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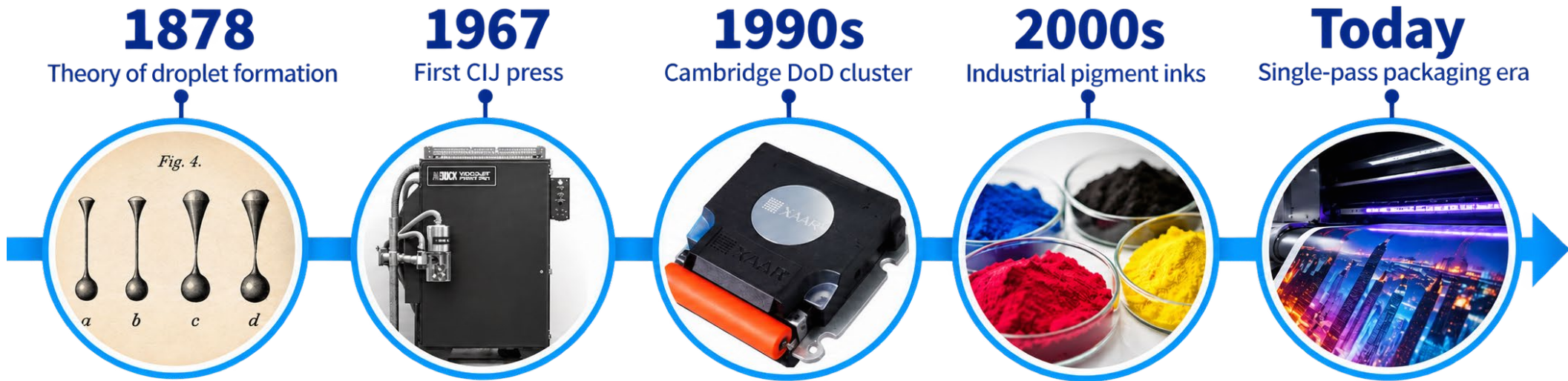
Where Color Meets Consciousness

