PROTECTIVE PACKAGING

The growing use of UV inkjet ink technology for packaging applications requires ink manufacturers to be stringent about consumer safety. Migration-optimised UV inkjet inks could be the answer, according to Dr. Ralf Mueller

Dr. Ralf Mueller is Head of Sales UV Inkjet EMEA at Siegwerk

Digitally printed tubes produced on a Polytype DigiTube press using Siegwerk migration-optimised UV inkjet inks

UV-curable inks are an ideal solution when brilliant, glossy colours as well as flexible and resistive prints are required. This has promoted wide use of UV-curable inks in packaging applications, especially in the narrow web markets. With the development of piezoelectric drop-on-demand inkjet systems for industrial printing, a market transformation from analogue to digital has been initiated. Furthermore, inkjet printing has introduced a new level of freedom by enabling contactless printing of digital high resolution images.

Due to its jetting performance and print stability, UV inkjet has rapidly gained market share in label printing and created new possibilities for label-less decoration of consumer goods by direct-to-object printing. This is why ink manufacturer Siegwerk is convinced that UV inkjet is the best digital print technology for narrow web applications, whilst advocating water-based inkjet technology for large width digital printing on thin polymer films and porous material.

Using UV-curable inks on consumer goods, particularly food products, requires special consideration. After all, it was the concern about the use of ITX photo-initiators in UV inks in 2005 which led to significant changes in awareness around migration of low molecular weight substances from printed layers and accentuation of legal boundaries for food packaging manufacturers.

LEGAL FRAMEWORK

With the growth of UV inkjet ink technology in packaging applications, ink manufacturers need to demonstrate extensive formulation know-how to ensure consumer safety while offering best-in-class ink solutions. Within the European Union, the legal basis concerning consumer health and interests is defined by three regulations:

- European Framework Regulation (EC) No 1935/2004
- Regulation (EC) 2023/2006 on Good Manufacturing Practice
- Regulation (EU) No 10/2011

However, there is currently no specific EU legislation addressing printing inks for food packaging. The 'Swiss Ordinance' in its revised version (quoted as SR 817.023.21) is today the only regulation providing clear boundaries for ink formulations for food packaging. It contains a list of currently 5290 substances classified into Part A (toxicologically evaluated) or Part B (non-evaluated).

Part A substances are listed either with Specific Migration Limits (SMLs) or with a general Overall Migration Limit (OML) of 60ppm [parts per million]. These substances can be used in inks, provided that the migration limits are not exceeded in the final packaging.

Part B substances may only be used if they are not classified as 'CMR' substances (i.e. carcinogenic, mutagenic or reprotoxic according to classes 1A, 1B or 2 of the CLP Regulation) and if their migration is not detectable with a limit of 10ppb [parts per billion].

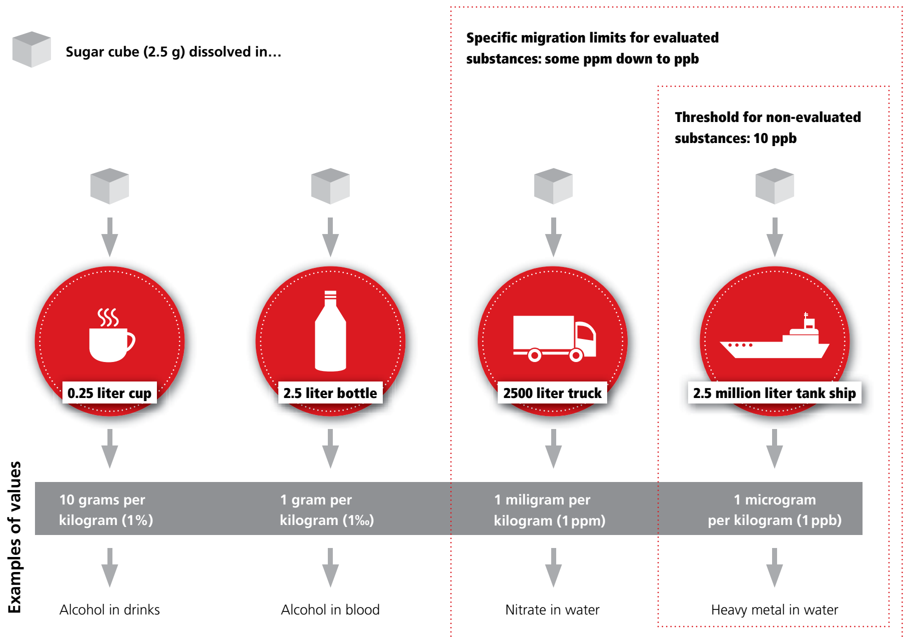
> *"UV inkjet has created new possibilities for label-less decoration of consumer goods by direct-to-object printing"*

UNDERSTANDING MIGRATION

Siegwerk advises using migration-optimised (MO) printing inks for all print applications related to Nutrition, Pharma or Hygiene packaging ('NPH' applications). However, usage of migration optimised inks requires accurate process control to properly mitigate the migration risk.

