

# Targeted multidimensional gas chromatography using a heart cutting device and cryogenic focusing for the determination of benzophenone derivatives in foodstuffs

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## 1. INTRODUCTION AND STRATEGY

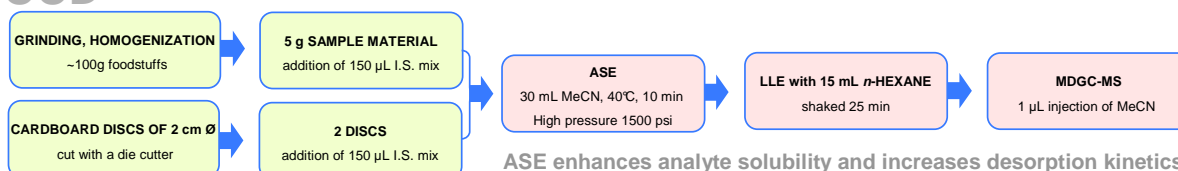
Often we mainly refer to pesticides, veterinary drugs, dioxins, PCB and other environmental chemicals when speaking about food contamination, thus neglecting to envisage that possibly food contact materials might be one of the predominant sources of tainted foodstuffs. Amongst the many potential chemical contaminants from food packaging materials, photo-initiators are in the forefront as they can easily migrate into foodstuffs by direct diffusion or contamination from outer to unprinted inner layers of the packaging during a set-off process. Benzophenone derivatives are commonly used photo-initiators to promote polymerization of printing inks and varnishes during UV curing, but they are also suspected to possess carcinogenic activities. Recently, benzophenone (BZP) and 4-methylbenzophenone (4-MeBZP) have been flagged by the Rapid Alert System

for Food and Feed (RASFF) that noticed several food contaminations by those derivatives. In order to tackle this problematic, a fast and selective method was developed for the determination of BZP and 4-MeBZP in cereal-based foodstuffs as well as in cardboard packaging. Food samples or packages were rapidly extracted by accelerated solvent extraction (ASE) with acetonitrile and defatted with n-hexane. The analysis was performed by multidimensional gas chromatography-mass spectrometry (MDGC-MS) using a heart-cutting approach, to reduce background from complex matrices as well as to pre-concentrate compounds thanks to a cryotrapping step. The procedure was fully validated with cereal-based foodstuffs and a survey of BZP and 4-MeBZP levels in chocolate-derived "müeslis" from the Swiss market has been performed.

## 2. ANALYTICAL METHOD

### Sample preparation

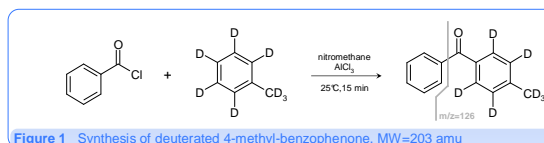
#### FOOD



#### PACKAGES

### Internal standard synthesis

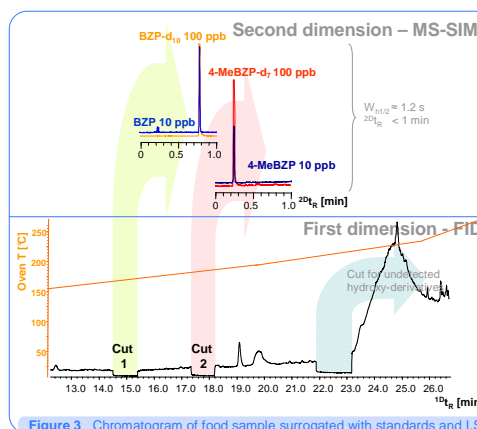
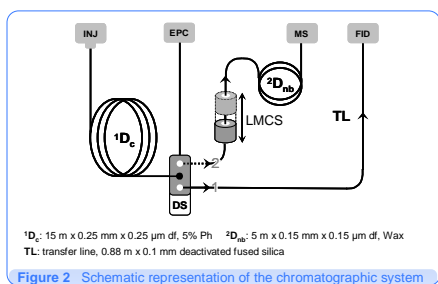
For accurate quantification, deuterated 4-MeBZP was synthesized in-house as this compound was not commercially available. The synthesis is based on a straightforward Friedel-Crafts reaction between deuterated toluene and benzoyl chloride. Purity of resulting 4-MeBZP-D<sub>5</sub> was controlled by TLC and GC-MS. Its GC-EIMS fragment at m/z=126 can specifically be used for quantitation.