Water Based Inks

Digital Packaging at an Inflection Point

Paul Edwards | Vice President, INX Digital Division

The Evolution of Ink Jet Technology



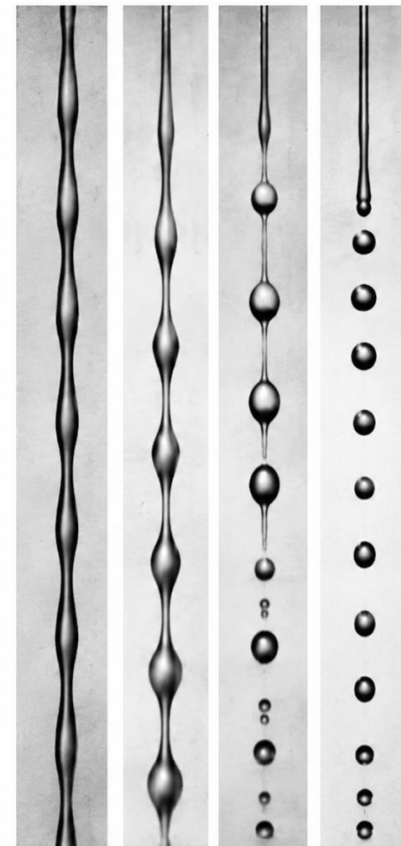
The Origins of Inkjet: 1878–1967

1878 | The Theoretical Foundation of Inkjet

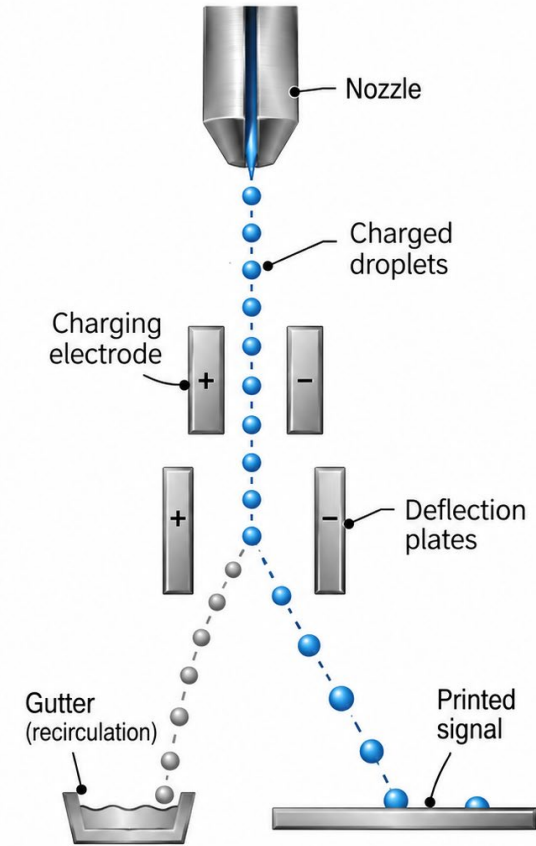
Lord Rayleigh established the theoretical basis for inkjet printing by describing how a liquid stream could be broken into controlled droplets—a principle that would take nearly a century to reach commercialization.

1967 | Mead Advances Continuous Inkjet

Mead Digital Systems began developing continuous inkjet technology in Dayton, Ohio. The work ultimately led to the DIJIT system, designed for high-speed variable printing and an important step in the development of industrial inkjet technology.



Droplet formation



Electrostatic droplet control

Early Industrial Inkjet: The Evolution of Ink Technology

Early industrial inkjet relied heavily on dye-based inks formulated around the requirements of the printhead, substrate and production environment. Solvent- and water-based systems were developed for different applications, each with distinct advantages and limitations.

Solvent Dye Inks

- Non-absorbent substrates: glass, metal, HDPE and PET
- MEK, ethanol and acetone for rapid drying
- Low viscosity (1–5 mPa·s) for reliable jetting

Limitations

- Poor lightfastness
- Limited chemical resistance
- High VOC emissions

Water-Based Dye Inks

- Primarily absorbent substrates
- Corrugated and paper substrates
- Textile substrates – direct & indirect print
- Lower-VOC alternative to solvent systems

Limitations

- Slower drying on films and plastics
- Adhesion challenges on non-absorbent substrates
- Primers often required

These early technologies established the printhead engineering and fluid dynamics knowledge that would support the development of water-based pigment inks for packaging graphics.

From Labels to Industrial Inkjet

Early 2000s | Digital label printing

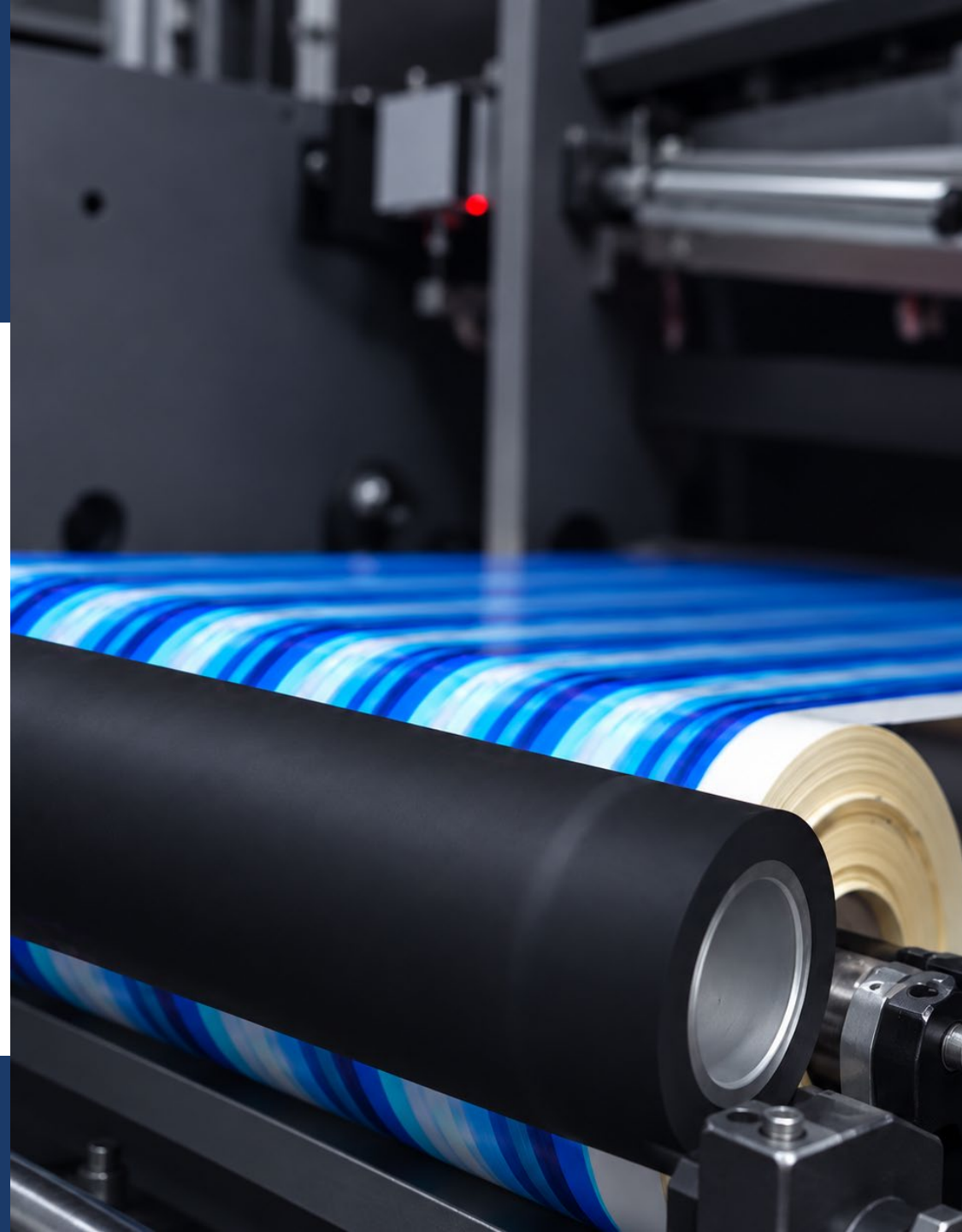
HP Indigo and early piezo inkjet systems made full-color short runs and variable data commercially viable for label converters.

