# Supporting Information

# Instant detection of synthetic cannabinoids on physical matrices, implemented on a low-cost, ultra-portable device.

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## Movies

**Movie S1.** Ultra-portable device detection of synthetic cannabinoids on variety of physical matrices. See video file in online supporting information.

# Figures

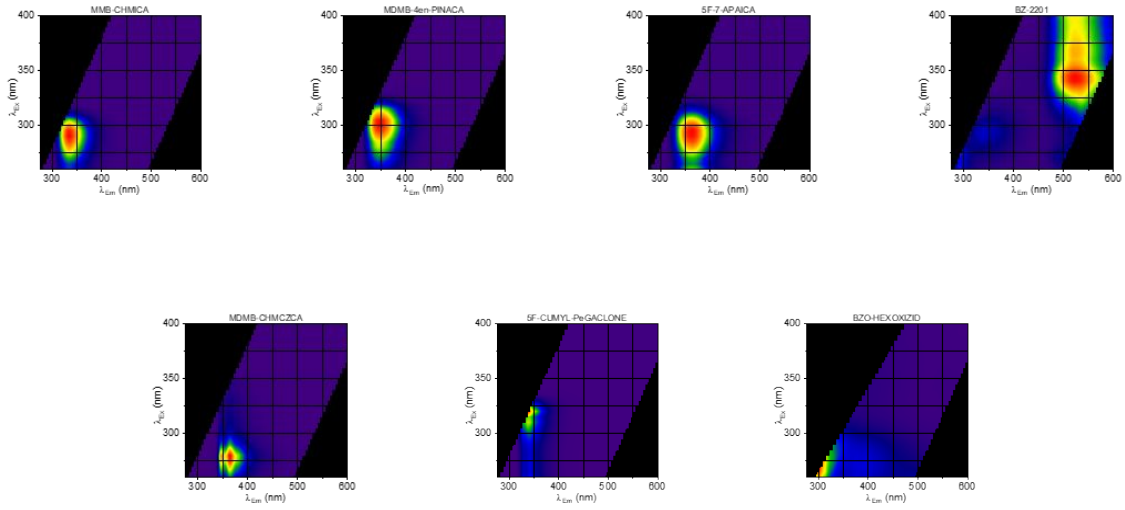



**Figure S1.** Example FSFs for the range of 'core' moieties that give rise to SC fluorescence.

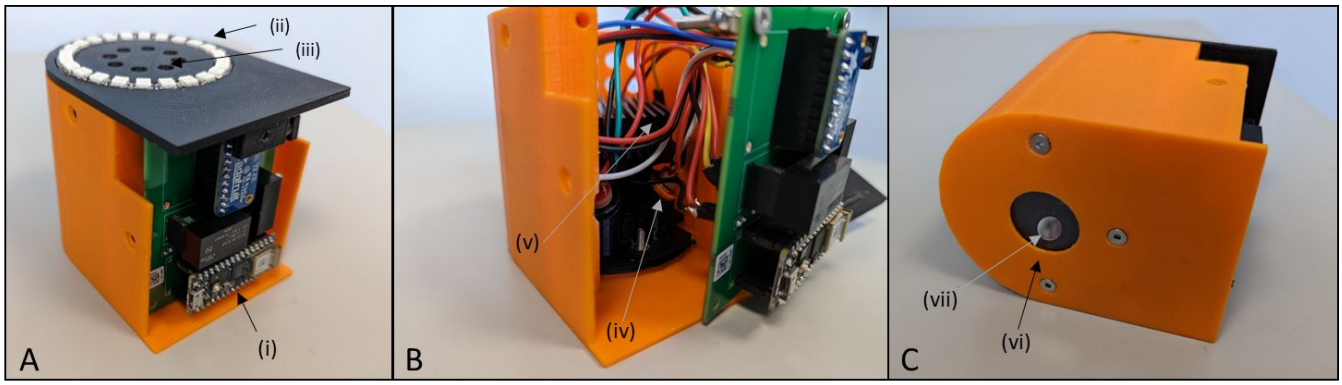



**Figure S2.** Further details of device design. (i) Custom PCB with power handling and conversion, LED driver, ADC and microcontroller. (ii) LED ring for reporting. (iii) ventilation for heatsink. (iv) Photodiode (one of four). (v) The heatsink. (vi) a sapphire window to protect the bandpass filters. (vii) bandpass filter (one of four).

