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International Journal of Artificial Intelligence and Machine Learning

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Research Paper

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Comparative Analysis of Ink Trapping of Conventional and Bio-based Inks on various papers using Offset Printing Process

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ABSTRACT

The present study presents a comparative analysis of ink trapping behaviour of conventional and bio-based inks on various paper substrates using the offset printing process. Ink trapping plays a vital role in achieving accurate colour reproduction and consistent print quality in multicolour printing. Printing trials were carried out using conventional inks and bio-based inks on various papers under identical press conditions. A standard trapping test chart was employed, and trapping efficiency was evaluated using densitometric and spectrophotometric measurements. The results indicate that ink trapping is significantly influenced by ink formulation and paper surface characteristics. Bio-based inks exhibited variations in trapping performance compared to conventional inks, particularly on absorbent substrates, due to differences in ink setting and absorption behaviour. Although bio-based inks offer environmental advantages, their trapping performance requires optimization to meet the demands of commercial offset printing applications.

KEYWORDS: Bio-based Inks, Conventional Inks, Ink Trapping, Art Gloss Paper, Art Matte Paper, Chromo paper, Maplitho Paper, Offset Printing, Print Quality

Introduction

Offset printing is a widely used lithographic printing process in which the inked image is transferred from a plate to a rubber blanket and then onto the substrate, typically paper or paperboard, allowing high-quality and high-volume reproduction for commercial, packaging, and publication printing (Kipphan, 2001).

Conventional offset inks are formulated with pigments, resins, drying oils, solvents, and additives designed to provide good colour strength, viscosity, and drying behaviour suitable for the press and substrate conditions (Cwiernia & Bosi, 2022). These traditional inks often rely on petrochemical-derived components, but environmental concerns and regulatory pressures have driven research and industrial efforts toward inks based on renewable, bio-derived materials such as vegetable oils and natural resins (Leach & Pierce, 1988; Aydemir & Özsoy, 2020).

Bio-based inks including soy-based and other plant-oil-derived formulations aim to reduce the environmental footprint of printing by decreasing volatile organic compound emissions and increasing biodegradability while maintaining acceptable print performance characteristics (Roy et. al., 2007; Hayta et. al., 2020).

Ink trapping in offset printing refers to the ability of a previously printed ink layer to accept an overprint of another ink layer during multicolour printing, affecting colour reproduction accuracy, tonal stability, and print quality (Robert, 2015). Trapping efficiency depends on ink formulation, paper surface properties, and press conditions; importantly, the upper ink layers in process printing do not trap with full thickness compared to printing directly on paper, which narrows the printable colour gamut if not optimised. Coated papers often facilitate better trapping performance than uncoated substrates due to controlled absorbency and smoother surfaces, while poorly trapped inks can lead to colour inaccuracies or print defects, especially in wet-on-wet printing sequences (Nguyen, 2021; Samanta et. al., 2025).

RESEARCH OBJECTIVES

The primary objective of this study is to comparatively evaluate the ink trapping behaviour of conventional and bio-based inks used in the offset printing process. By analysing ink trapping performance under controlled printing conditions, the study aims to assess the suitability of bio-based inks for multicolour commercial offset printing and to identify areas where process or formulation optimisation is required.

- To analyse the ink trapping behaviour of bio-based and conventional inks in multicolour offset printing.
- To identify the influence of different paper substrates on the ink trapping efficiency of both ink systems.

Research Methodology

The study was carried out in an industrial production environment at Pinetree Packaging Pvt. Ltd. using a Heidelberg CD LX sheetfed offset printing machine to evaluate ink trapping behaviour under standard commercial printing conditions. Four different paper substrates i.e., Art Gloss, Art Matte, Chromo, and Maplitho papers were selected to represent both coated and uncoated categories commonly used in offset printing. Three ink formulations, namely conventional ink, bio-based ink, and soya-based ink, were used for the comparative analysis. Printing trials were performed using a specially designed standardized test chart comprising solid ink patches, tonal values at 25%, 50%, and 75%, overprint areas for trapping assessment, grey balance regions, and colour control strips. Each ink formulation was printed on all selected substrates with identical press settings to ensure consistency across all trials.