Early 2000s | UV inkjet printing

Instant curing and adhesion to films, plastics, and coated board expanded inkjet into display graphics and other industrial applications.

Late 2000s–early 2010s | UV-LED curing

Lower heat output and energy use made UV inkjet more suitable for heat-sensitive films.



The Packaging Era: 2010s to Today

Corrugated | Industrial-scale digital printing

EFI Nozomi C18000 brought single-pass UV inkjet to corrugated production. Durst Delta SPC 130 advanced high-speed corrugated printing with water-based inks.

Folding cartons | Water-based inkjet

Koenig & Bauer VariJET 106 combined B1-format digital printing with inline finishing for carton production.

Flexible packaging | Short runs and versioning

HP Indigo enabled converters to produce shorter runs and multiple package versions without conventional plates.





CHAPTER 2

Market Demand: Brands & Converters

A \$37 billion market accelerating toward \$60 billion — driven by brand owners demanding customization and converters integrating digital into mainstream production.

Digital Packaging: What the Industry Data Shows

DIGITAL PACKAGING

Industry signals at a glance

PACKAGING PRINTERS

Offer digital printing



PACKAGING PRINTERS

Report growing SKUs



BRAND OWNERS

Prefer digital-capable converters



~30%

Projected SKU growth

Brand owners expect this increase over the next two years.

The data points to a shift in packaging production: more versions, shorter runs, and tighter turnaround expectations are making digital printing a more valuable part of the mix. Digital content opportunities and potential for an interactive experience with the product package gaining interest with brands.

What this means for converters

- More SKUs create more short runs and version changes.
- Digital printing helps manage those jobs without new plates for every design.
- Faster turnaround depends on an efficient path from approved file to finished package.

Sources: Alliance Insights (2025); NAPCO Research / PRINTING United Alliance.

What Brand Owners Are Demanding



Mass Customization

Brands need versioned, personalized packaging at scale. Digital printing avoids new plates and setup waste for every design.



Sustainability Credentials

Water-based inks can reduce VOC emissions compared with solvent-based systems, supporting brand environmental goals.¹



Faster Time-to-Market

Food and beverage brands need faster packaging cycles for new product launches. Digital printing removes plate lead time.



