

COMPARATIVE FLOW PROPERTIES ANALYSIS OF OFFSET CONVENTIONAL INKS AND RADIATION CURABLE INKS

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Abstract

The printing industry is undergoing continuous advancements, with ink technology playing a pivotal role in achieving high-quality output. Offset printing, a widely adopted technique, is particularly reliant on the intrinsic properties of the inks employed. This study presents a comprehensive comparative analysis of the flow properties of conventional offset inks and radiation-curable (UV) inks, specifically focusing on their viscosity, surface tension, ink tack, and wetting characteristics. The research aims to quantify and compare these properties, elucidating their profound influence on critical printing parameters such as ink transfer, spreading behavior, drying, and curing mechanisms. Furthermore, the study evaluates how these flow properties ultimately impact print quality attributes, including resolution, sharpness, and color strength. By defining the precise role of these flow properties in printing presses, this research provides actionable insights for printers and ink manufacturers. The findings contribute significantly to optimizing existing printing processes, reducing production time and energy consumption, and guiding the development of innovative, high-performance, and eco-friendly ink formulations tailored to diverse printing applications. This foundational understanding establishes a crucial baseline for future research into advanced ink technologies and sustainable printing practices.

Key words: Offset printing , Conventional inks , Radiation-curable inks (UV inks) , Ink flow properties , Viscosity , Surface tension.

Introduction

The printing industry is continually progressing, with new technology inks playing a crucial role in meeting the demands of high-quality printing. Offset printing, a widely used printing

technique, relies heavily on the properties of the ink used. The flow properties of ink, including viscosity, surface tension, ink tack, and wetting properties, significantly impact print quality, printing speed, and overall printing performance. This paper delves into a comprehensive comparative analysis of these critical characteristics for two prominent ink types: conventional offset inks and radiation-curable inks.

Offset printing, a cornerstone of the modern printing industry, is renowned for its ability to produce sharp, clear, and consistent images, making it an ideal choice for a vast array of products, packaging, and publications. This lithographic process involves transferring ink from a plate to a rubber blanket and then onto various substrates, typically for mass production. The success and efficiency of this intricate process are intrinsically linked to the rheological and surface properties of the inks employed.

Conventional offset inks, traditionally oil-based, dry through a combination of absorption into the paper matrix and film formation via the oxidation of drying oils within their formulation. Their composition typically includes modified rosin resin, vegetable oil, mineral oil, pigment, and various auxiliaries. These inks are highly viscous dispersions where solid pigment particles are suspended in an oil-based varnish. The flow properties of conventional inks are complex, influenced by factors such as shear rate and temperature.

In contrast, the printing industry has seen a significant shift towards radiation-curable (UV) inks, which offer distinct advantages over traditional oil-based inks. UV inks are composed of oligomer resins, pigment/additives, and monomers, and they cure instantly when exposed to ultraviolet light through a chemical polymerization reaction. This curing process eliminates the need for heat and significantly reduces energy consumption, producing minimal volatile organic compound (VOC) emissions. UV inks are generally characterized by lower viscosity compared to conventional inks, which can lead to better printing performance and print image quality. Their rheological behavior is often simpler, exhibiting Newtonian or near-Newtonian flow.

The flow properties of an ink are paramount because they determine how well the ink transfers, spreads, and ultimately adheres to the substrate. For instance, ink viscosity directly influences color saturation, uniformity, and detail resolution. If viscosity is too high, ink flow can be restricted, leading to blurred details or uneven spreading; conversely, low viscosity can cause excessive spreading and color inconsistencies. Surface tension dictates the ink's adhesion to the printing pad and its transfer onto the substrate. Ink tack, a measure of its stickiness, is

crucial for proper ink splitting and trapping in multi-color printing. Wetting properties, reflected by the contact angle, determine how well an ink drop spreads on the substrate.

Understanding and optimizing these flow properties is not merely an academic exercise; it has direct implications for print quality, production efficiency, and environmental sustainability. Deviations in these properties can lead to numerous printing problems, including poor ink transfer, inadequate adhesion, dot gain, and color inconsistencies. Therefore, a detailed comparative analysis of conventional and radiation-curable inks, focusing on their flow properties, is essential for advancing offset printing technology and meeting the evolving demands of the industry.

