Radiation Curing for Packaging

By Adam Page

New research shows a growing awareness and enthusiasm for radiation curing from packaging converters and end users. Pira International, a publisher, conference organizer and market research organization, has been tracking the printing and packaging industries for the past 70 years.

This article is based on an exclusive primary research survey that specifically looked at the global market for radiation curing in the packaging industry and the latest reports on the global packaging market.

It will discuss top-line trends in the global packaging market with specific reference to trends in North America, establish the global market for radcure in packaging, and finally examine a key factor in the adoption of radcure—food contact legislation.

Packaging Market

The fastest growing sector of the North American market over the next five years is likely to be rigid plastic packaging with sales forecast to rise by almost 3% each year to $27.1 billion by 2009 (Table 1). Paper, paperboard and flexible plastics sales are set to grow at a rate of 2-2.5% and there will be gains across all other sectors with the exception of glass packaging as glass continues to lose share to plastics in key food and beverage segments. Food packaging will remain the largest single sector in 2009 at $60 billion, ahead of industrial packaging sales at $31 billion.

The progression of global packaging demand is influenced by a wide range of factors from year to year as well as by factors with a much longer-term influence. While the economy plays a central role in influencing the size and growth of the market, there are a number of other factors that can be seen to have a direct or at least indirect influence on packaging demand or, at any rate, the nature of this demand, irrespective of the performance of the economy. These include:

- The aging world population.
- The trend toward smaller households.
- The increasing requirement for convenience among consumers.
- Rising health awareness among consumers.
- The trend toward "on-the-go" lifestyles among increasingly time-poor consumers.
- Growing requirements for brand enhancement/differentiation in an increasingly competitive environment.
- New packaging material development.
- The move toward smaller pack sizes as the incidence of families eating together at the dinner table becomes less common.

TABLE 1

Packaging consumption by type, 2004-2009, North America forecast

U.S. $ million	2004	2009*	Compound Annual Growth Rate (%) 2004-2009
Paper and board	53,592	60,129	2.3
Rigid plastics	23,704	27,101	2.7
Flexible plastics	20,666	22,968	2.1
Metal	25,843	27,351	1.1
Glass	5,527	4,996	-2.0
Other	5,569	6,120	1.9
Total	134,901	148,666	2.0

Note: *totals may not add up due to rounding

Source: Pira International Ltd.

- Increasing awareness of environmental issues and the adoption of new regulatory requirements on package recycling.

Shorter job sizes is another key development in the packaging industry for a number of reasons including:

- Greater variety of products.
- More frequent changes to advertising.
- Reduced stocks.

Radiation-cured materials offer certain advantages when it comes to achieving shorter changeover times in packaging production:

- UV&EB materials do not dry on the machines; therefore, cleaning times are shorter.
- The materials do not have to be removed from the coating/printing station immediately after the end of the work shift.
- Since the materials do not "dry," they can be left on the print stations for longer, provided there is a good quality or consistency of colors.
- Unlike solvent-based materials, radiation-cured inks do not precipitate changes in color tones as a result of solvent emissions.

Combine these advantages with the introduction of new printing presses designed for short runs, UV&EB materials offer a significant advantage.

Based on Pira's research, including a major survey of suppliers, converters and brand owners, we have established the total size of the radiation-curing market in packaging at around $480 million (EURO 388.5 million) with North American share at just over 32% (Table 2).

The development of UV&EB should be similar in both Europe and North America with strong demand for UV flexo and UV offset. In the U.S., there has been a greater usage of EB applications for some time while improvements in the quality of crosslinking have been achieved without photoinitiators.

Printing Methods

Printing and coating processes are needed for the production of packaging. Many of these methods are based on the use of solvent- or water-based materials, including printing inks, lacquers and adhesives.

The most important printing process for radiation-cured materials is offset printing, particularly of folding cartons and metal packaging. Offset's share of UV&EB inks and coatings is around 65%, but it is experiencing very low growth in Europe. Offset's share will fall slightly, although more UV equipment will be installed on offset presses. The share of UV offset in printing packaging is around 25-30%.

UV-flexo printing uses about 1,942 tons of UV inks in Europe, with the packaging market directly or indirectly accounting for around 80-90% of this.