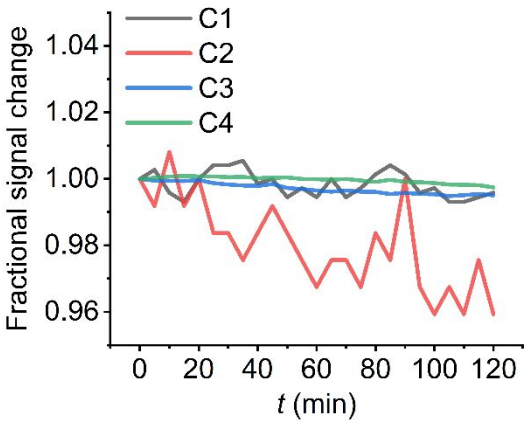



**Figure S3.** Fluctuation in signal for each recorded change with respect to time.

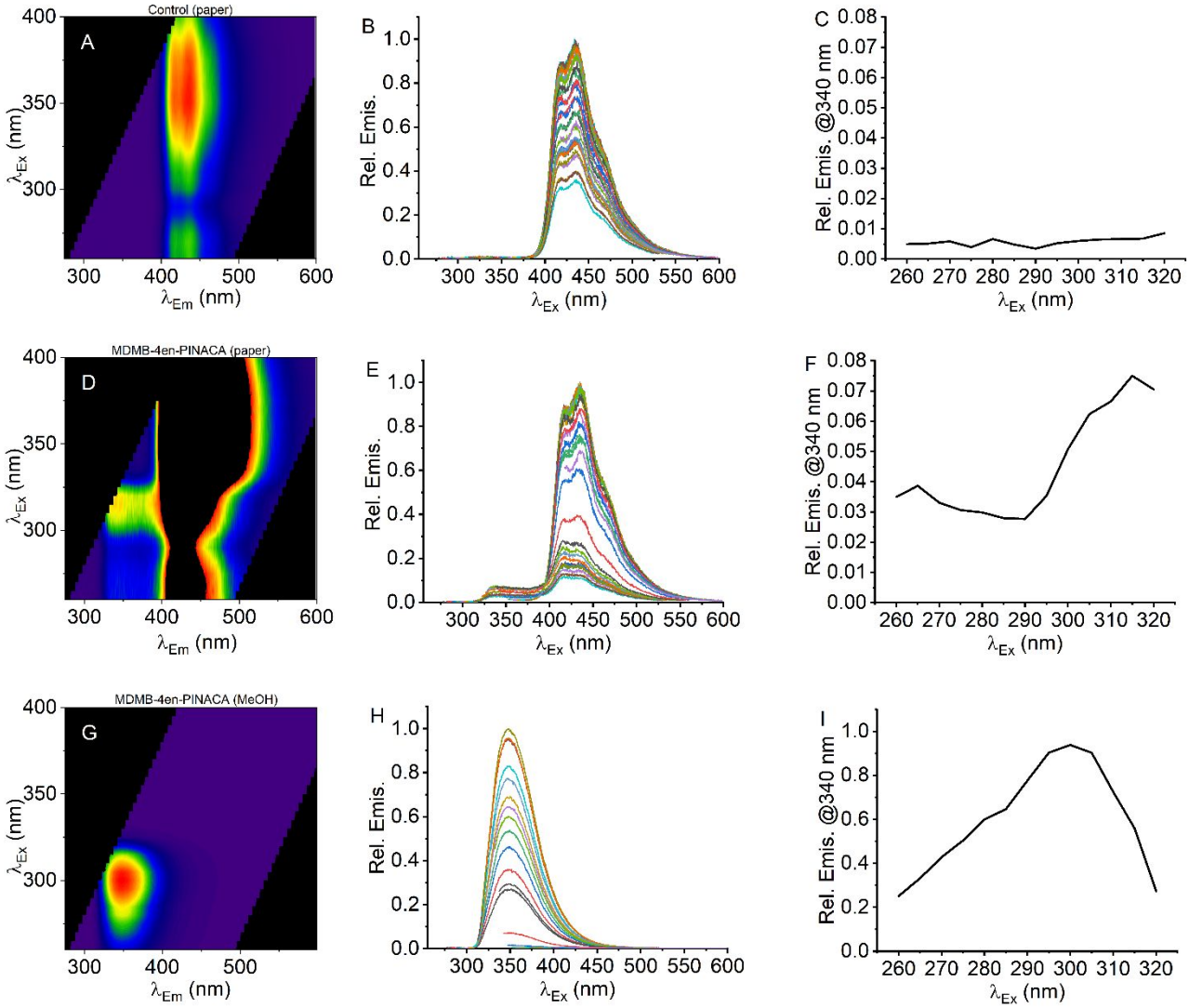



**Figure S4.** Fluorescence spectral data for an example SC (MDMB-4en-PINACA) on paper and in solution (MeOH). Each row shows the EEM (at left), constituent spectra (middle panel) and excitation spectrum at 340 nm emission (at right) for paper (**A-C**), paper with MDMB-4en-PINACA (**D-F**) and MDMB-4en-PINACA in MeOH (**G-I**).