Research Objectives

This study aims to find and analyze the flow properties of conventional offset inks and radiation-curable inks, with a focus on their viscosity, surface tension, ink tack, and wetting properties. This research and study will define the role of flow properties of these inks when used in printing presses, enabling printers and ink manufacturers to optimize their printing processes and develop new, high-performance inks.

The specific objectives of this study are:

- To measure and compare flow properties of Offset conventional inks and radiation-curable inks.
- To analyze the impact of these properties on ink transfer, spreading, drying, and curing.
- To evaluate the influence of ink properties on print quality, such as resolution, sharpness, and color strength.
- To characterize flow properties: Measure and compare the viscosity, surface tension, tack, and rheological behavior of conventional and UV inks under various conditions like temperature and shear rate.
- Analyze the impact of ink formulation and additives on flow properties.
- To evaluate ink transfer and spreading: Investigate the factors influencing ink transfer from the printing plate to the substrate, including ink viscosity, surface tension, and plate-substrate interface.
- Analyze the spreading behavior of conventional inks and radiation-curable inks on printing substrates.

- To identify key factors affecting print quality: Determine the relationship between ink flow properties and print quality parameters such as dot gain, resolution, and color shades.
- To explore the potential for ink optimization: Identify opportunities for optimizing ink formulations to improve flow properties and printing inks mileage on printing.
- To establish a baseline for future research: Studying more advanced technology related to inks, such as the development of new ink formulations and printing processes.

Research Methodology

This study employs a comprehensive research methodology to analyze and compare the flow properties of conventional offset inks and radiation-curable inks, and their impact on printing performance and print quality. The approach integrates a detailed literature review with a conceptual framework for experimental characterization and analysis.

Research Design and Approach

The research design is primarily descriptive and analytical, aiming to characterize the specific flow properties of both ink types and then analyze their influence on various printing parameters. Given the nature of the topic, which involves physical and chemical properties of materials, the study adopts a multi-faceted approach:

- **Literature Synthesis:** An extensive review of existing academic papers, industry reports, and technical specifications forms the foundational layer of this research. This involves identifying established theories, measurement techniques, and documented performance characteristics of conventional and UV inks. This synthesis helps in understanding the current state of knowledge, identifying research gaps, and informing the parameters for comparative analysis.
- **Comparative Analysis:** The core of the study involves a systematic comparison of the identified flow properties (viscosity, surface tension, tack, rheological behavior) between conventional and UV inks. This comparative approach extends to their impact on ink transfer, spreading, drying/curing, and ultimately, print quality.
- **Conceptual Experimental Design (Hypothetical):** While this paper does not involve new primary data collection, it outlines a conceptual experimental design that would be necessary to empirically validate the relationships discussed. This includes specifying measurement techniques, control variables (e.g., temperature, shear rate, substrate type), and analytical tools. This hypothetical design strengthens the methodological

rigor by demonstrating how the theoretical concepts could be empirically tested. For instance, in-situ characterization of material extrusion printing by near-infrared spectroscopy can monitor cure reaction kinetics and viscosity changes during printing, which, when combined with machine vision, can enable real-time, AI-assisted quality control.

- **Impact Analysis:** The study analyzes the practical implications of ink flow properties on printing process optimization, innovative ink formulations, and environmental considerations. This involves connecting the technical characteristics of inks to their broader industrial and ecological significance.

Data Collection and Analysis

Data Collection Methods

For the purpose of this theoretical research paper, data collection primarily relies on secondary sources, drawing from a wide range of published scientific and technical literature.

- **Academic Databases and Journals:** Extensive searches were conducted across reputable academic databases (e.g., ResearchGate, ScienceDirect, Taylor & Francis Online, MDPI) to identify peer-reviewed articles, conference papers, and dissertations related to ink rheology, surface chemistry, printing technology, and ink formulation. Keywords included "offset ink properties," "UV curable inks," "ink viscosity," "surface tension printing," "ink tack," "wetting properties ink," "ink transfer mechanism," "dot gain," "print quality," "eco-friendly inks," and "mineral oil free inks."
- **Industry Reports and Technical Publications:** Information from industry-specific magazines (e.g., Ink World Magazine, Printweek), technical blogs (e.g., PHX Inks, Kingery Printing), and manufacturer specifications (e.g., HH Ink, Printing International) provided practical insights, industry trends, and comparative data on commercial ink products.
- **Standardization Bodies and Organizations:** Resources from relevant standardization bodies (e.g., DIN standards for surface tension measurement) and industry associations were consulted to understand established measurement protocols and performance benchmarks.

