natural resin based inks can serve as sustainable alternatives to conventional petroleum derived ink system. [15]

Elisha Ginne Espiritu, Jenny Mae Orcino, Melody Reyes and Von Carlo Pangilinan (2022) carried out the research entitled ‘Extraction of annatto (Bixa orellana), vine spinach (Basella alba), and dragon fruit (Hylocereus undatus) as ink product’ developed natural inks from annatto, vine spinach and dragon fruit extracts and observed satisfactory colour, absorption and drying properties on paper. The study demonstrated the potential of plant derived pigments as sustainable alternatives for ink formulation and paper based printing application. [16]

Idara U. Ntuen, Aniekan Effiong Akpakpan, Godwin Ndarake Enin and Ukana Davies Akpabio (2024) carried out the research entitled ‘Preparation and characterization of ink from Hibiscus sabdariffa, Curcuma longa and Sorghum vulgare’ investigated the preparation of inks from natural plant extracts and observed satisfactory ink adhesion and colour intensity on paper substrates. The authors reported that the formulated inks possessed suitable physicochemical properties that indicating natural pigments can be effectively utilized for printing application and may serve as sustainable alternatives to synthetic inks. [1]

Maja Klancnik, Elena Koradin (2024) carried out the research entitled 'Extraction of anthocyanin dye from Staghorn sumac fruit in various solvents and use for pigment printing' examined the use of anthocyanin based natural inks for screen printing on paper and fabric substrates. Their findings revealed that natural dye extracted obtained using ethanol and water produced satisfactory print quality and demonstrated the feasibility of eco friendly inks for printing applications. [17]

Samiksha Bisht, Prachi Jain and Kirtiraj K. Gaikwad (2025) carried out the research entitled 'Printable edible ink based on Hibiscus for food safety and sustainable packaging, and printing' reported that hibiscus based natural ink provided good colour strength, rub resistance and uniform print quality during screen printing. The study highlighted the suitability of natural pigments as sustainable alternatives for printing applications requiring effective colour reproduction and substrate adhesion. [18]

III. Materials and Methodology

Materials

The present study was conducted to evaluate the print density on uncoated paper using natural extract based ink. The materials selected for the study were chosen to represent commonly used printing substrate, environmentally friendly printing inks and printing process.

Natural extract ink was used as the printing medium. The ink was prepared using naturally derived colour extracts obtained from flower based sources. The formulation was developed achieve suitable printing properties such as colour strength, flow behaviour and substrate adhesion.

Substrates was selected for the investigation such as uncoated paper having a grammage of 90 gsm. This substrate was chosen because of the absorption characteristics. The porous and absorbent surface of uncoated paper permits more ink penetration which can affect colour density, dot reproduction and overall print quality.

Screen printing process was used as printing method in this study. The ink was transferred onto the chosen substrates using a screen with a mesh count of 65 threads per inch with an appropriate squeegee. All materials and equipment were maintained under controlled conditions to ensure consistency throughout the experimental work.

Methodology

The research methodology was designed to investigate the influence of substrate characteristics on the print quality obtained using natural extract ink. The study involved ink preparation, printing, sample preparation and measurements of print quality parameters such as print density.

The natural extract ink was prepared with the help of flowers such as Hibiscus Rose, Marigold, Butterfly pea and Black Rose. With the help of these flowers, lake pigment was prepared to make them insoluble pigment with the help of solvents such as Ethyl Acetate and Iso propyl alcohol other than this binder was used such as nitrocellulose resin and some additives such as wax and dispersion additives are used to enhance the characteristics of ink. For a better colour

strength and achieve better colour development some of the synthetic pigment was also used in small amount.

Printing was performed using the screen-printing technique under identical operating conditions. Parameters such as screen mesh which is taken 65 thread per inch, squeegee pressure, printing speed and ink application were kept constant throughout the experiment to ensure perfect printing on uncoated paper with natural extracts ink and by screen printing process.

A standard test chart containing solid patches, halftone elements and colour control patches was printed on uncoated papers. Multiple samples were produced to improve the reliability and repeatability of the results. After printing the samples were allowed to dry completely under controlled conditions before evaluation.

The printed samples were assessed using print quality parameter such as solid ink density. Solid ink density was measured to determine the colour strength and the amount of ink present on the printed surface. Higher density values generally indicate stronger colour reproduction and improved ink coverage. That parameter was measured with the help of x-rite spectrophotometer.

The measured values obtained from uncoated paper sample was recorded and analysed. A evaluation was then performed to identify the influence of substrate characteristics on print quality such as print density. The results were used to determine colour strength and how much ink absorbed by the uncoated paper.

IV. Data Collection and Analysis

The objective of the data collection procedure was to assess the solid ink density that natural extract based inks can achieve on uncoated paper. To achieve this objective a test chart was developed and printed under comparable operating conditions and featuring solid sections of cyan, magenta, yellow and black colours. The same type of uncoated paper, printing process and ink application circumstances were maintained throughout the experiment to limit variation caused by external influences. 50 printed samples were chosen for measurement and examination.

An x-rite spectrophotometer was used to determine the solid ink density of the CMYK colour patches. Before beginning the measurement process, the instrument was calibrated using the approved calibrated procedure. After calibration the spectrophotometer was placed carefully over the solid colour patches of each sample. From each printed sample, four density readings representing cyan, magenta, yellow and black were obtained.