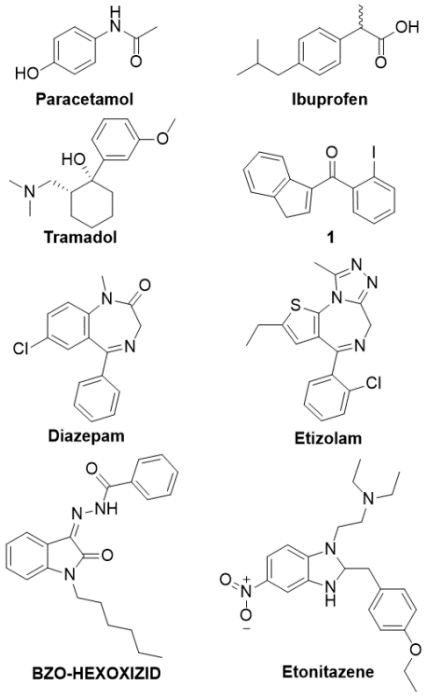
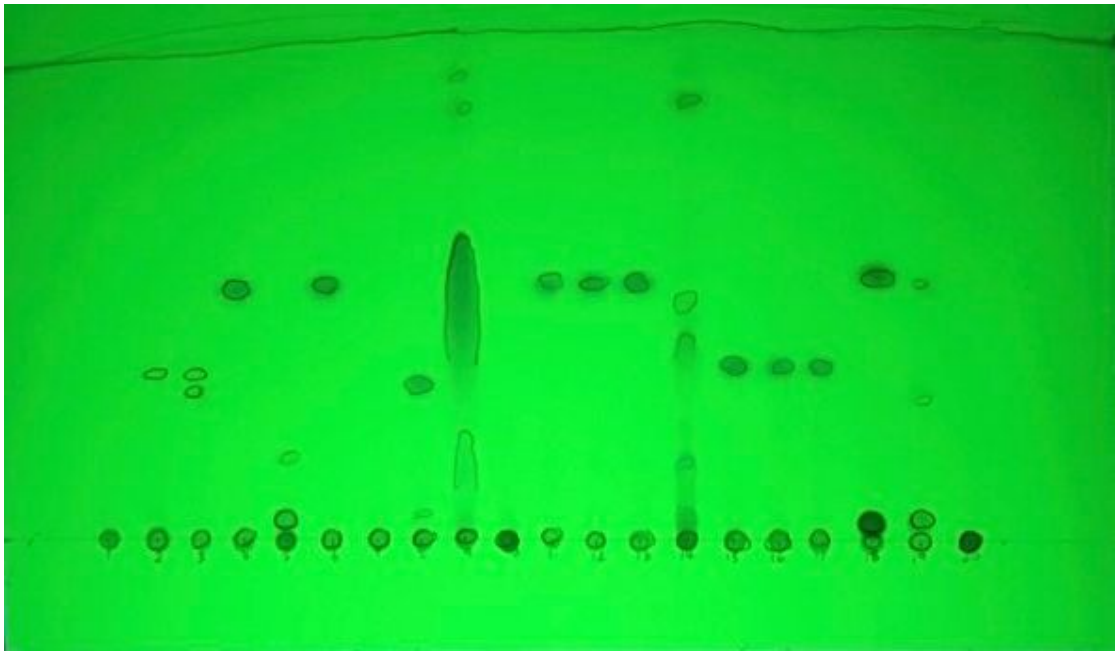
