# ION MOBILITY – MASS SPECTROMETRY AS A NEW APPROACH FOR THE SCREENING OF PESTICIDE RESIDUES IN FOOD

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**Introduction**

Pesticide residue analysis requires methods that can determine hundreds of compounds at low levels in complex food matrices. This challenge has given rise to multi residue methods, the only efficient analytical approach. This type of analytical method entails a "generic" extraction followed by a soft or no purification step to avoid any analytes looses. With over a 1000 active compounds with different physical chemical properties, gas and liquid chromatography are used as complementary separative techniques.

In the past decade, the determination has been performed on tandem mass analyzers, a powerful tool to overcome co-eluting compounds with excellent sensitivity. Nevertheless, these instruments can guarantee these results per acquisition cycles for more or less 150 compounds. This represents a serious limitation when the number of pesticides to be sought for monitoring and MRL enforcement is growing each year. As multiple injections from the same sample are not viable for laboratories, alternative options have to be explored. We propose the investigation of ion mobility (IM) coupled with mass spectrometry as a new approach for pesticide residue analysis in food.

**Materials and methods**

A selection of 190 standard pesticides based on the prior list of official European monitoring programs were purchased from Dr. Ehrenstorfer (Ausburg, Germany), dissolved to a concentration of 1mg/mL in methanol (Biosolve) and stored frozen at -27°C. Before use, stocked solutions were diluted at 1µg/mL in 50/50 MeOH/$H_2O$ for direct injection and dilute to 100 and 10 ng/mL in 90/10 $H_2O$/MeOH for chromatography injection. The real samples (lettuce, strawberry) were prepared as described previously by Granby et al.

ESI-IM-MS experiments were performed on a Synapt HDMS G2 spectrometer (Waters, Manchester, UK), in positive ion mode electrospray ionization. The source settings were as follow: a capillary at 3.0 kV, a sampling cone at 30.0 V, an extraction cone at 6.0 V, a source and desolvation temperatures of 120 and 300°C respectively, and a backing pirani readback pressure of 2.89 mbar.. Ion mobility has been performed via a travelling wave IM device using nitrogen at a pressure of 3.01 ± 0.05 mbar, a wave velocity of 800 m/s and a wave height of 28 V. To prevent fragmentation upon entrance in the high-pressure IM cell, the IM cell was preceded by an helium cell (0.015 ± 0.05 mbar). The bias voltage was set at 37V. Optimization of ion mobility separation requires a fine tuning of many dependent parameters. A Plackett-Burman experimental design followed by a central composite design were carried out at this stage.

LC-ESI-IM-MS experiments were performed by coupling the Synapt G2 with a CapLC (Waters). The column used is a $C_{18}$ pepmap (ID 300µm * length 15cm) with a precolumn $C_{18}$ pepmap (ID 300µm * length 1cm) in front. The separation were obtained by linear gradient elution, using the eluents A (MeOH/$H_2O$ 10/90 with 5mM ammonium acetate) and B (MeOH/$H_2O$ 90/10 with 5mM ammonium acetate) according to the following profile: 0-3min, 100% A; 3-35min, 100-0% A; 35-45min, 0% A; .45-55min, 0-100% A; 55-74min, 100% A. The flow-rate was 2.8µL/min, except during the loading phase 30µL/min (0-3min).

**Results and discussion:**

Ion mobility allows separating an ion packet of a given m/z by the mean of an electric field applied to the ion mobility cell containing a neutral gas at a control pressure (e.g. $N_2$). We first investigated the capacity of ion mobility to discriminate between two isobaric pesticides: phoxim and quinalphos, $C_{12}H_{15}O_3N_2SP$, m/z=299.0619). Optimized IM conditions (bias at 37V, waveheight at 28V, wave velocity at 900 m/s, IMS cell pressure at 3.23 ± 0.05 mbar, Helium cell pressure 0.016 ± 0.05 mbar) led to a drift time of 6.6ms for the quinalphos and of 7.2ms for phoxim due to a difference of cross section in the gas phase. In addition, the method has been tested on isomers (E and Z) of mevinphos ($C_7H_{14}NO_5P$, m/z=225.0528).

An interesting feature of this analytical approach is to couple IM-MS with high performance liquid chromatography (HPLC). Hyphenated HPLC-IM provides real orthogonal dimensions of separation. However, IM parameters must be adapted to a multi residues method (about 200 pesticides). An experimental design was performed to obtain the best IM parameters. A Plackett-Burman design followed by a Central Composite Design were applied to four selected pesticides: metamidophos (m/z=142.0092), dicrotophos (m/z=238.0844), pyrimicarb (m/z=239.1508), furathiocarb (m/z=383.1641). The selected pesticides exibit different molecular structures but they cover the whole mass range. The screening Plackett-Burman design highlighted two major parameters having significant impact in ion mobility drift: the bias and the gas pressure inside the IM cell. The bias is the last voltage before the IM cell and it pushes ions inside the cell. The optimized conditions under CCD design give the mobilogram shown in Figure 1.