There are two types of migration relevant for packaging applications. The imminent migration risk originates from diffusion of small molecules through the substrate material, so-called diffusion migration. The diffusion of small molecular species can be suppressed, or at least slowed down, by applying appropriate substrates, e.g. polymeric films with high barrier properties or absolute barrier materials such as aluminium or glass.

However, when printing roll to roll or stacking printed materials such as cups or trays, set-off migration from the cured ink surface to the unprinted side needs to be considered as well. Therefore, we generally recommend specific migration assessments for each NPH application case.



Representation of tolerable migration thresholds for evaluated and non-evaluated substances

FORMULATION CHEMISTRY

From an ink formulator's perspective, the main focus for developing migration-optimised UV inks is on monomer and photo-initiator chemistry. The monomers represent the main part of an UV ink formulation and will mainly determine the properties of the final ink film. Thus, they are critical for achieving proper adhesion, flexibility and resistance of the cured film.

For conventional printing inks, high molecular weight monomers or oligomers are usually the starting point for migration-optimised UV-curable systems. However, the most widely used printhead technologies in single pass UV-inkjet operate in a viscosity range between 5 and 15mPa*s. This low viscosity prevents the usage of high molecular weight monomers or oligomers.

Apart from molecular weight, high reactivity and polyfunctionality can also help to suppress migration. However, as functionality is also connected to size, highly reactive acrylic monomers usually offer the best performance for MO UV inkjet formulations. Fast and complete polymerisation leads to dense polymer networks which can incorporate residual low molecular weight substances, preventing them from migrating.

PHOTO-INITIATORS

Free radical photo-initiators (PIs) are commonly used for printing inks. Radical formation can propagate via two mechanisms, sub-classified into type 1 and type 2 photo-initiators. In type 1, photochemical cleavage of molecular functions, such as aldehydes and ketones, creates two radical moieties which can induce the polymerisation reaction. Widely-used commercial examples are phosphine oxide based compounds such as BAPO or TPO-L. However, as the photochemical

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cleavage reaction results in formation of small breakdown-products, type 2 PIs are typically more common for MO inks.

Type 2 PIs do not undergo fragmentation, rather hydrogen abstraction from a donor molecule. Such donor molecules are typically tertiary amines, also referred to as amine synergists. Derivates of benzophenones and thioxanthones are common examples of commercial type 2 photo-initiators.

Extensive research has been carried out in the last decades to increase the molecular weight while maintaining high PI reactivity. This has led to the introduction of polymeric photo-initiators, where highly reactive photochemical functions are crafted onto polymeric backbones. Polymeric derivates of benzophenone and thioxanthone are today widely used in MO UV inkjet inks. They have fewer by-products resulting from their photo-chemical reaction and show a higher probability of being incorporated into the cured polymer matrix.

APPLYING HIGH STANDARDS

To enable brand owners, printers and converters worldwide to offer safe solutions to their customers, Siegwerk has established internal formulation guidelines on a global level. Thus ink formulators are given clear guidance on raw material regulations, classifications and purities when formulating inks for NPH applications. As an EuPIA member, Siegwerk is committed to the non-use of raw materials classified as CMR Cat. 1 in any kind of inks and applies the EuPIA Exclusion Policy on a worldwide basis, to not only protect consumers but also production and press operators. ■

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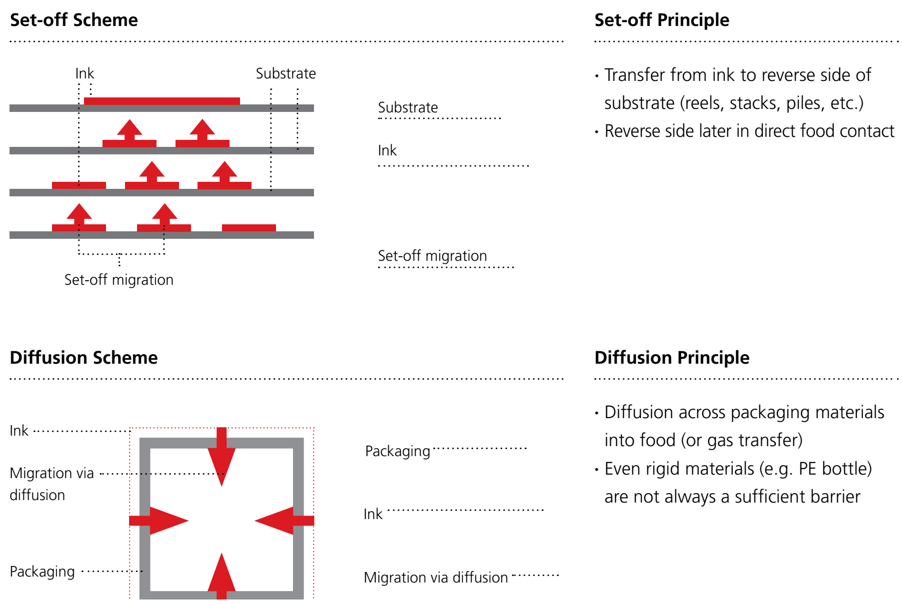

Migration of low molecular weight substances mainly happens via diffusion or set-off principle