# California and Oregon's Complete Residual Pesticide Analysis using a Shimadzu LCMS-8060

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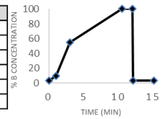
## 1. Introduction

With the increase in medicinal and recreational cannabis legislation throughout the United States there is an emerging demand for pesticide testing on cannabis products. Currently each state is setting individual regulatory guidelines. This results in variation between the number of analytes tested and their required action levels; currently California regulates a total of 66 pesticides and Oregon regulates a total of 59 pesticides. To analyze these complete lists, laboratories commonly use both LCMS and GCMS because some compounds do not ionize well by ESI-LCMS. This study evaluates using both ESI and APCI ionization techniques to quantitate the complete California list using only LCMS. The resulting APCI-LCMS and ESI-LCMS MRM methods was tested in cannabis flower extract on a Shimadzu LCMS-8060. The LOQ determined for each pesticide was below the regulatory action level (Table 1).

## 2. Methods

A Shimadzu LCMS-8060 triple quadrupole mass spectrometer coupled with a Shimadzu Nexera X2 UHPLC system was employed for this evaluation. A total of 10 pesticides were analyzed by atmospheric pressure chemical ionization liquid chromatography mass spectrometry (APCI-LCMS). All other pesticides were analyzed by electro spray ionization liquid chromatography mass spectrometry (ESI-LCMS). Final method conditions can be seen in Figure 1 and 2. For each pesticide one to five MRM transitions were acquired. Separation was accomplished and retention times determined on column using neat standards prior to in-matrix evaluation. Matrix-matched calibration curves were prepared by serial dilution of spiked flower extract with blank flower extract and evaluated for each pesticide. The calibration set included multiple different concentrations, ranging from 1.0 ng/g to 2000 ng/g.

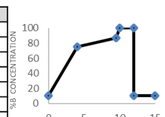
| Time | %B |
|---|---|
| 0 | 3 |
| 1 | 10 |
| 3 | 55 |
| 10.5 | 100 |
| 12 | 100 |
| 12.01 | 3 |




| | |
|---|---|
| Drying Gas | 10.0 L/min |
| Heating Gas | 10.0 L/min |
| Interface Temperature | 350°C |
| DL Temperature | 200°C |
| Heat Block Temperature | 300°C |
| Flow rate | 0.4 mL/min |
| Injection Volume | 1µL |
| Column Oven Temperature | 30°C |
| Sample Tray Temperature | 10°C |

Figure 1 LCMS-8060 APCI Method Conditions

| Time | %B |
|---|---|
| 0 | 10 |
| 0.5 | 10 |
| 4 | 75 |
| 9.5 | 87 |
| 10 | 100 |
| 12 | 100 |
| 12.01 | 10 |




| | |
|---|---|
| Drying Gas | 15.0 L/min |
| Heating Gas | 15.0 L/min |
| Interface Temperature | 100°C |
| DL Temperature | 200°C |
| Heat Block Temperature | 100°C |
| Flow rate | 0.5 mL/min |
| Injection Volume | 1µL |
| Column Oven Temperature | 40°C |
| Sample Tray Temperature | 10°C |