The market for digital printing of packaging with UV inks is still very small and will remain so over the next five years, since there are various obstacles to the wider expansion of this method. While growth rates are extremely high, sales remain low.

There are not yet any solutions for the high-technological demands of the packaging market. In certain conditions, inks or lacquers do not adhere properly to some substrates such as polypropylene (PP) and polyamide (PA).

Due to the high-ink consumption, UV inks are uneconomical for use in rotogravure.

New methods of engraving (e.g., with laser) may provide a solution in the long run. The wetting of the surfaces, however, requires different engraving treatments due to the high viscosity of UV inks. No major changes in applications for UV&EB technology are expected in this sector.

Screenprinting is an interesting field for UV&EB use, which currently accounts for 7% of the market, and has shown a clear rise in consumption year after year. Sales are already high at around $22.6 million. Screenprinting, using the rotative printing process, offers considerable opportunities in the labels segment. When large amounts of materials are necessary for decorative purposes, screen printing can provide

TABLE 2

UV&EB market by geographic region, 2004-2009 ($U.S. Million)

Region/Country	2004	2009	Growth 2004-2009
Europe	136.1	155.9	14.5
UK	46.8	50.4	7.7
Germany	20.4	22.8	11.8
France	25.2	28.8	14.3
Italy	14.4	16.8	16.7
Spain	7.2	10.2	41.7
Central and Eastern Europe	22.2	27.0	21.6
North America	149.9	169.1	12.8
Southeast Asia, Africa, Middle East	179.9	225.5	25.3
TOTAL	466.0	550.6	18

Source: Pira International Ltd.

an elegant solution. Of course, it remains a limited, specialized area.

The primary reason for using coatings in the packaging sector is the high-gloss results that can be achieved by radiation-curing systems. For end users, this often gives products a higher value in the marketplace. The high resistance to humidity is another advantage for cartons. UV&EB units need less space in a printing machine than air drying systems, which is an important argument in favor of refitting for radiation curing.

There are limited opportunities for lamination in the application of UV&EB materials. The essential conditions for its widespread use are still missing. The need to inhibit crosslinking reactions and difficulties associated with sterilization has yet to be solved satisfactorily. The potential in this area could be enormous, because issues regarding the use of conventional adhesives can be solved with just-in-time delivery systems.

Over the next five years, radiation curing has potential in major sectors. In particular, an increase can be expected in the sectors for stand-up pouches and sleeves.

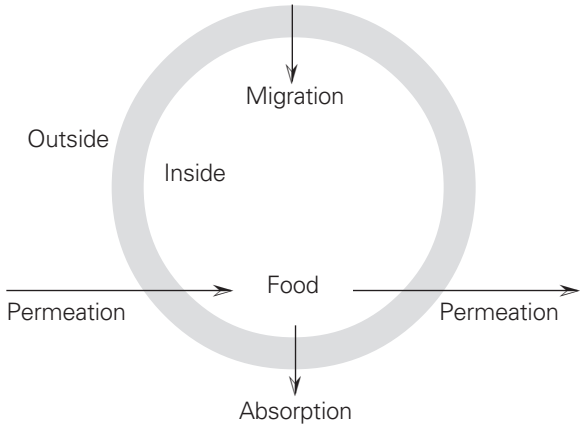
Frozen foods and dried foods have a greater share of UV&EB inks and lacquers usage due to the volume of UV-offset printing of folding cartons. Pet food offers further opportunity for UV&EB usage with UV flexo being used in the printing of aluminium foils and folding cartons. In addition, all packaging markets have a label segment in which UV-flexo printing is the main process.

Food Contact Legislation

All the legal factors governing the use of solvent- or water-based inks are similar to those affecting the use of radiation-cured materials in food packaging. There are similar regulations influences in the non-food areas.

FIGURE 1

Different reactions of food, packaging and surroundings



Source: Pira International Ltd.

The main factors (Figure 1) are:

- Permeation. The transportation of substances through the packaging material (both in and out).
- Absorption. The transportation of food substances into the packaging material.
- Migration. The transportation of packaging materials into food.