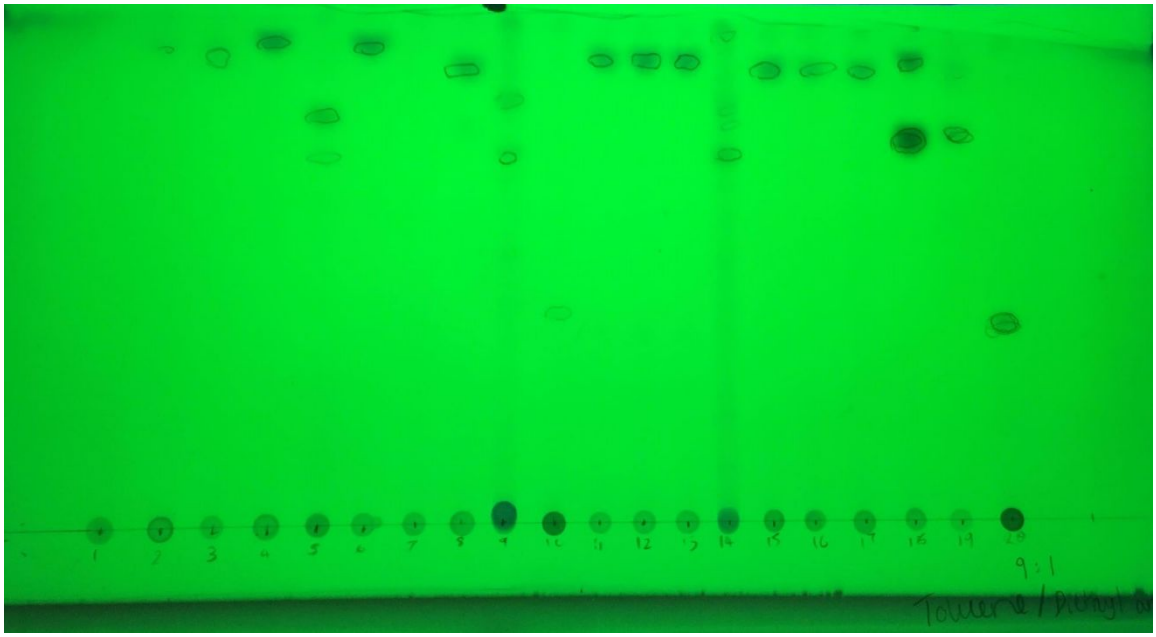


