Inks for Low Migration Applications

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Introduction
The manufacturers of ink and substrates for the packaging industry regularly get questions about what “Low Migration” really means. It is Nazdar’s hope that this article will help demystify the term and provide basic answers to the following important questions:

1. How is “Low Migration” defined?
2. What is migration?
3. How does an ink designed for low migration applications differ from an ink that meets a specific industry guideline?

Explaining Low Migration
Low migration is a blanket term used for a system of barrier substrates and inks that work in concert to reduce or eliminate the diffusion of un-polymerized ingredients through the printed substrate. We use the term “in concert” because simply having an ink that has been formulated to be low migration doesn’t guarantee that the final printed system will prove itself to significantly reduce or even prevent ingredient diffusion. An ink printed on a substrate that is not designated by the manufacturer as a functional barrier (uncoated paper for example) cannot be considered a low migration construction.

From the perspective of an ink manufacturer, an ink for “low migration” applications is an ink that is formulated with high molecular weight ingredients. While there is no standardized definition today for what constitutes a LM ingredient, many in the industry have begun using a threshold of 1000 daltons as the dividing line between compounds that regulatory bodies are interested in and those that typically pose no risk. The dalton is a standard unit that quantifies mass on a molecular scale. Compounds with a molecular weight greater than 1000 daltons are not likely to migrate through a functional barrier printed substrate. Compounds with molecular weights that are less than 1000 daltons are considered potential migrants and are typically addressed by various regional or industry specific guidelines.

For screen print and analog narrow web inks, sticking to the 1000 dalton threshold is not difficult. For inkjet inks however, using ingredients with molecular weights greater than 1000 daltons is not always possible, as they are too heavy/viscous to meet the viscosity requirements from printhead manufacturers. For inkjet printed packaging and labels, meeting a specific guideline and/or thorough migration testing is a necessity. When formulating inkjet inks for LM applications, we typically select ingredients that appear in one or more industry guidelines or regulations; a topic that we will cover later in this article.

Nazdar’s Short Statement on “Low Migration” products:
Nazdar offers ranges of UV/LED Inkjet and Flexo inks and coatings that have been formulated for applications where migration and odor are a concern. When using an ink that is offered as a low migration product, it is the responsibility of the end user to determine the suitability of the final package construction by appropriate migration testing in accordance with the governing regulations or industry guidance. All possible sources of migration and contamination should be evaluated for compliance.
What is Migration?

When we speak about migration in package printing, we are referring to the potential for food contamination by unpolymerized (uncured) ink compounds. When analyzing or testing a printed construction, there are four different types of migration that must be considered:

- **Through Migration** – diffusion of un-polymerized ingredients through the substrate
- **Set-Off** – The transfer of un-polymerized ingredients from the print surface to the food contact surface. Examples are labels that are rolled up on themselves, or cylindrical containers that are stacked with the outer printed surface of one container coming in contact with the inner surface of the next in the stack.
- **Vapor Phase** – Ink compounds and substrates that are volatilized through heating, allowing compounds to permeate through the packaging. An example would be a microwave meal that you leave the printed top on when cooking.
- **Condensation Extraction** - Condensation of ink compounds during cooking or factory sterilization through steam distillation.

Industry Guidelines and Regulations

The difference between simply claiming that a product is low-migration and **proving** that a product is indeed suitable for low-migration applications comes down to regulations and guidelines.

A number of regulatory bodies and large consumers of print packaging have developed sets of ingredient lists that ink manufacturers can follow. These lists help us define what low-migration really means, and can help the industry certify that an ink is compliant with LM best practices. While there are more being added every year, the most common are:

- **EuPIA** – general guidelines and an exclusion list of components (European Framework Regulation (EC) No. 1935/2004 on materials and articles intended to come into contact with food)
- **Swiss Ordinance** (Ordinance on Materials and Articles in Contact with Food, SR 817.023.21 – an inclusive list of compounds.
- **Nestlé Guidance Notes on Packaging Inks** – exclusion list released and managed by the Nestlé Corporation. Inks that comply with this list are better known as “Nestlé Compliant”
Even with guidelines in place, an ink that has been formulated to conform to a specific guideline can still be used incorrectly. Examples would be: printing on a substrate not defined as a functional barrier (cheesecloth for example), printing second surface with the ink coming in direct contact with the contents of the package, or having the ink under cured due to poor equipment maintenance.

**Qualification of an Ink**

For inks formulated to a specific guideline, an ink manufacturer should be prepared to self-certify that their formulas are compliant. Most ink manufacturers have internal regulatory teams that are not only responsible for the development of Safety Data Sheets, but can also analyze the ink formulas against various regulations and inventory lists. Nazdar regularly publishes letters stating our compliance with a wide variety of global regulations. If necessary, an independent laboratory can be engaged under a formula protecting non-disclosure agreement to certify that the formulation does indeed meet the guidelines.

**Migration Testing**

Because an ink manufacturer cannot possibly know or simulate all the possible substrate/food combinations for which a specific ink will be used, the manufacturer can never guarantee at 100% certainty that migration will not occur. This is why migration testing by an accredited analytical laboratory of each variation of packaging must be carried out by the manufacturer of the finished packaging.

An accredited laboratory can select the correct food simulant for the type of food product that will be packaged. Simulants include Aqueous Foods, Acidic Foods, Ethanolic Foods, Semi-Fatty Foods, Fatty Foods, and Dry Foods.

Laboratories can also test for other sources of contamination from the substrate manufacturing and print processes.

- Press wash solvents, cleaning chemicals, and lubricants from the printing equipment
- Plasticizers from substrates
- Monomers from plastics and coatings
- Adhesive components
- Recycled content contaminants in the substrate

Different global regions will have different guidelines for how the tests are conducted, what specific conditions are used (temperature, duration, etc.), and what food simulant is to be contained in the printed packaging. The allowable level of migrated contaminants and/or set-off can also vary regionally, but is typically defined as 10 parts per billion. A typical migration test is commonly based on 600 cm$^2$ of printed packaging material, 1 kg of food (or food simulant), and 10 days of storage at 40°C.
Variables in Day-to-Day Print Production

Inks designed for low migration applications are formulated against specifically defined sets of print conditions such as speed, total UV dosage, and ink densities that are provided by the manufacturer of the print equipment. Print conditions are expected to change over time, which is why it is imperative that migration testing be repeated on a regular frequency. Some of the most common variables are:

- **Substrate selection** – is the substrate defined by the manufacturer as a functional barrier?
- **Cure Conditions** – Are all the features of the press functioning properly (pin lamps, final cure lamps, oxygen inhibition systems, etc.)
- **Completeness of cure** – As mercury lamps age, or as curing unit reflectors are not properly maintained, the dosage of energy that they can impart can be reduced. Ink manufacturers will specify the minimum UV energy requirements to achieve complete cure. It is the responsibility of the print production facility to monitor cure levels as systems age.

**Conclusion**

To be truly considered a “Low Migration” package, the print provider must work closely with the ink manufacturer and the substrate supplier to make sure that the best practices for low migration manufacturing are being followed in every step of the process.

In this paper, we have taken care to refer to our ink products as “inks for low migration applications” and not describe them as “low migration inks”. We do this to emphasize that the inks themselves do not determine whether a final printed piece will prevent migration. Even an ink that an independent lab has certified as EuPIA, Swiss Ordinance, or Nestlé Compliant will not help if applied in a manner inconsistent with quality manufacturing practices, or applied to a substrate that does not provide an appropriate barrier.