To eliminate process-related variability, printing parameters such as ink feed, dampening levels, and press speed were maintained uniformly throughout the experimentation. For each ink–paper combination, 50 sheets were printed, out of which 20 sheets were randomly selected to ensure statistical reliability of the measurements. Instrumental evaluation of the printed samples was conducted using spectro-densitometric measurement tools to determine ink trapping values from the overprint and solid areas of the test chart. The measured data were systematically analysed to compare the ink trapping performance of conventional, bio-based, and soya-based inks on different paper substrates, enabling an objective assessment of the influence of ink formulation and substrate characteristics on trapping efficiency in offset printing.

DATA COLLECTION AND ANALYSIS

To evaluate the ink trapping performance of bio-based and conventional inks in the offset printing process, key trapping-related parameters were measured under controlled printing conditions. The data collected include ink trapping values derived from solid and overprint ink densities across different paper substrates. The following tables present a comparative analysis of ink trapping performance, highlighting variations between conventional, bio-based, and soya-based inks on coated and uncoated papers. The results are further illustrated using corresponding graphs to provide a clear visual representation of differences in trapping behaviour among the ink systems and substrate types.

Table 1. Average Ink Trapping (%) of Conventional, Soya-based and Bio-based Inks on Art Gloss Paper

Ink Type	Paper		
	Red (M+Y)	Green (C+Y)	Blue (C+M)
Conventional Ink	82.71	83.57	84.42
Soya-based Ink	78.45	79.05	79.72
Bio-based Ink	73.02	73.81	74.24

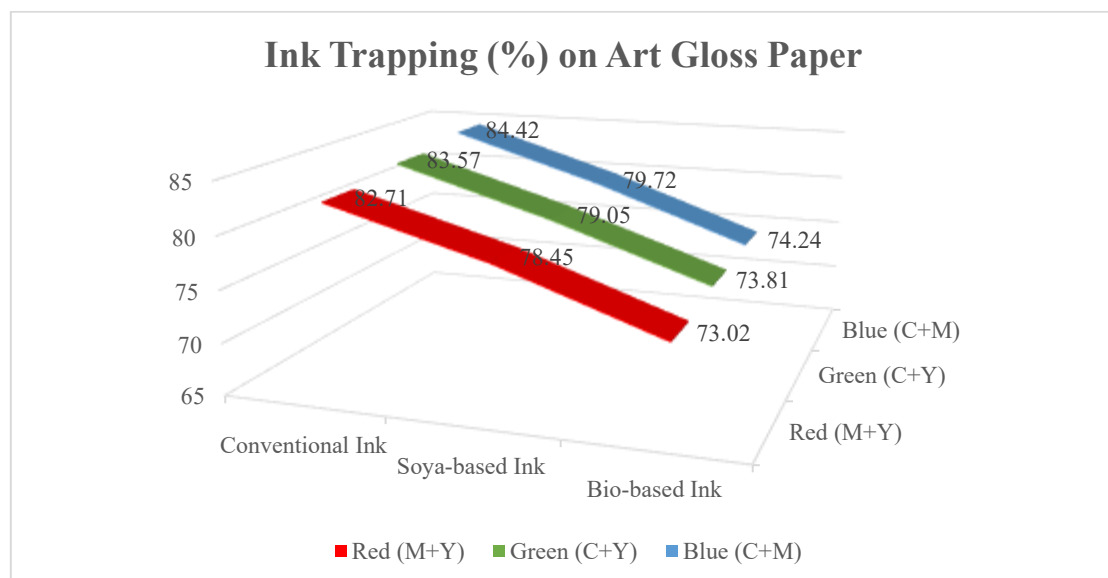


Fig. 1, Comparative Ink Trapping (%) Analysis of Conventional, Soya-based and Bio-based Inks on Art Gloss Paper

Table 1, provides a comparative summary of the average ink trapping percentages for overprint colours i.e., Red (M+Y), Green (C+Y), and Blue (C+M) printed with Conventional, Soya-based, and Bio-based inks on Art Gloss paper. The results indicate that conventional ink achieved the highest trapping performance across all overprint colours, with trapping values of 82.71% for Red, 83.57% for Green, and 84.42% for Blue. Soya-based ink exhibited intermediate trapping efficiency, recording 78.45% for Red, 79.05% for Green, and 79.72% for Blue. In contrast, bio-based ink demonstrated comparatively lower trapping performance, with values of 73.02% for Red, 73.81% for Green, and 74.24% for Blue, highlighting noticeable differences in trapping behaviour among the ink formulations on Art Gloss paper.