**Figure S5.** Structures of analytes shown in Figure 5.



Silica TLC plate showing ASP 1-20, run in hexane : diethyl ether, 2 : 1




Silica TLC plate showing ASP 1-20, run in toluene : diethyl amine, 9 : 1

**Figure S6.** TLC Data of extractions from samples ASP 1-20.

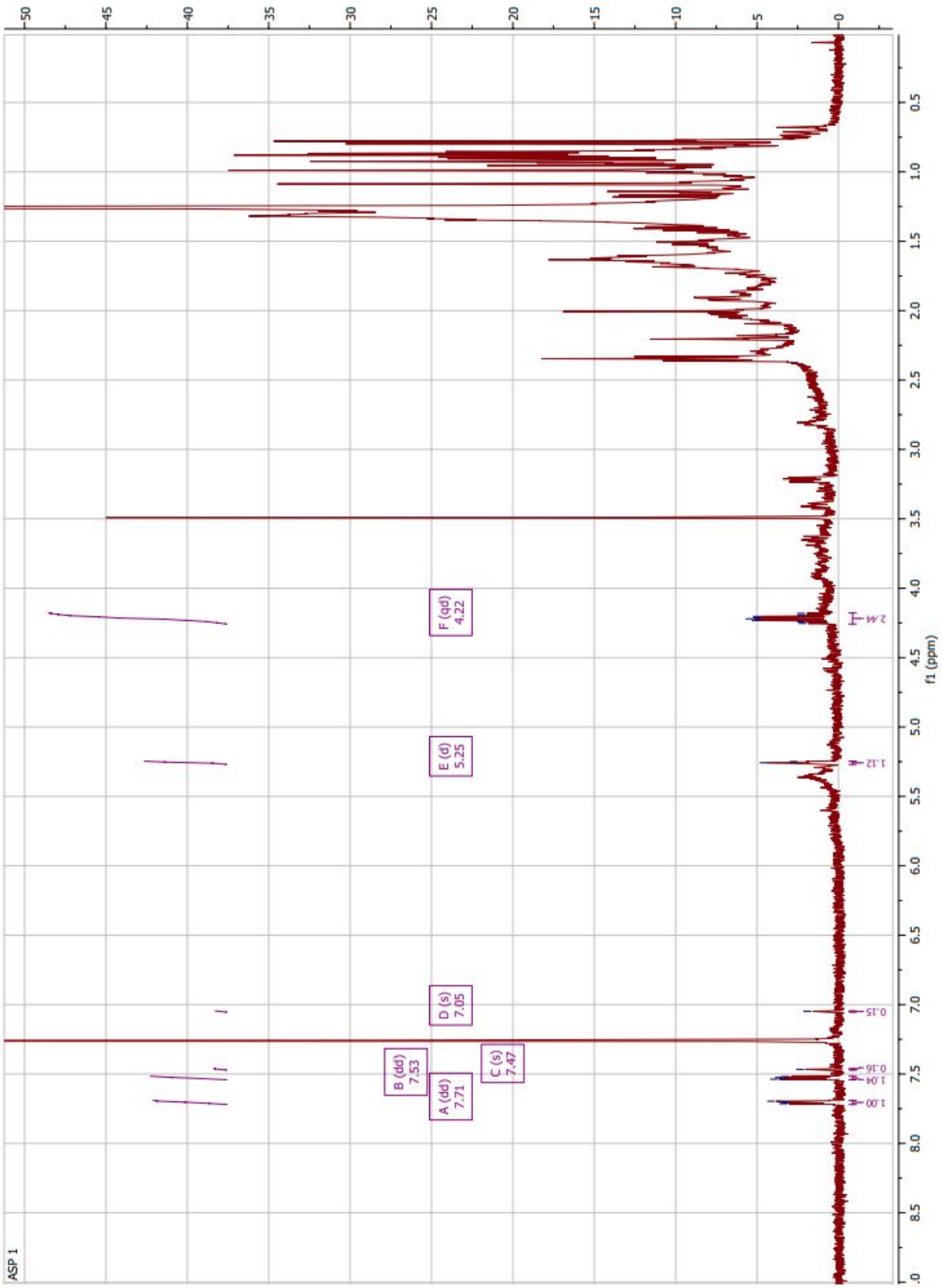