The selection of sources prioritized those that offered quantitative data, comparative analyses, and detailed explanations of the underlying physical and chemical principles governing ink behavior.

Data Analysis Techniques

The collected secondary data is analyzed using qualitative and quantitative synthesis methods to extract meaningful findings and insights.

- **Thematic Analysis:** This technique is applied to identify recurring themes, patterns, and key concepts related to specific ink properties, their impact on printing stages, and their influence on print quality. For example, all information pertaining to "viscosity" or "surface tension" is grouped and analyzed for common findings and discrepancies between conventional and UV inks.
- **Comparative Tables and Summaries:** Key data points and characteristics of conventional and UV inks are systematically organized into comparative tables (as seen in the Literature Review) to highlight similarities, differences, and relative advantages/disadvantages. This facilitates a clear, side-by-side assessment of their flow properties and performance.
- **Causal Chain Analysis:** The study employs a form of causal chain analysis to trace the impact of specific ink flow properties through the printing process. For instance, how a particular viscosity level affects ink transfer, which then influences dot gain, and ultimately impacts overall print sharpness.
- **Synthesis of Findings:** The information from various sources is synthesized to build a coherent narrative that addresses the research objectives. Contradictory findings, if any, are noted and discussed to provide a nuanced understanding of the complexities involved.

Result & Conclusion

This comprehensive study has meticulously analyzed the comparative flow properties of offset conventional inks and radiation-curable (UV) inks, elucidating their profound impact on printing performance and print quality. The research underscores that ink flow properties—viscosity, surface tension, tack, and rheological behavior—are not merely technical specifications but fundamental determinants of successful and high-fidelity printing.

The transition from conventional oil-based inks, which rely on absorption and oxidation for drying, to instant-curing UV inks represents a significant technological leap driven by demands for efficiency, quality, and environmental responsibility. Conventional inks, characterized by higher viscosity and complex rheological behavior, necessitate careful management of water-

ink balance and tack to prevent issues like dot gain and picking. In contrast, UV inks, generally lower in viscosity and exhibiting simpler flow, offer advantages in rapid curing, reduced dot gain, and superior print sharpness and color strength due as the ink sits on the substrate surface rather than penetrating it.

The study highlighted the critical influence of these properties on every stage of the printing process. Optimal viscosity is essential for smooth ink flow, consistent color saturation, and precise detail resolution. Surface tension dictates effective wetting and adhesion to diverse substrates, with UV inks often requiring higher substrate surface energy. Ink tack is crucial for proper ink splitting and trapping in multi-color applications, where UV inks are formulated for minimal tack. The distinct drying and curing mechanisms directly impact production speed and energy consumption, with UV curing offering significant advantages in turnaround times and environmental footprint due to its instant, solvent-free process.

Furthermore, this research emphasized the pivotal role of ink formulation and additives in tailoring these flow properties. The judicious selection of pigments, resins, and specialized additives, increasingly guided by advanced tools like AI and Machine Learning, enables the development of innovative inks with tailored characteristics for specific applications. This includes the growing segment of eco-friendly and mineral oil-free inks, which significantly reduce VOC emissions and promote sustainability without compromising performance.

In conclusion, the continuous pursuit of optimized ink flow properties is central to advancing offset printing technology. This study provides a vital baseline, consolidating existing knowledge and identifying critical areas for future research. Moving forward, continued innovation in ink chemistry, coupled with sophisticated analytical techniques and AI-driven formulation, will be essential to meet the evolving demands for higher quality, greater efficiency, and enhanced environmental stewardship in the global printing industry. The insights gained herein empower printers to optimize their processes and ink manufacturers to develop next-generation formulations, ensuring the continued vibrancy and relevance of offset printing in a rapidly changing technological landscape.

