New approach to evaluate indirect transfer processes of printing ink compounds from UV printed packaging into food

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Introduction

UV curing technology is prevalent nowadays in food packaging printing. However, the application is partly a problem. Due to the raw materials and curing parameters of printing inks as well as the packaging storage conditions, indirect transfer processes (e.g. set-off) of printing ink compounds into foodstuff can possibly occur. For example in 2005 and 2009 high concentrations of photoinitiators isopropylthioxanthone (ITX) as well as benzophenone and methylbenzophenone were determined in baby milk products and cereals, respectively. The consequences are new legislative requirements (GMP Regulation 2023/2006/EC) as well as new quality standards for the food industry. However, there is insufficient knowledge about indirect migration processes of printing ink compounds. Hence, the overall objective of this study is to develop an innovative and cost-effective approach for the examination and assessment of indirect mass transfer processes of printing ink, as well as varnish compounds from UV printed outer layers of food packaging into filled products. The analytical measurements are focused on photoinitiators (PI) and acrylates as they are the most critical migration compounds.

Material and Methods

Different packaging materials (flexible films, cardboards and plastic containers), each printed with various UV printing inks (Table 1), have to be manufactured in order to study indirect migration processes.
To determine concentrations of the PI and acrylates sensitive analytical methods are required. The analysis will be done using LC-MS/MS- and GC-MS-techniques. The development and application of new appropriate methods which are the basis for the further examinations, will be the focus of work package IV (WP IV) (Figure 1).

Table 1: Food packaging samples under study

Packaging	Printing	
	Kind of photoinitiator	Covering
Flexible films	monomeric	with varnish
		without varnish
	polymeric	with varnish
		without varnish
Cardboards	monomeric	with varnish
		without varnish
	polymeric	with varnish
		without varnish
Plastic containers	monomeric	with varnish
		without varnish
	polymeric	with varnish
		without varnish

Project work

The concentration and migration potential of PI and acrylates are being determined by carrying out a comprehensive series of migration and set-off tests. Simulants such as ethanol/water mixtures, poly(oxy-2,6-diphenyl-1,4-phenylene) and also real foods having differing amounts of surface fat and water are used for migration tests. Acceptor materials e.g. PP, PE, PET and varnished aluminum foils are used for set-off tests (WP V). These migration and set-off tests are being undertaken under different conditions (storage conditions, and storage time contact time, contact temperature,). The test conditions must be as realistic as possible. The next stage of the research project involves systematically studying the indirect material transfer processes, namely the set-off effect, permeation, and a combination thereof, as possible material transfer mechanisms for the PI and acrylates (WP VI). This is achieved by carrying out systematic studies whereby the printed substrates are contacted with various acceptor materials (e.g. PP, PE, PET, varnished aluminum foils) as well as food simulants such as different ethanol/water mixtures, isooctane, and/or poly(oxy-2,6-diphenyl-1,4-phenylene) followed by monitoring the migration over time as a function of the temperature and contact pressure. In order to be able to define the extent of the set-off relative to the set-off potential in the outer layer ($c_{P,0}$), and for the subsequent modelling, it is important to quantify the outer layer components that are able to migrate in all the acceptor systems under study. This was achieved by determining the initial concentrations of the migrating substances in the printing inks or lacquer layers via total extraction with a solvent that swells the packaging. The determination of the underlying physical-chemical

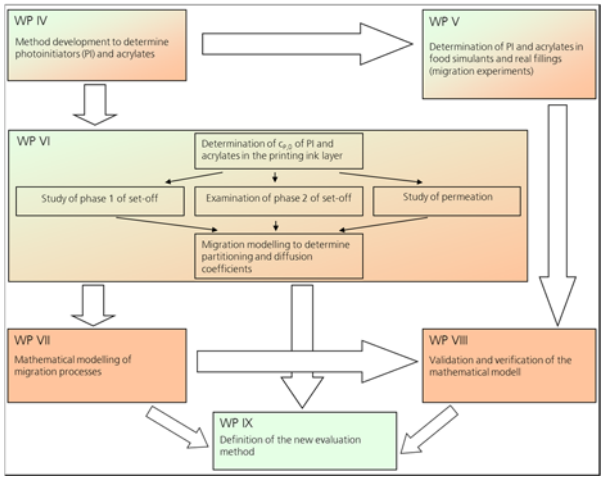

Figure 1: Project flow chart

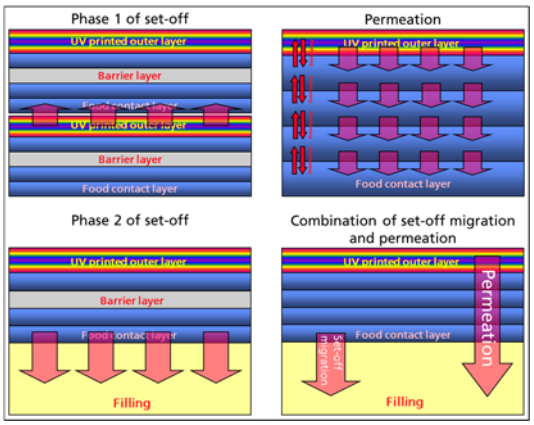

Figure 2: Indirect material transfer processes under study

parameters by mathematical modeling (diffusion coefficients, partition coefficients, kinetic effects, etc.) allows parameters for the material transfer to be generated which form the basis for a tool for evaluating (via migration modeling) the potential migration from the outer layers (WP VII). Using the data from the aforementioned experiments, and numerical calculation of the set-off and permeation, material transfer from printed and/or lacquered outer packaging layers into foods can be calculated for situations commonly encountered in practice. There is positive validation of the method for estimating material transfer if the experimental values $c_{F,t}$ lie within the distributions of the estimated values, namely if the data generated by the method either overestimate or are the same as the measured values (WP VIII).

Aspired results

Several new analytical methods to determine PI and acrylates in different matrices are generated. However, the main results are the physico-chemical parameters partition and diffusion coefficients, which are the underlying parameters of indirect mass transfer. These parameters are used to model the indirect transfer processes and are the basis for a new assessment tool (via migration modelling) to estimate the potential migration of photoinitiators and acrylates into foodstuff. The main feature and innovation of this model is the recognition of permeation and the set-off process as sources of migration. Therefore, the project will provide a cost-effective method of testing compliance of UV printed products, in fulfilling the requirements of Art. 3 of Regulation (EC) 1935/2004 (health safety and migration of substances into foods). Furthermore, the printing ink and/or packaging manufacturers can utilise the new tool directly for the technological optimisation.

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Poster presentation at the 5th international Symposium on Food Packaging, 14-16 November 2012, Berlin