**Figure S7.** Labelled $^{1}H$ NMR of ASP1 in $CDCl_3$.

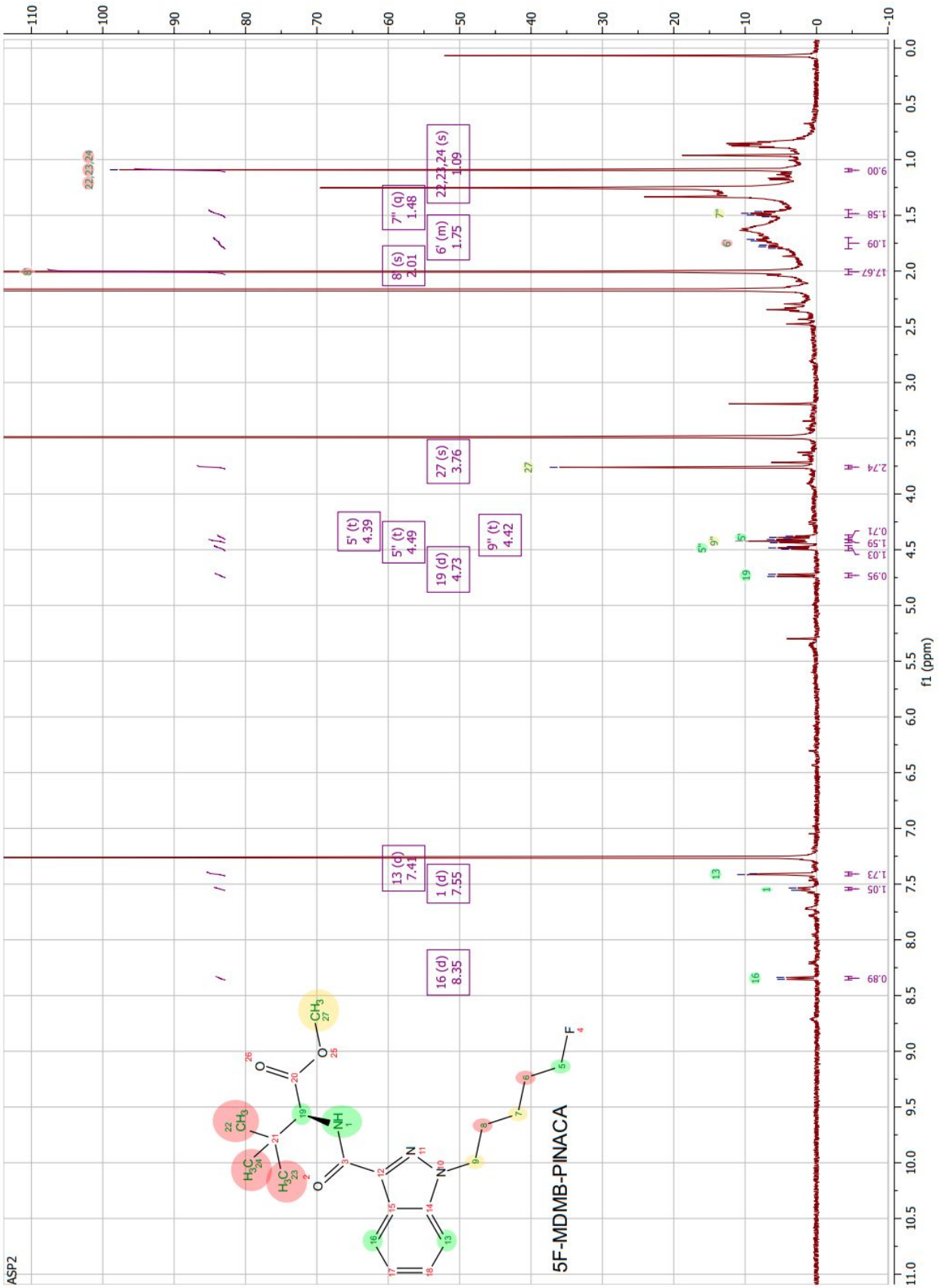



**Figure S8.** Labelled $^{1}H$ NMR of ASP2 in $CDCl_3$.

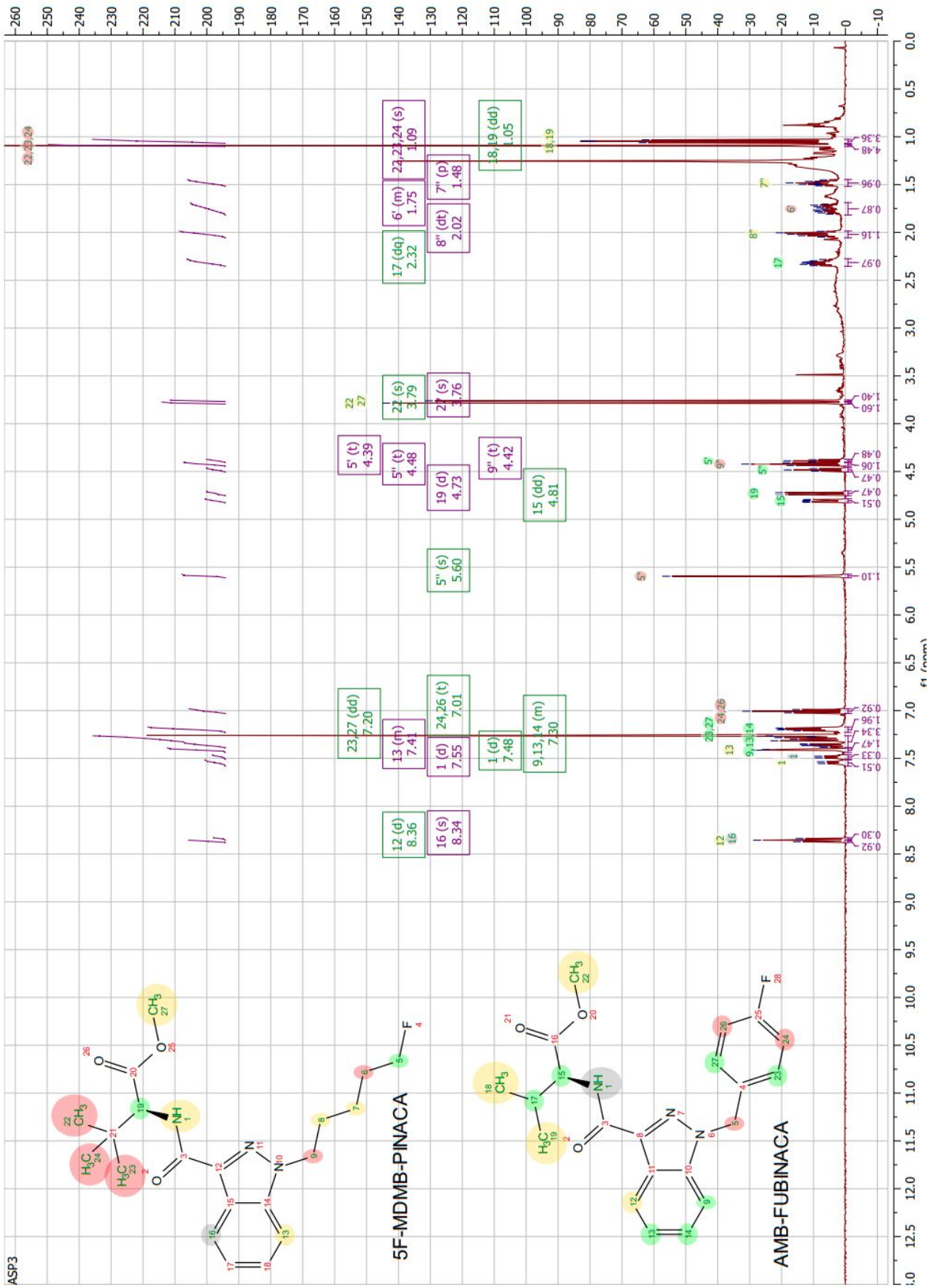