Table 2. Average Ink Trapping (%) of Conventional, Soya-based and Bio-based Inks on Art Matte Paper

	Red (M+Y)	Green (C+Y)	Blue (C+M)
Conventional Ink	78.69	79.06	79.67
Soya-based Ink	73.26	73.91	74.36
Bio-based Ink	71.08	71.83	72.16

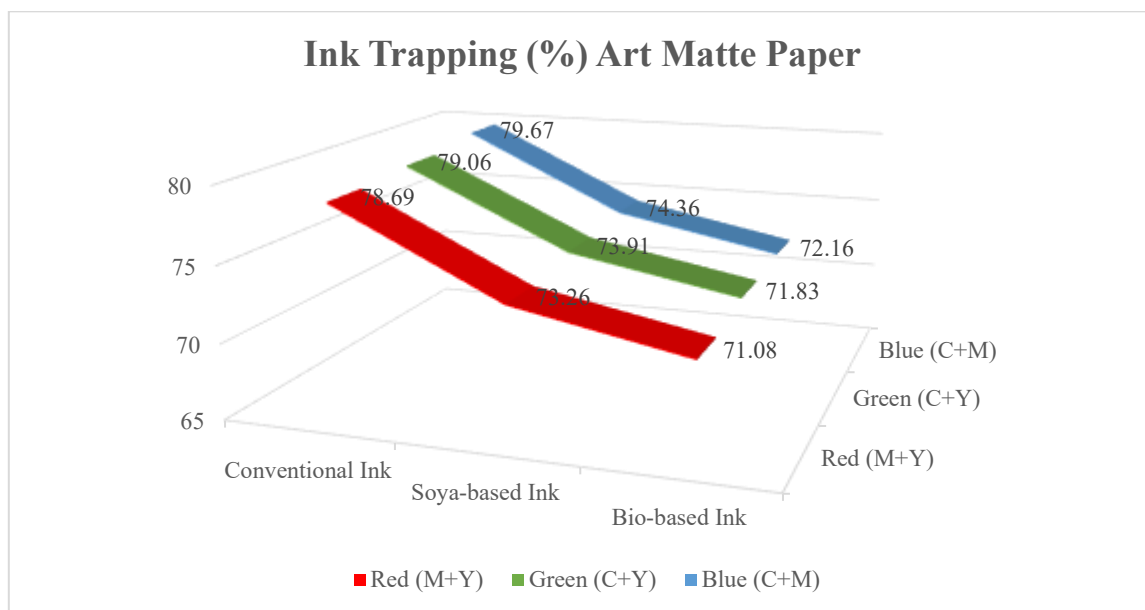


Fig. 2, Comparative Ink Trapping (%) Analysis of Conventional, Soya-based and Bio-based Inks on Art Matte Paper

Table 2, presents a comparative analysis of the average ink trapping percentages for overprint colours i.e., Red (M+Y), Green (C+Y), and Blue (C+M)—printed using Conventional, Soya-based, and Bio-based inks on Art Matte paper. The findings show that conventional ink achieved the highest trapping efficiency across all overprint colours, with trapping values of 78.69% for Red, 79.06% for Green, and 79.67% for Blue. Soya-based ink exhibited moderate trapping performance, recording 73.26% for Red, 73.91% for Green, and 74.36% for Blue. In comparison, bio-based ink demonstrated the lowest trapping efficiency, with values of 71.08% for Red, 71.83% for Green, and 72.16% for Blue, indicating comparatively reduced ink acceptance on Art Matte paper.