Regulatory Compliance

Food packaging inks must be evaluated as part of the finished package to meet requirements for its intended use.²

¹ U.S. EPA, Evaluation of Flexographic Inks on Wide-Web Film. ² Regulation (EC) No 1935/2004.



Three Shifts in Digital Packaging

Digital is becoming a practical production decision: converters are assessing where it adds flexibility and improves job economics across their operations.

1 • Shorter Runs, Faster Turnaround

More SKUs mean smaller jobs. Digital reduces plate costs and makeready, improving short-run economics.

2 • Hybrid Press Investment

Narrow-web converters are combining inkjet with flexo and inline finishing to add capability within existing workflows. (Labels/corrugated)

3 • Beyond Specialty Jobs

Digital is expanding across labels, flexible packaging, cartons, and corrugated as a production option. The balance point between where Ink Jet becomes a more profitable choice will define the % market penetration.

A man in a grey hoodie and dark vest is smiling and looking at a large, colorful printed map or design spread out on a table in a workshop. He is holding the edge of the print. In the background, there is a large industrial machine, likely a digital printer, with a warning label that reads "ATTENTION: ALL ACCESS POINTS TO THE MACHINE ARE LOCKED DURING OPERATION".

CHAPTER 3

Packaging Applications

Digital printing across materials, formats, and production processes

Where Digital Printing is Used in Packaging

Digital printing now plays a role across every major packaging market, from labels and flexible packaging to cartons, corrugated, metal, and direct-to-object.

Labels: Established digital application for short runs and versioning

Flexible packaging: Growing use for multiple SKUs and shorter runs

Corrugated: Single-pass inkjet at industrial scale

Folding cartons: Digital production with inline finishing

Metal decoration: Printing on cans, closures and aerosols

Direct-to-object: Printing on glass and rigid plastics



Labels: The Most Mature Digital Packaging Segment

Labels accounted for 38.6% of the digital packaging market in 2025, and the label market was valued at \$20.6 billion.¹ Their established use of digital printing reflects the day-to-day demands of label production.

Short runs and versioning

Digital helps converters manage more SKUs and frequent artwork changes without making new plates for each version.

A fit for existing workflows with hybrid systems

Digital and hybrid presses can combine printing with conventional processes and inline finishing.

Production performance matters

Ink, substrate, drying or curing, and end-use requirements must work together at production speed.



Digital Label Press Technologies

These systems illustrate the range of digital technologies used in label production, from toner to UV and water-based inkjet. Many systems available commercially today.

Press	Manufacturer	Key Spec
Xeikon CX500	Xeikon	Dry toner EP; water-based-compatible; 508mm web, food-safe
Durst Tau Series	Durst	UV \$ LED -based inkjet; up to 80 m/min; 1,200 dpi; narrow web labels
Domino N610i	Domino	UV-based pigment inkjet; up to 75 m/min; 7-colour; narrow web
Epson SurePress L-6534VW	Epson	Water-based & UV inkjet; 600×600 dpi; pressure-sensitive labels
Memjet-powered presses (e.g. Colordyne, Afinia)	Various	Water-based pigment inkjet; high-speed; entry-level narrow web

Flexible Packaging: The Fastest-Growing Opportunity

Digital printing is already established for short-run flexible packaging. Water-based inkjet is now being developed for longer production runs, with press speed and cost becoming more competitive with conventional processes.

HP Indigo (LEP) established digital production for short-run, versioned pouches and sachets, including work with converters such as Amcor.

Water-based inkjet is emerging for medium -run volumes of 5,000–50,000 linear meters.

Digital Flexible Packaging Presses

Press	Key Spec	Ink
Uteco Sapphire EVO	200 m/min, Kodak Ultrastream heads	✓ Waterbased
Bobst Mouvent LX 530	530mm web,	✓ UV Inks
Screen Truepress Jet 520 FP	80m/min, 520mm web, food-safe	✓ Waterbased
HP Indigo 200K	Wide web, short-to-medium runs	✓ LEP / WB

Corrugated Packaging: Industrial Scale Arrives

Single-pass digital presses now support industrial corrugated production, giving converters more flexibility for versioned packaging and shorter runs. These presses use two different ink and curing approaches.

Water-Based Inkjet

Drying must keep pace with the press while maintaining print quality on corrugated board and printer reliability.