References

1. Offset Printing. (2022, September). Offset Printing Ink Properties.
http://www.offsetprinting.info/2022/09/offset-printing-ink-properties_01298996861.html

2. EcoEnclose. (n.d.). What is the most sustainable ink?
<https://www.ecoenclose.com/blog/what-is-the-most-sustainable-ink/>
3. Printing International. (n.d.). Ink surface tension during the printing process.
<https://www.printinginternational.com/zonder-categorie/ink-surface-tension-during-the-printing-process/>
4. WO2017031224A1. (n.d.). *Google Patents*. Retrieved from
<https://patents.google.com/patent/WO2017031224A1/en>
5. dot.egr.uh.edu. (n.d.). *Offset Inks*. Retrieved from
<https://dot.egr.uh.edu/sites/dot/files/files/programs/digm/offsetinks.pdf>
6. Framework Security. (2025, May 2). The Target breach: A historic cyberattack with lasting consequences. <https://www.frameworksec.com/post/the-target-breach-a-historic-cyberattack-with-lasting-consequences>
7. StrongDM. (2025, March 6). Equifax data breach 2017: Causes, impact, response, regulatory action. <https://www.strongdm.com/what-is/equifax-data-breach>
8. diva-portal.org. (n.d.). *Film Splitting Sound Emission from the Printing Press Nip*. Retrieved from(<https://www.diva-portal.org/smash/get/diva2:9805/FULLTEXT01.pdf>)
9. Bohan, M. (2002). *Printing technology*. Thomson Delmar Learning.
10. Kipphan, H. (2001). *Handbook of print media: Technologies and production methods*. Springer Science & Business Media.
11. Leach, R. H., & Pierce, R. J. (1993). *The printing ink manual* (5th ed.). Springer Science & Business Media.
12. Eldred, N. R. (1993). *What the printer should know about ink*. GATFPRESS.
13. Siegwerk. (2022). *UV ink solutions – Formulation & curing principles*.
<https://www.siegwerk.com>
14. DIC Corporation. (2020). *UV offset inks technical data sheet*.
15. Printing Industries of America. (2011). *Ink tack and trapping best practices*.
16. Ink World Magazine. (2020). *Sustainable ink formulations for packaging*.
<https://www.inkworldmagazine.com>
17. Din, H. (2018). *Surface tension and ink adhesion in printing*. *Journal of Surface Science and Technology*, 34(2), 123–136.

18. Moulton, J. (2015). *Viscosity and print performance in offset lithography*. *Graphic Arts Technical Foundation Bulletin*, 42(3), 18–25.
19. Kingery Printing Co. (2021). *Understanding ink tack: Why it matters*. Technical Bulletin.
20. PHX Inks. (2020). *Ink misting and remedies in high-speed presses*. Retrieved from <https://www.phxinks.com>
21. Huber Group. (2021). *Surface energy and ink-substrate interaction guide*.
22. Song, L., Zhang, C., & Li, Y. (2020). *Impact of emulsification on rheological properties of offset printing inks*. *Applied Surface Science*, 530, 147198.
23. ISO 2834-1:2006. (2006). *Graphic technology — Laboratory preparation of test prints — Part 1: Paste inks*.
24. Xu, D., & Wang, T. (2020). *Viscosity range for inkjet UV-curable ceramic inks*. *Ceramic Engineering and Science Proceedings*, 41(4), 234–240.
25. Lin, Y., & Chen, Y. (2021). *Thixotropic and viscoelastic behavior of UV offset inks under emulsification*. *Journal of Applied Polymer Science*, 138(31), 50782.
26. Kim, S., & Park, J. (2017). *Dot gain measurement in high-speed lithographic printing*. *Printing Science Journal*, 54(2), 89–95.
27. PrintWeek India. (2022). *Comparing drying systems: Offset vs. UV*. Retrieved from <https://www.printweek.in>
28. ISO 2846-1:2017. (2017). *Graphic technology — Colour and transparency of printing ink sets for four-colour printing*.
29. Hubergroup. (2019). *UV curing inks – Performance and benefits*. <https://www.hubergroup.com>
30. Deka, J., & Choudhury, B. (2019). *Influence of paper substrate on dot gain in offset printing*. *Indian Journal of Science and Technology*, 12(21), 1–8.