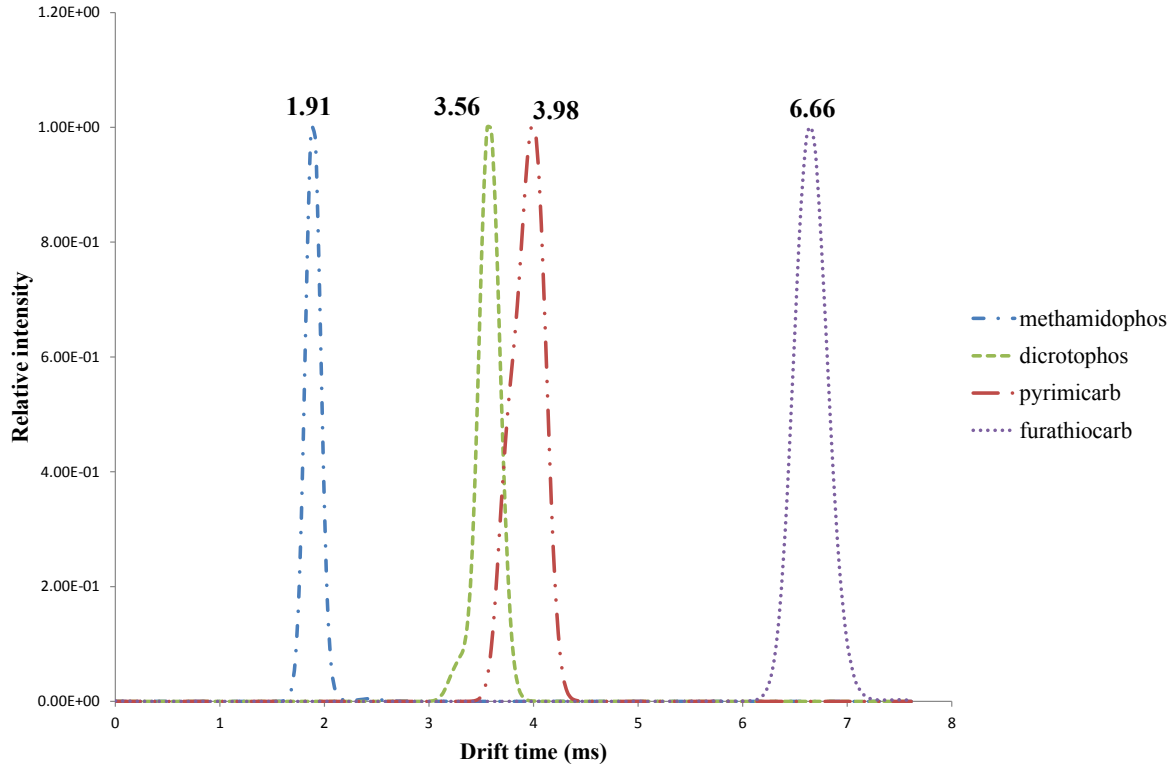


Figure 1: Mobilogram of the 4 selected pesticides: metamidophos (m/z=142.0092), dicrotophos (m/z=238.0844), pyrimicarb (m/z=239.1508), furathiocarb (m/z=383.1641).

These optimized IM parameters were then used with LC-ESI-IM-MS experiments to determine the drift time of all pesticides. Figure 2 shows some slices of unresolved chromatographic peaks separated in drift time.

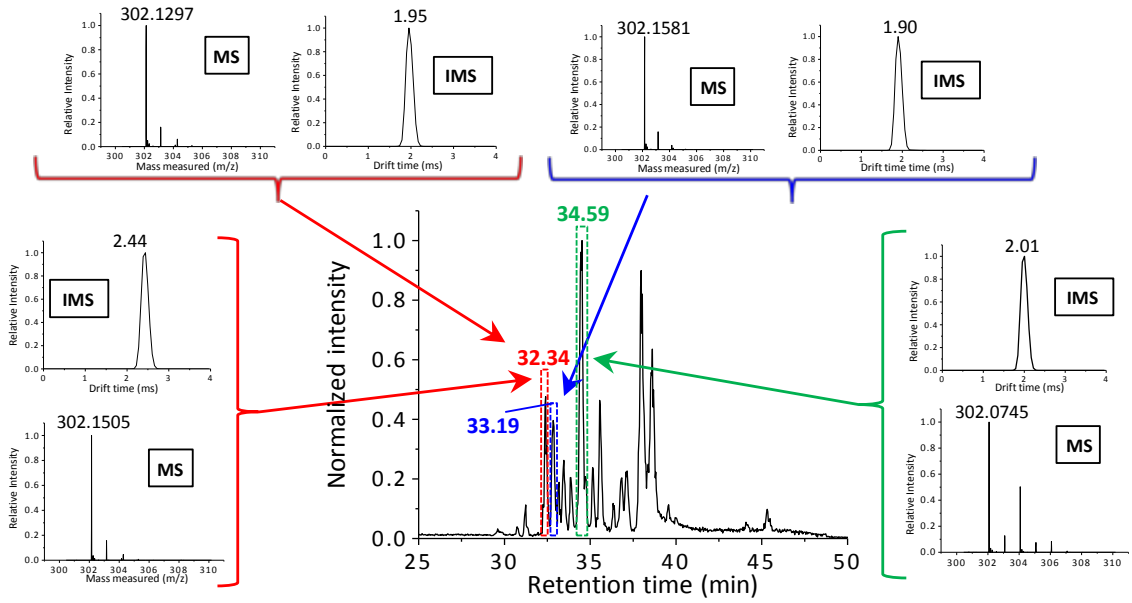


Figure 2: example of a LC-ESI-IM-MS chromatogram.

One of advantages of the hyphenated LC-ESI-IM-MS method IS the potential to separate target ions from matrix background and other co-eluting compounds from liquid chromatography improving signal to noise ratio of characteristic ions. This makes easier the identification process of non target pesticide approach (ions ratio, exact mass, fragmentation pathway,…). Another advantage is that the drift time provides an additional information on pesticide identification: the time required for each ion to travel through the mobility cell. This information could be seen as an additional criteria of identification for non target pesticide monitoring.

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**References:**

Granby K, Anderson J H, Christensen H B. (2004); *Analytica Chimica*. 520: 165-176