UV LED Inkjet

Rapid curing supports production speed and print durability across a range of corrugated applications.

Manufacturer	Press	Technology	Key Spec	Ink Type
Koenig & Bauer / Durst	Delta SPC 130	Waterbased single-pass	1,300mm wide, 800–1,000 dpi, 9,000 sh/hr	Water-based
EFI	Nozomi C18000	UV LED single-pass	1,800mm wide, 720 dpi, 75 m/min	UV LED
EFI	Nozomi 2	UV LED single-pass	Next-gen platform, enhanced speed & quality vs C18000	UV LED
Barberan	Jetmaster 1680	UV LED single-pass	1,680mm wide, up to 100 m/min, piezo inkjet	UV LED
Barberan	Jetmaster 2100	UV LED single-pass	2,100mm wide format, high-volume corrugated	UV LED

Folding Cartons:

B1-format single-pass inkjet is bringing digital printing into larger folding-carton formats. With sheet sizes comparable to offset presses, it helps converters manage shorter runs and versioned designs. The presses shown use different approaches to carton production.

Sheetfed production

Larger sheets print multiple cartons at once and fit established coating and finishing workflows.

Ink and finishing

Water-based and UV inkjet require different drying or curing processes. Both must print consistently on carton board and work with the planned finishing steps.

Manufacturer	Press	Ink Type	Key Spec
Koenig & Bauer / Durst	VariJET 106	✓ Waterbased	B1-format (750×1060mm), offset-matched throughput, inline finishing
Heidelberg	Jetmaster Dimension	✓ Waterbased	B2-format sheetfed inkjet, targets pharma & cosmetics cartons, waterbased inks
Inca Digital (Agfa)	Onset X3 HighSpeed	UV LED	B1+ format, 4,800 sh/hr, UV LED, folding carton & display board
Ricoh	Pro VC80000	✓ Water-based	High-speed web-fed inkjet, waterbased inks, targets carton and commercial

Digital Printing for Metal Packaging (2&3 Piece applications)

Aerosols & closures (3 Piece)

UV inkjet cures quickly on nonporous metal. Water-based technology remains in development. Digital corrugated printers adapted for application.

2 Piece Beverage Cans

UV ink technology adapted to DTO can printers – short run applications. Replacing labels and shrink sleeve.

Ink requirements

Inks must adhere to aluminum and tinplate, withstand forming and necking, and endure any required pasteurization or sterilization. Food packaging also requires a regulatory compliance assessment.

System	Application	Ink Type	Key Spec
Hinterkopf D240	Cans & tubes	UV	Widely deployed; high-quality short-run production
Polytype DigiCan	Beverage cans	UV	360° full-colour; no minimum order quantities
Velox CanJet	Beverage cans	UV	Company recently purchased by Hinterkopf

Direct-to-Object: Glass, Rigid Plastics & Single-Use

Glass Bottles

- Premium spirits, wine and cosmetics
- **Key challenge:** Ink adhesion to smooth glass and resistance to washing

Rigid Plastics

- PET, HDPE and PP containers for personal care and food
- **Key challenge:** Surface pre-treatment to achieve reliable adhesion

Single-Use Packaging

- Short-run, versioned cups, trays and foodservice containers
- **Key challenge:** Durability through filling and handling, with indirect food-contact requirements where applicable. New sustainable packaging substrates (Fiber etc.)

Ink Formulation Challenges

- Inks must maintain adhesion and durability through production and use.
- Water-based DTO inks are less commercially established than UV inks; food packaging applications also require migration assessment.