Figure 2 LCMS-8060 ESI Method Conditions

Table 1 LOQ determined for each Pesticide and the mode of Ionization

| Residual Pesticide | LOQ (ng/g) | Method of Ionization | Residual Pesticide | LOQ (ng/g) | Method of Ionization |
|---|---|---|---|---|---|
| Abamectin (-) | 31 | ESI or APCI | Fluopyram (+) | 2 | ESI |
| Acephate (+) | 20 | ESI | Hexythiazox (+) | 15 | ESI |
| Acequinocyl (+/-) | 15 | ESI or APCI | Imazalil (+) | 10 | ESI |
| Acetamiprid (+) | <2 | ESI | Imidacloprid (+) | 4 | ESI |
| Aldicarb (+) | <2 | ESI | Kresoxim-methyl (+) | 4 | ESI |
| Allethrin (+) | 50 | ESI | Malathion (+) | 2 | ESI |
| Azoxystrobin (+) | 4 | ESI | Metalaxyl (+) | 2 | ESI |
| Bifenazate (+) | 2 | ESI | Methiocarb (+) | 4 | ESI |
| Bifenthrin (+) | 4 | ESI | Methomyl (+) | <2 | ESI |
| Boscalid (+) | 4 | ESI | Methoprene (+) | 50 | ESI |
| Buprofezin (+) | <2 | ESI | Methyl-parathion (-) | 8 | APCI |
| Captan (-) | 8 | APCI | Mevinphos (+) | 4 | ESI |
| Carbaryl (+) | 10 | ESI | MGK 264 (+) | 15 | APCI |
| Carbofuran (+) | <2 | ESI | Myclobutanil (+) | 10 | ESI |
| Chlorantraniliprole (+) | 2 | ESI | Naled (+) | 2 | ESI |
| Chlordane (-) | 15 | APCI | Novaluron (-) | 15 | ESI |
| Chlorfenapyr (-) | 8 | APCI | Oxamyl (+) | 2 | ESI |
| Chlorpyrifos (+) | 10 | ESI | Paclobutrazol (+) | 2 | ESI |
| Clofentazine (+) | 4 | ESI | Pentachloronitrobenzene (PCNB) (-) | 63 | APCI |
| Clothianidin (+) | 4 | ESI | Permethrin (+) | 10 | ESI |
| Coumaphos (+) | 4 | ESI | Phenothrin (+) | 10 | ESI |
| Cyantraniliprole (-) | 2 | ESI | Phosmet (+) | 10 | ESI |
| Cyfluthrin (-) | 15 | APCI | Piperonyl butoxide (+) | 5 | ESI |
| Cyfluthrin (+) | 500 | ESI | Pirimicarb (+) | 2 | ESI |
| Cypermethrin (+) | 60 | ESI | Prallethrin (+) | 10 | ESI |
| Cyprodinil (+) | 10 | ESI | Propiconazole (+) | 60 | ESI |
| Daminozide (+) | 15 | ESI | Propoxur (+) | 2 | ESI |
| Deltamethrin (+) | 30 | ESI | Pyraclostrobin (+) | 10 | ESI |
| Diazinon (+) | <2 | ESI | Pyrethrins (+) | 100 | ESI |
| Dichlorvos (DDVP) (+) | 15 | ESI or APCI | Pyridaben (+) | 2 | ESI |
| Dimethoate (+) | <2 | ESI | Resmethrin (+) | 35 | ESI |
| Dimethomorph (+) | 5 | ESI | Spinetoram (+) | 2 | ESI |
| Dinotefuran (+) | 2 | ESI | Spinosad (+) | <2 | ESI |
| Dodemorph (+) | 4 | ESI | Spirodiclofen (+) | 10 | ESI |
| Endosulfan-sulfate (-) | 4 | ESI | Spiromesifen (+) | 20 | ESI |
| Ethoprophos (+) | 2 | ESI | Spirotetramat (+) | 2 | ESI |
| Etofenprox (+) | 4 | ESI | Spiroxamine (+) | 2 | ESI |
| Etoxazole (+) | <2 | ESI | Tebuconazole (+) | 2 | ESI |
| Fenhexamid (+) | 20 | ESI | Tebufenozide (+) | 5 | ESI |
| Fenoxycarb (+) | 2 | ESI | Teflubenzuron (-) | 15 | ESI |
| Fenpyroximate (+) | 10 | ESI | Tetrachlorvinphos (+) | 4 | ESI |
| Fensulfothion (+) | 5 | ESI | Tetramethrin (+) | 4 | ESI |
| Fenthion (+) | 100 | ESI | Thiacloprid (+) | <2 | ESI |
| Fenvalerate (+) | 100 | ESI | Thiamethoxam (+) | <2 | ESI |
| Fipronil (-) | 2 | ESI | Thiophanate-methyl (+) | 5 | ESI |
| Flonicamid (-) | 25 | ESI | Trifloxystrobin (+) | <2 | ESI |
| Fludioxonil (-) | 2 | ESI | | | |

## 3. Results

Using the same sample, the entire California and Oregon residual pesticide list was analyzed. The APCI-LCMS method demonstrated accurate and precise trace-level quantitation in cannabis flower for 10 pesticides that are traditionally analyzed by GCMS and the ESI-LCMS method demonstrated the same robust and reproducibility for the remaining 84 pesticides. Both gradient methods were successfully used for chromatographic separation and identification of all 94 pesticides (Figure 3 and 4). The LOQ for each pesticide was below the California and Oregon action levels in cannabis, and precision and accuracy results were excellent. LOQs were determined for each pesticide using their corresponding retention time and a S/N calculation above 10:1.