In food packaging, the level of migration is particularly important as the transition of physically dubious substances from packaging into food must be avoided. The following is a summary of the U.S. Food and Drug Administration (FDA) and the EU (89/109//90/128//93/10 EEC) rules:

- Manufactured "according to Good Manufacturing Practice (GMP)."
- "Does not emit substances in a quantity which could pose a risk to human health or....unacceptable change in the composition or deterioration in the organoleptic characteristics of the food."

Under the concept of GMP, a number of national and international regulations must be observed. As a result, the following are important:

- Cooperation. Cooperation is necessary between material suppliers (substrates, inks, adhesives and varnishes), converters and end users to deal with factors like permeation and migration. The interaction between filling goods, substrates and coatings must be checked.
- Formulation. The composition of the materials being used must comply with national and international rules from organizations such as the FDA, German Institute of Human and Animal Health (BGVV) and European Union (EU).
- Raw materials. The general rule that materials should "guarantee the smallest possible risks with regard to health" must be kept in mind. The European trade association for coatings and printing ink producers (CEPE) has drawn up a list of materials that should not be used because they are:
  - Very toxic (T+)
  - Toxic (T)
  - Carcinogens
  - Genotoxic
  - Toxic for reproduction

  Or contain:
  - Solvents such as methanol
  - Heavy metals such antimony, arsenic or cadmium
  - Plasticizers such as chlorinated paraffins
  - Asbestos
  - Benzene

Application practice, general requirements include:

- No direct contact between coatings and food
- Effective barriers
- Best quality (e.g., low odor, migration limits)
- Process stability (e.g., sterilization, sealing, pasteurization, resistance to food)

There are no general differences in the use of different printing inks, if the above needs are observed. In principle, the solvent- or water-based inks have the same legal and practical restrictions as radiation-cured products.

Critical points in the practical use of radiation-cured materials for packaging are:

- Proof of crosslinking
- No impact of photoinitiators on food
- No smell or taste from crosslinked or damaged materials arising from the EB ray treatment of substrates.

The questions as to which process delivers the best results from radiation curing and which is the most economical remains. Among the issues to be resolved is the use of EB without photoinitiators but with high-energy density. Another question surrounds the use of cationic systems with high-crosslinking capabilities. There is also the matter of free radical systems with inert atmosphere and extremely low-photoinitiator concentrations.

These questions must be examined and weighed in each individual case.

In addition, most countries have authorized organizations to examine the issue of migration. EU rules provide guidance based on testing of materials used in food packaging. Thus, the standard limit on migration is 10mg/dm2 or 60mg/kg food. But EU guidelines 82/711 EEC, 93/8 EEC and 97/48 EEC only deal with the basic principles governing migration. Since this often poses difficult analytical problems, standard solvents are used with certain food types.

Of course because some food can be fatty and acidic at the same time, combinations or multiple determinations are necessary. In Table 3, fatty and acid food has to be checked with test solvent D and B. The test conditions specifications are determined by the applications. A packaging product will need to be examined for more than a few hours or as long as days or weeks. The most critical temperature conditions must also be taken into account with pasteurization or sterilization conditions, in particular, providing the basis for tests at temperatures of 80˚C or 121°C.

TABLE 3

Test solvents for food migration test

Type of food	Test solvent	Abbreviation
Water-based food (ph > 4.5)	De-ionized water	Solvent A
Acid food (water-based food with ph > 4.5)	Acretic acid 3%	Solvent B
Alcoholic food	Ethanol (10%). This concentration has to be optimised if the food has an alcohol concentration of more than 10%	Solvent C
Fatty food	Olive oil or fatty solvents	Solvent D
Dry food	Nothing	Nothing

Source: Pira International Ltd.

Conclusion

Following this first attempt to quantify and forecast the global market for radiation curing for packaging, it is clear further research is needed to fully understand some of the specific underlying trends and establish niche market sizes in more detail.

Pira is currently expanding its current program of multi-client research and will be looking to launch a new study in 2006 on radcure for packaging.

As well as providing market sizes, the study is likely to explore the current state of technology, establish end-user perceptions of radcure, define their requirements over the next five years, and examine other factors that could affect the market including food contact legislation.

Author's Note

Pira International specializes in graphic arts, media and technology-led industries and is based near London, UK, with offices in Portland, Maine.

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