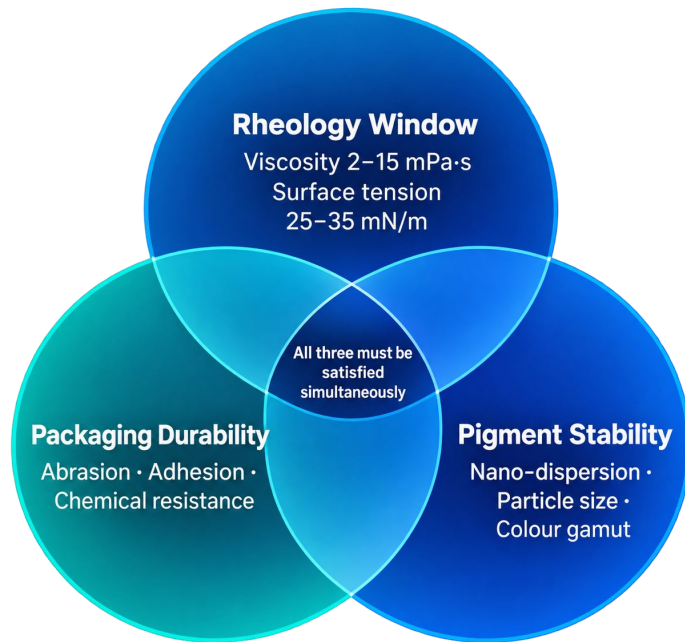


CHAPTER 4

Technical Challenges

Developing water-based digital inks for packaging requires solving a set of deeply interconnected technical problems—from printhead rheology to food-safe migration compliance.

Ink Formulation: Balancing Performance Parameters



The formulation challenge

Water-based inkjet inks must jet reliably through the printhead, dry at production speed, and deliver the durability packaging requires. Improving one property can affect the others.

Resin and binder selection: Polyurethane and acrylic dispersed binders can support droplet formation and printed-film durability while maintaining jetting and nozzle reliability.

Pigment nano-dispersion: Particle size, concentration, and long-term colloidal stability affect color gamut, optical density, and ink shelf life.

Drying: The ink must dry on the substrate at production speed without drying prematurely at the nozzles.

Substrate Adhesion & Drying on Non-Absorbent Films

Water-based inkjet on non – absorbent film depends on the ink, surface preparation, and drying system working together.

1. The substrate challenge

PET, OPP and PE do not absorb water like paper. Their surfaces can also make ink adhesion and controlled ink spread difficult.

2. Primers and precoats

Applied before printing, these can improve ink adhesion, print quality, and lamination performance.

3. Controlled drying

IR, NIR and hot air remove water quickly while limiting heat distortion, especially on thin films. Improved alternative drying technologies are also under development.



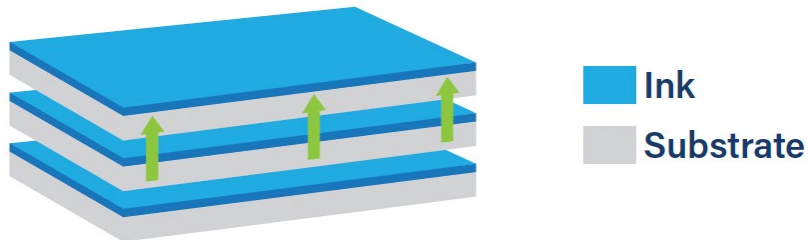
Food Safety & Migration Compliance

Food packaging must be assessed as a finished package: ink components can reach food through the packaging material or through set-off when printed material is wound or stacked.

The ink challenge

- Evaluate the full formulation: pigments, binders, additives, and surfactants.
- Control set-off from the printed side to the food-contact side.
- Water-based inks avoid UV photo-initiators but still require migration assessment.

Ink Set-Off
Example



Compliance Frameworks

EU Regulation 1935/2004 — General safety requirements for food-contact materials. eur-lex.europa.eu

Swiss Ordinance — Substance requirements for food-packaging inks. blv.admin.ch

Nestlé Packaging Ink Guidance — Customer-specific requirements for packaging inks.

EuPIA GMP — Good manufacturing practice for food-contact inks.

EU Regulation 1935/2004; Swiss FSVO; EuPIA food-contact ink guidance; Nestlé guidance

Printhead Compatibility & Ink Stability

Reliable inkjet performance depends on how well the ink works with the printhead and how consistently it performs over time.

Printhead compatibility: Ink properties and waveform settings are tuned for each platform.

Ink stability: The formulation must resist pigment settling and foaming to support consistent jetting and reduce nozzle clogging.

Stability testing: Turbiscan AGS and LUMiFuge help evaluate the formulation before it reaches production, along with more traditional evaluation of viscosity and filtration.

Seiko

Fuji Samba

Epson

Konica Minolta

Ricoh

Kyocera



Durability: Abrasion, Moisture and Chemical Resistance

Packaging inks must hold up through filling, distribution, and handling. On nonabsorbent substrates, water-based inkjet systems need particular attention to wet rub and abrasion resistance.