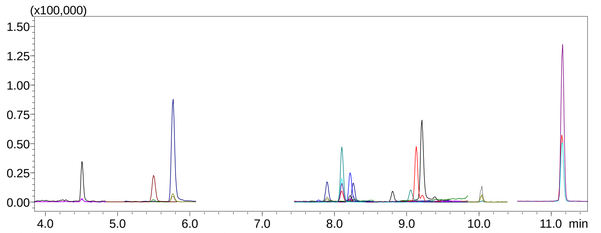



Figure 3 Representative Chromatogram for 10 pesticides using APCI-LCMS

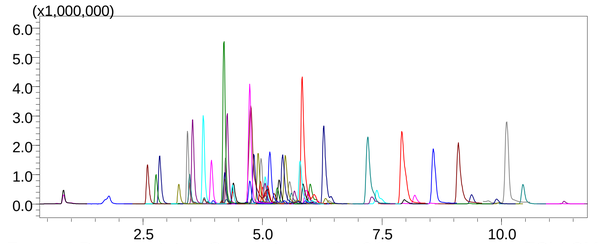



Figure 4 Representative Chromatogram for 84 pesticides using ESI-LCMS

### 3-1. Quantitative Analysis in Cannabis Matrix

Matrix-matched calibration curves were prepared by serial dilution of spiked flower extract with blank flower extract and evaluated for each pesticide. All calibration curves demonstrated linearity with a range from 1 ng/g to 2000 ng/g on flower concentrations. A 1/C weighting factor was used for statistical calculations and resulted in R2 >0.99 for all pesticides. Representative chromatograms and calibration curves can be found in Figure 5 and 6. Chromatographic separation of analytes from matrix interferences resulted in low signal suppression and yielded good signal intensity.

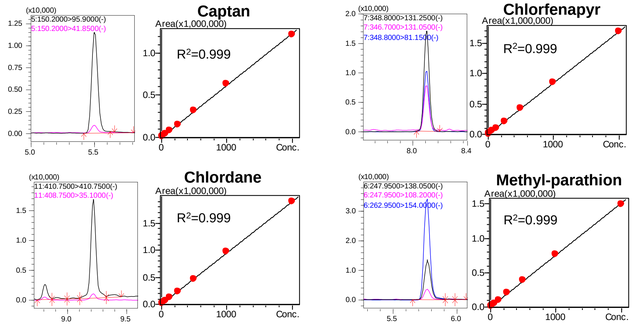



Figure 5 Calibration Curves and MS Chromatograms at 62 ng/g for APCI

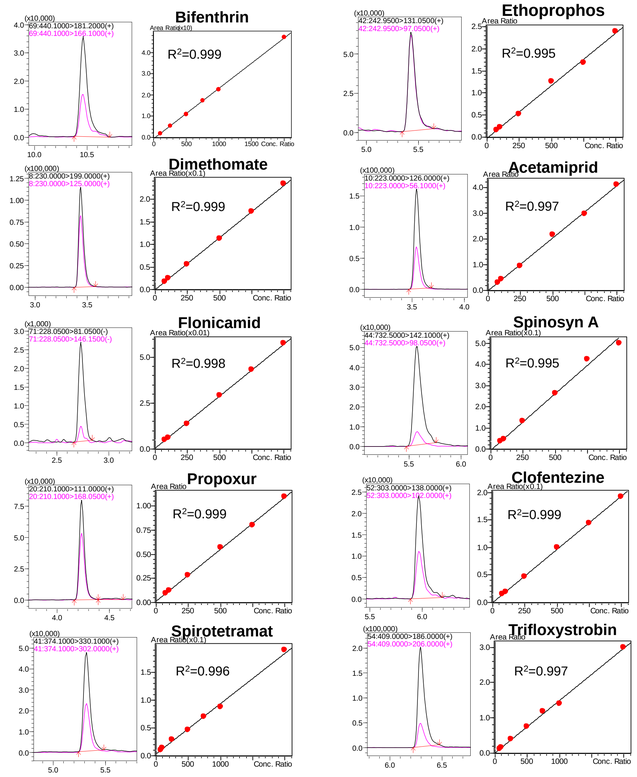



Figure 6 Calibration Curves and MS Chromatograms at 75 ng/g for ESI

## 4. Conclusions

A complete LCMS solution was developed for residual pesticide testing in cannabis matrix utilizing both APCI and ESI ionization techniques coupled with a single Shimadzu LCMS-8060. The APCI-LCMS method was developed and tested in cannabis flower matrix for the analysis of 10 California and Oregon regulated pesticides that have been traditionally analyzed by GCMS. An ESI-LCMS was further optimized and tested in cannabis flower matrix for the analysis of 84 total pesticides. The LOQs determined in this method were well below the action limits required by California and Oregon, demonstrating the viability of an LCMS total solution for cannabis testing in these two programs. The use of the ultrafast polarity switching capability of the LCMS-8060 allowed for accurate and sensitive quantitation of all 94 pesticides currently being regulated by California or Oregon.