### Multi-dimensional GC-MS

Multidimensional gas chromatography consists of a sequential arrangement of 2 columns of different selectivity. In this study, a non-polar column was used as first dimension whereas a shorter polar support was chosen as second dimension. The benefit of this chromatographic technique is ensured by transferring only the interesting portions of the first dimension effluent to the second dimension. Also called "heartcutting", this strategy is controlled by a pneumatic flow switching valve (Dean's switch valve - DS) connected to a

longitudinally moving cryogenic trap (LMCS). The latter interfaces the two dimensions and traps selected fractions from the primary column before re-launching focused components onto the secondary dimension. The first dimension is monitored by a flame ionization detector whereas the second dimension is coupled to a mass spectrometer. The scheme of the device is depicted in Figure 2 and analytical conditions are described below.

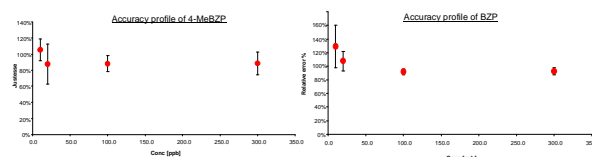


## 3. METHOD PERFORMANCES

Performance of the method was assessed by evaluating calibration and control samples. The general approach was based on a variance analysis (ANOVA) to determine precision and trueness of the data over 3 days. The validation range was between 60 to 1800 ppb. Calibrations curves were weighted by a 1/x factor.

Compounds	Theoretical Concentration (ppb)	Measured Concentration (ppb)	Trueness (n=3, 3 days, %)	Repeatability (n=3, 3 days, %)	Intermediate Precision (n=3, 3 days, %)
BZP	60	77	129	1.4	9.7
	120	129	108	2.1	5.3
	600	555	92	1.0	1.8
	1800	1665	93	0.5	2.1
4-MeBZP	60	63	105	2.2	5.2
	120	105	88	7.8	11.3
	600	529	88	3.1	4.5
	1800	1592	88	3.9	6.4

Precision included the relative standard deviations of repeatability (R<sub>RSB</sub>) and the intermediate precision (IP<sub>RSB</sub>). Linearity was determined by plotting concentrations versus their theoretical values. For food analysis the limit of quantification was set at 70 µg/kg for both target compounds.



## 4. RESULTS AND DISCUSSION

This MDGC-MS method based on a heart-cutting approach allowed unambiguous determination of BZP and 4-MeBZP in cereals and packaging materials. Thank to the use of a cryotrapping step, compounds were focused before being released on the second dimension, allowing peak widths to be reduced by a factor 3 compared without a trapping step. This strategy not only decreased background signal, but also significantly improved the limit of detection. Moreover, good analytical performances were obtained in terms of linearity, precision and accuracy. Works are in progress to implement hydroxybenzophenone derivatives in the method. We performed a survey of BZP and 4-MeBZP levels in chocolate-based "müeslis" from the Swiss market to assess the utilization of a such photoinitiators. This evaluation showed several non conform results as BZP

was found in foodstuffs at concentrations up to 9 times the limit value of 0.6 mg/kg. Indeed, the highest level of benzophenone in food was 7.6 mg/kg, giving rise to a novel European alert through the RASSF system and confirming the utilization of BZP compounds as photoinitiator for packaging of commercially available cereals. Recently, the European Food Safety Authority (EFSA) was urged to reassess the toxicological evaluation of BZP and examine the case of 4-MeBZP, but so far the specific migration limit of 0.6 mg BZP/kg foodstuffs has still legal force.