Table 3. average Ink Trapping (%) of Conventional, Soya-based and Bio-based Inks on Chromo Paper

	Red (M+Y)	Green (C+Y)	Blue (C+M)
Conventional Ink	75.26	75.93	76.66
Soya-based Ink	71.53	72.04	72.71
Bio-based Ink	70.36	70.87	71.39

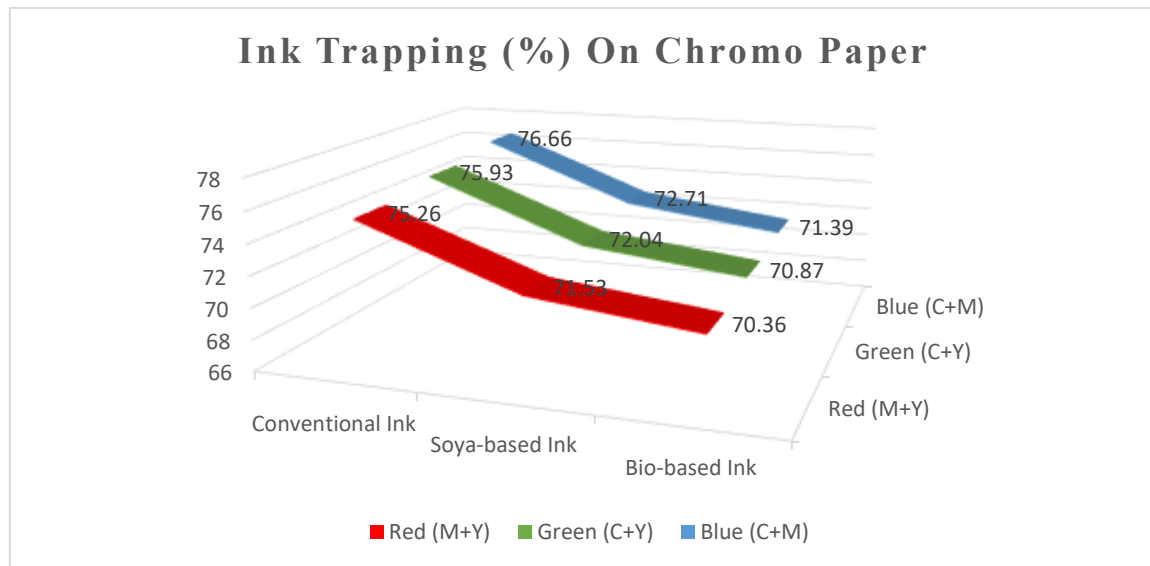

Fig. 3, Comparative Ink Trapping (%) Analysis of Conventional, Soya-based and Bio-based Inks on Chromo Paper

Table 3, presents a comparative summary of the average ink trapping percentages for overprint colours i.e., Red (M+Y), Green (C+Y), and Blue (C+M)—printed with Conventional, Soya-based, and Bio-based inks on Chromo paper. The results indicate that conventional ink achieved the highest trapping efficiency across all overprint colours, with trapping values of 75.26% for Red, 75.93% for Green, and 76.66% for Blue. Soya-based ink exhibited intermediate trapping performance, recording 71.53% for Red, 72.04% for Green, and 72.71% for Blue. In contrast, bio-based ink showed comparatively lower trapping efficiency, with values of 70.36% for Red, 70.87% for Green, and 71.39% for Blue, reflecting reduced ink acceptance on Chromo paper compared to the other ink systems.

Table 4. Average Ink Trapping (%) of Conventional, Soya-based and Bio-based Inks on Maplitho Paper

	Red (M+Y)	Green (C+Y)	Blue (C+M)
Conventional Ink	70.18	70.86	71.50
Soya-based Ink	67.09	67.74	68.22
Bio-based Ink	65.26	65.83	66.30

