Inks and Coatings for High Temperature Applications

Printing inks for food packaging are - in the majority of cases - intended to be exposed to normal ambient temperatures which are usually well below 100°C.
All EuPIA members' inks are designed to be safe for food packaging under these conditions.

However, over the past years, food packaging has been developed with several additional features / functions, one of them being that the packaging is more and more often used as a container in which to heat or even bake the food ("*ready-to-heat*").

There are several scenarios where printed packaging material is heated. There is heating during the packaging production, with processes such as drying in press or coating units, heat sealing of films, cut sealing, extrusion coating or corrugation of board. A characteristic for all of these processes is that the heat is applied for very short periods in industrial processes. This is seen as a very low risk area.

There are also heating processes that can occur during filling / packaging. These are under the control of the filler and are also seen as low risk. However, it should be remembered that migration rates increase, and substrate barrier properties may be affected, at higher temperatures. They include:

- Heat sealing (very short times, thus very low risk)
- Pasteurization of the packed food (usually <95°C)
- Hot filling (usually below 100°C)
- Retort / Steam Sterilization of the packed food (121 – 135°C)

The emphasis for this information note is on situations where the consumer heats packaged food. This is not always highly controlled and there is the potential for higher risk:

- "Boil-in-the-bag" (~100°C)
- Food packaging intended to be microwave-heated at the consumer (up to 160°C)
- Food packaging intended to be heated in the oven at the consumer (up to 220°C)
- Food packaging intended to be microwave-heated with susceptors (>260°C possible)
- Food in packaging not intended to be heated at home, but foreseeable to be re-heated in the oven or microwave: Pizza boxes, paper coffee cups, hamburger wrappers/boxes…Temperatures are as microwave or oven heating.

Note that domestic oven thermostats can vary by as much as +/- 20°C, and may oscillate around the set-point as the power cycles on and off.

Formation of new compounds:
By far the most critical situations are those that are not under control of the converter. The heating process at the consumer is the least predictable and prone to inadequate and unforeseeable times and temperatures.

Avenue E. Van Nieuwenhuyse 6 - BE-1160 Brussels
Tel: +32 (0)2 676 7480 - Fax: + 32 (0)2 676 7490 - E-mail: eupia@cepe.org *- Internet:* http://www.eupia.org/

All heating goes along with an increased risk: As the exposure to heat leads to greater physical activity of all substances, the standard risk assessment of potential migrants, in these cases, is not sufficient. During the heating, several chemical reactions (e.g. decomposition and breakdown reactions) may take place. These reactions depend on various parameters, like the structure of the chemicals, their potential reaction partners (from packaging or environment, e.g. oxygen), the temperatures or the duration of the heat treatment, etc. This results in the formation of an unpredictable variety of many new compounds - all of which necessitate a sound risk assessment to ensure the safety and the compliance of the final packaging.
The prediction of newly formed compounds is even more complex considering the possible reactions with other components of the packaging, i.e. adhesives, substrates, other inks and varnishes.

Some examples of what may happen (always depending not only on the temperatures but on many parameters as explained above):

1) Decomposition of nitrocellulose inks with the potential formation of nitrosamines if a secondary amine is present (can take place over a range of elevated temperatures; for further information please refer to your ink supplier)
2) Breakdown of polymers into smaller fractions (e.g. acrylic resins) (>160°C)
3) Decomposition of polyurethane resins (>170°C)
4) Cleavage of certain diarylide pigments may result in the release of potentially carcinogenic primary aromatic amines (>200°C)
5) Potential cleavage of phthalocyanine pigments (>>220°C)

Barrier properties:
Additionally, the barrier properties of the substrate change at the same time. For example, at retort temperatures (121 – 135°C), permeability and diffusivity of some materials can be more than 1000 times greater than they are at room temperature. This effect may be promoted under high pressure, which is often used in sterilisation processes. The rate of migration via diffusion is expected to approximately double for every 10°C increase in temperature.
Paper and board also show increased potential to release unwanted compounds at higher temperatures.

Responsibility of the ink manufacturer:
The ink manufacturer can evaluate the potential heat-formation of new compounds based on his knowledge of the composition of the ink. However, since the ink maker does not know about the use of other inks, coatings or adhesives, or about the details of the substrate, packaging properties or heating conditions, he cannot evaluate the risk from the final packaging. It is almost impossible to predict all reactions that can happen when packaging is exposed to heat.

Responsibility of the converter:
The chemical reactions cannot be predicted with calculation models, in fact, they have to be assessed in migration studies, and the risk for the consumer then needs to be thoroughly evaluated.

Applying the demands of the GMP Regulation[1] on the supply chain, there is clear responsibility on converters, food packers or Brand Owner/Retailers to conduct their own robust risk assessment on the safety in use of packs exposed to such extreme conditions in order to satisfy their own legal responsibilities.

In summary, the exposure of inks and coatings to high temperatures introduces significant risk in assuring safety-in-use of printed food packaging. Internal EuPIA risk management guidance and ongoing tightening of product design specifications within Brand Owners reflect the level of caution that ink makers need to show in responding to demands for inks and coatings to work in extreme conditions.

Ink makers act with great caution in providing products into this sector of the market.

Customers of the ink industry are informed that it is their responsibility to carry out an independent rigorous risk assessment against safety in use of inks/coatings applied into specific pack/food types under conditions that would be considered as worst-case in application (consumer or industry based heating, considering all possible routes of exposure).

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[1] COMMISSION REGULATION (EC) No 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food