SID	CYAN	MAGENTA	YELLOW	BLACK
Avg. Value	1.04	1.10	1.21	1.3
Min. Value	1	1.06	1.18	1.28

Max. Value	1.11	1.18	1.24	1.32
S.D Value	1.30	1.35	0.9	1.6

Table 1: Data Collection Table of SID

After completing the measurements, the obtained CMYK density values were arranged logically in a table. Separate columns were used for the sample number and the measured average, minimum, maximum and minimum density values cyan, magenta, yellow and black. ISO 12647-5 standard solid ink density values (S.D value) also included in the table for comparison. The experimental readings were analysed colour wise so that the performance of each natural extract based ink could be evaluated separately.

The measured average values were compared with the corresponding ISO 12647- 5 standard density values. The difference between the experimental and standard values was used to determine the level of deviation for each CMYK colour. The obtained data offered a solid foundation for assessing the print density performance of natural extract based CMYK inks.

V. Result and Discussion

The result of solid ink density from the 50 printed samples were evaluated against the standard density values specified in ISO 12647- 5. The individual average density values for cyan, magenta, yellow and black were calculated and displayed as a bar graph. In the chart, one bar shows the average solid ink density from the printed samples while the other bar denotes the related ISO standard value. This analysis aided in comprehending the effectiveness of inks derived from natural extracts on uncoated paper.

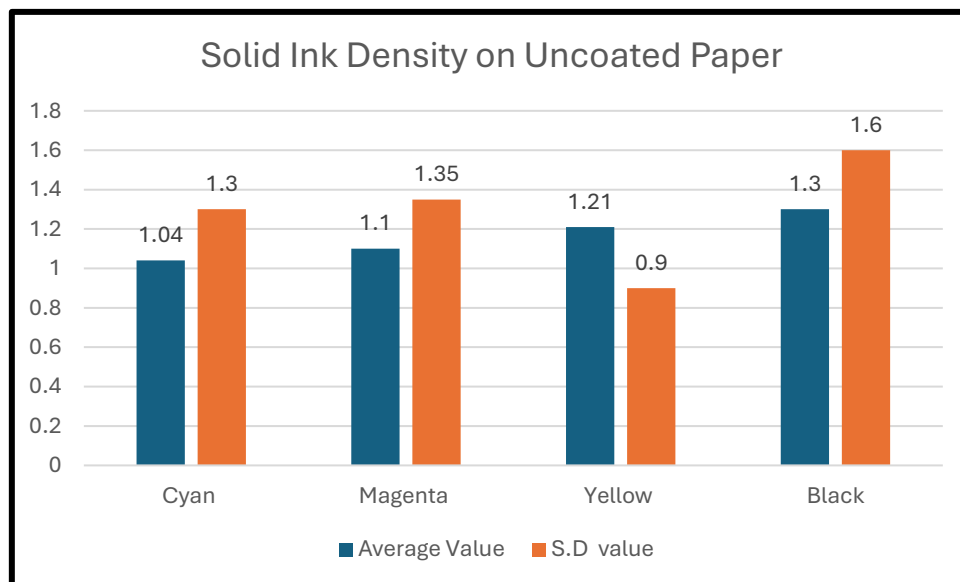


Fig 1: Bar graph representing solid ink density on uncoated paper (Average value and Standard value)

The result showed that average solid ink density of cyan was lower than the standard density value. This lower value may be related to the limited colour strength of the natural cyan extract. The porous surface of uncoated paper may also have absorbed a considerable amount of ink

and reducing the amount of colourant remaining on the surface. As a result the cyan print appeared to have a lower density compared with the required standard.

A similar result was observed for magenta. The difference may have occurred because natural magenta colourants generally have lower pigment strength and stability than conventional printing pigments. Uneven interaction between the ink and paper fibres may also have affected the formation of a uniform ink film on the substrate.

The black ink also produced a lower solid ink density than the standard value. Black density is usually influenced by pigment concentration, opacity and the thickness of the deposited ink film. In the natural extract based ink the black colorant may not have provided sufficient opacity or covering strength. The absorption of the ink into the uncoated paper could have reduced the darkness and overall density of the printed black area.

The yellow ink showed a higher average solid ink density than ISO standard value. This indicates that the yellow natural extract produce comparatively stronger colour development on the uncoated paper. The higher value may be due to a greater concentration of yellow colorant, better ink deposition or a thicker ink film. However, a density value higher than the standard does not always indicate better print quality. Excessive ink application may affect drying, cause unevenness and change the intended colour appearance.

Overall, the results indicate that the natural extract based inks showed different density behaviour for each process colour. Cyan, magenta and black require improvement in colourant concentration, ink viscosity, dispersion and ink transfer. On the other hand, yellow may require better control of ink film thickness to bring its density closer to the standard value. The findings suggest that natural extract based inks have the potential to produce printable CMYK colours but further modification of the formulation is required to achieve density values comparable to ISO standards.

VI. Conclusion

This research evaluated the print density of natural extract based CMYK inks printed on uncoated paper. An X- Rite spectrophotometer was used to assess the density of 50 printed samples on uncoated paper. The findings were compared to the ISO 12647-5 standard values. The average solid ink density of cyan, magenta and black was found to be lower than the matching ISO standard values. This may be due to lower colour strength, ink absorption and the porous surface of the uncoated paper. In contrast, yellow produced a higher density than the usually value that indicating stronger colour deposition or a comparably thicker ink film. The findings demonstrate that natural extract based ink is compatible with the screen printing process and can produce visible and measurable CMYK prints on uncoated paper. However, the ink formulation is not yet totally equivalent with standard printing inks. Further developments in pigment concentration, viscosity, dispersion and ink film control is necessary to obtain balanced density values and greater printing uniformity.

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