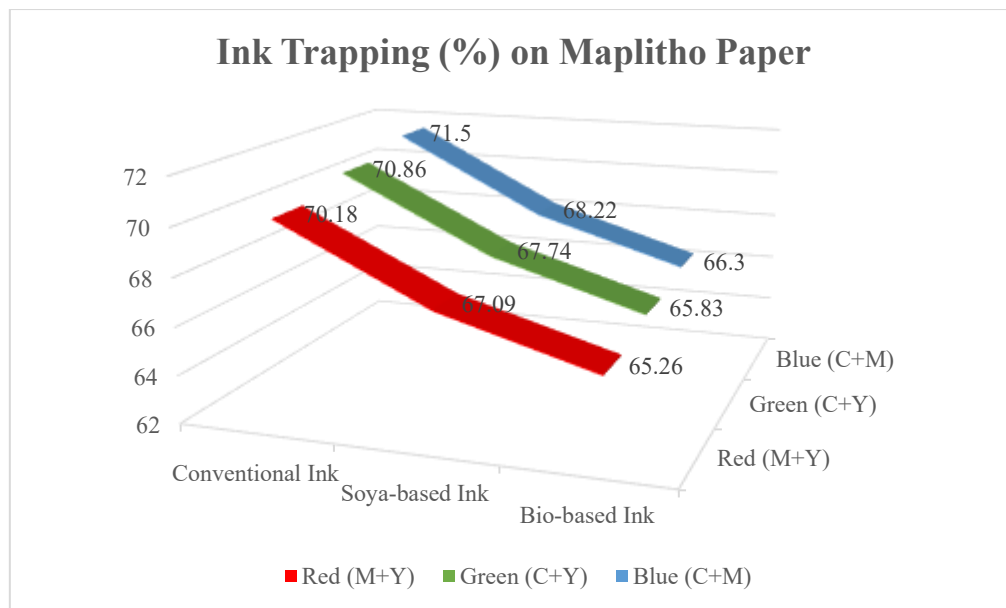


Fig. 4, Comparative Ink Trapping (%) Analysis of Conventional, Soya-based and Bio-based Inks on Maplitho Paper

Table 4, presents a comparative analysis of the average ink trapping percentages for overprint colours i.e., Red (M+Y), Green (C+Y), and Blue (C+M)—printed using Conventional, Soya-based, and Bio-based inks on Maplitho paper. The data show that conventional ink achieved the highest trapping efficiency across all overprint colours, with trapping values of 70.18% for Red, 70.86% for Green, and 71.50% for Blue. Soya-based ink demonstrated moderate trapping performance, recording 67.09% for Red, 67.74% for Green, and 68.22% for Blue. In comparison, bio-based ink exhibited the lowest trapping efficiency, with values of 65.26% for Red, 65.83% for Green, and 66.30% for Blue, indicating reduced ink acceptance on the more absorbent Maplitho paper.

Results And Discussion

1. Ink Trapping on Art Gloss Paper- Art Gloss paper showed the highest ink trapping performance due to its smooth surface and controlled absorbency, which allows effective overprint acceptance. Conventional inks performed best, followed by soya-based inks, while bio-based inks exhibited lower trapping efficiency. The coating facilitated uniform ink film formation and stable colour reproduction.
2. Ink Trapping on Art Matte Paper- Ink trapping on Art Matte paper was slightly lower than on Art Gloss, as the matte coating has higher surface roughness and absorbency. Conventional inks maintained superior performance, with soya-based inks showing moderate trapping and bio-based inks lower. Overall, coated characteristics still supported reasonable trapping for all ink types.
3. Ink Trapping on Chromo Paper- Chromo paper exhibited reduced ink trapping compared to fully coated papers. Faster ink absorption limited overprint efficiency, especially for bio-based inks. Conventional inks remained the most effective, while soya-based and bio-based inks showed moderate to lower trapping performance.
4. Ink Trapping on Maplitho Paper- Maplitho paper, an uncoated and highly absorbent substrate, demonstrated the lowest ink trapping across all ink systems. The rough surface and high absorbency reduced overprint acceptance, particularly affecting bio-based inks. Conventional inks performed relatively better, but overall trapping efficiency was lower than on coated substrates.

Conclusion

1. Conventional inks consistently exhibited the highest ink trapping performance across all substrates. Their stable rheology, rapid setting, and strong film formation enable effective overprint acceptance and uniform colour reproduction. This makes them highly reliable for multicolour offset printing.
2. Soya-based inks showed moderate trapping efficiency, performing slightly lower than conventional inks. While more environmentally friendly, their slightly slower setting and different rheological behaviour limit overprint acceptance, particularly in wet-on-wet printing.
3. Bio-based inks demonstrated the lowest trapping efficiency among the three ink types. Differences in absorption, slower setting, and reduced film cohesion affected overprint performance, highlighting the need for formulation optimization for commercial offset printing applications.

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