End-use durability

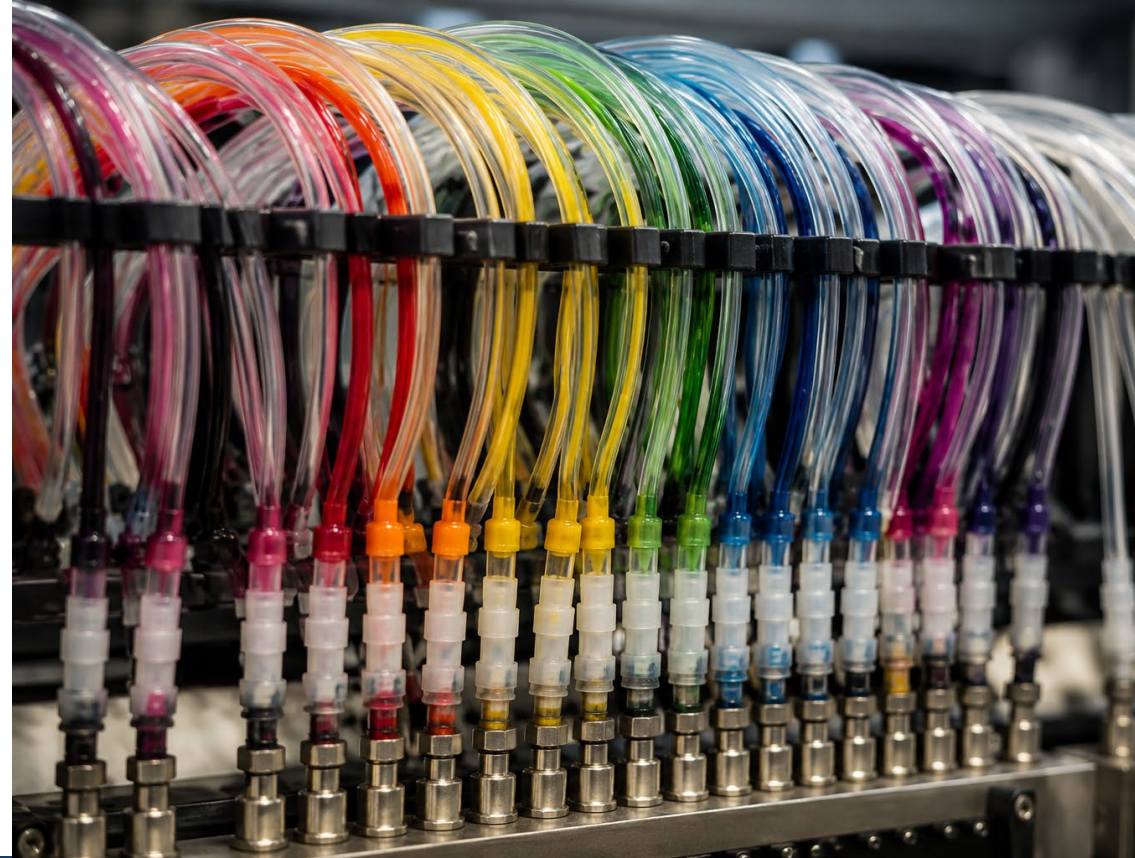
An ink that jets well must also resist moisture, rubbing and scuffing on the finished package. Some applications also require pasteurization, retort and lamination challenges.

Durst WT approach (Water-UV)

Thermal drying followed by UV crosslinking improves gloss and scratch resistance without a separate overcoat is a novel approach.

Qualification

Test the printed package against the exposures it will face in use, including abrasion and foodstuffs where applicable.



The Path Forward for Water-Based Inkjet

Water-based inkjet is gaining ground in packaging. Regulatory tailwinds and advances in press technology are creating opportunities, while production performance will determine how far it can go.

Regulatory tailwinds

VOC limits and food-contact requirements are increasing interest in water-based ink systems.

Technology convergence

Advances in pigment dispersion, printheads and single-pass presses are expanding what water-based inkjet can produce at scale.

The defining opportunity

There are many reasons why water-based ink jet technology can play a significant part in the growth of digital packaging. However, maximum progress can only be achieved by optimization of the ink and printing system together for a given application.



**THANK YOU –
Questions?**