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Comparative Quality Parameters Analysis of Vinyl, Polyutherene, Polyamide, Acrylic, and Nitro-Cellulose based Inks used in Gravure Printing Process

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Abstract
This research paper provides an in-depth comparative analysis of various ink formulations—namely vinyl, polyurethane, polyamide, acrylic, and nitro-cellulose—used in the gravure printing process. The performance of each ink type was evaluated based on key quality parameters such as adhesion, gloss, drying time, abrasion resistance, print sharpness, and chemical stability. Laboratory trials were conducted on polyethylene and BOPP substrates to assess real-world behavior under standard gravure printing conditions. The findings aim to guide printers and packaging professionals in selecting optimal inks based on end-use requirements and print quality expectations.

1. Introduction

Gravure printing is widely used in high-volume packaging applications due to its ability to deliver fine details, rich colors, and durability. The choice of ink plays a pivotal role in determining the final print quality and functional performance of the product. Different resin systems—vinyl, polyurethane, polyamide, acrylic, and nitro-cellulose—are utilized depending on the nature of the substrate and application conditions. This paper explores the comparative performance of these inks and evaluates their suitability for different types of packaging materials.

2. Materials and Methods

2.1 Inks and Substrates

Ink Types:

Vinyl-Based Ink
Polyurethane-Based Ink
Polyamide-Based Ink
Acrylic-Based Ink
Nitro-Cellulose-Based Ink

Substrates:
Polyethylene (PE)
Biaxially Oriented Polypropylene (BOPP)

2.2 Printing Method
Printing Technique: Rotogravure printing
Press: Laboratory gravure printer with standard cylinder
Speed: 150 m/min
Drying Conditions: 60°C hot air with 5-second dwell time

2.3 Quality Parameters Evaluated
Adhesion (ASTM D3359)
Gloss (at 60° angle)
Drying Time (Tack-free test)
Abrasion Resistance (Taber Abrasion)
Print Sharpness (Microscopy and visual inspection)
Chemical Resistance (Solvent rub test)

3. Results and Discussion
3.1 Adhesion Polyurethane and acrylic inks showed excellent adhesion to both PE and BOPP, with crosshatch test results of 5B. Nitro-cellulose and vinyl showed moderate adhesion, while polyamide underperformed on PE.

3.2 Gloss Acrylic and polyurethane-based inks exhibited the highest gloss (above 85 GU), making them suitable for premium packaging. Nitro-cellulose and vinyl inks offered medium gloss (~70 GU), while polyamide was the lowest (~60 GU).

3.3 Drying Time Nitro-cellulose and vinyl inks dried the fastest (within 5 seconds), making them ideal for high-speed production lines. Polyurethane took ~7 seconds, while acrylic and polyamide took slightly longer (8–10 seconds).

3.4 Abrasion Resistance Polyurethane ink ranked highest in abrasion resistance, followed by acrylic and polyamide. Nitro-cellulose and vinyl were more prone to surface wear, especially under high-friction conditions.

3.5 Print Sharpness All ink types showed acceptable sharpness under standard magnification.
3.6 Chemical Resistance Polyurethane and acrylic inks showed superior solvent resistance. Nitro-cellulose inks degraded slightly after 20 rubs, while polyamide was most affected by alcohol and mild solvents.

3.7 Composite Performance Score

Rank	**Ink Type**	**Adhesion**	**Gloss**	**Drying Time**	**Abrasion Resistance**	**Chemical Resistance**	**Composite Score**
1	Polyurethane-Based	5B	87	7 sec	Excellent	Excellent	0.95
2	Acrylic-Based	5B	89	9 sec	Good	Excellent	0.92
3	Nitro-Cellulose-Based	4B	71	5 sec	Moderate	Moderate	0.84
4	Vinyl-Based	4B	69	5 sec	Moderate	Fair	0.79
5	Polyamide-Based	3B	61	10 sec	Good	Poor	0.73

4. Conclusion

This comparative analysis highlights that polyurethane and acrylic-based inks deliver superior overall performance in gravure printing applications, particularly when high adhesion, gloss, abrasion resistance, and chemical durability are required. Nitro-cellulose and vinyl inks remain valuable for their fast drying properties and cost-efficiency but may fall short in high-end applications.

These findings are crucial for packaging converters and ink formulators aiming to balance cost, performance, and application requirements. Future research can explore hybrid formulations or biodegradable alternatives for more sustainable gravure printing.

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