**Figure S9.** Labelled $^{1}H$ NMR of ASP3 in $CDCl_3$.

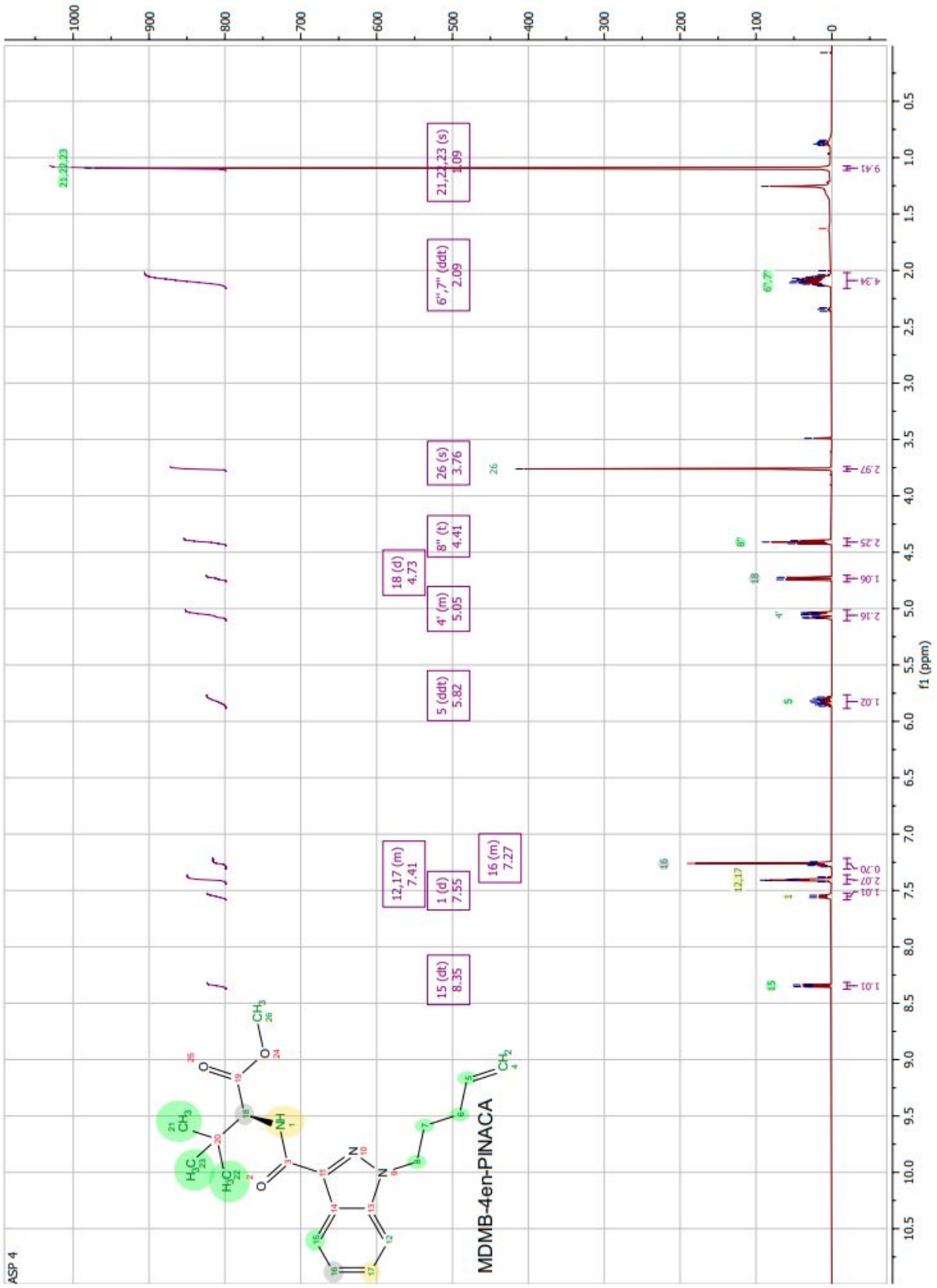



**Figure S10.** Labelled $^{1}H$ NMR of ASP4 in $CDCl_3$.

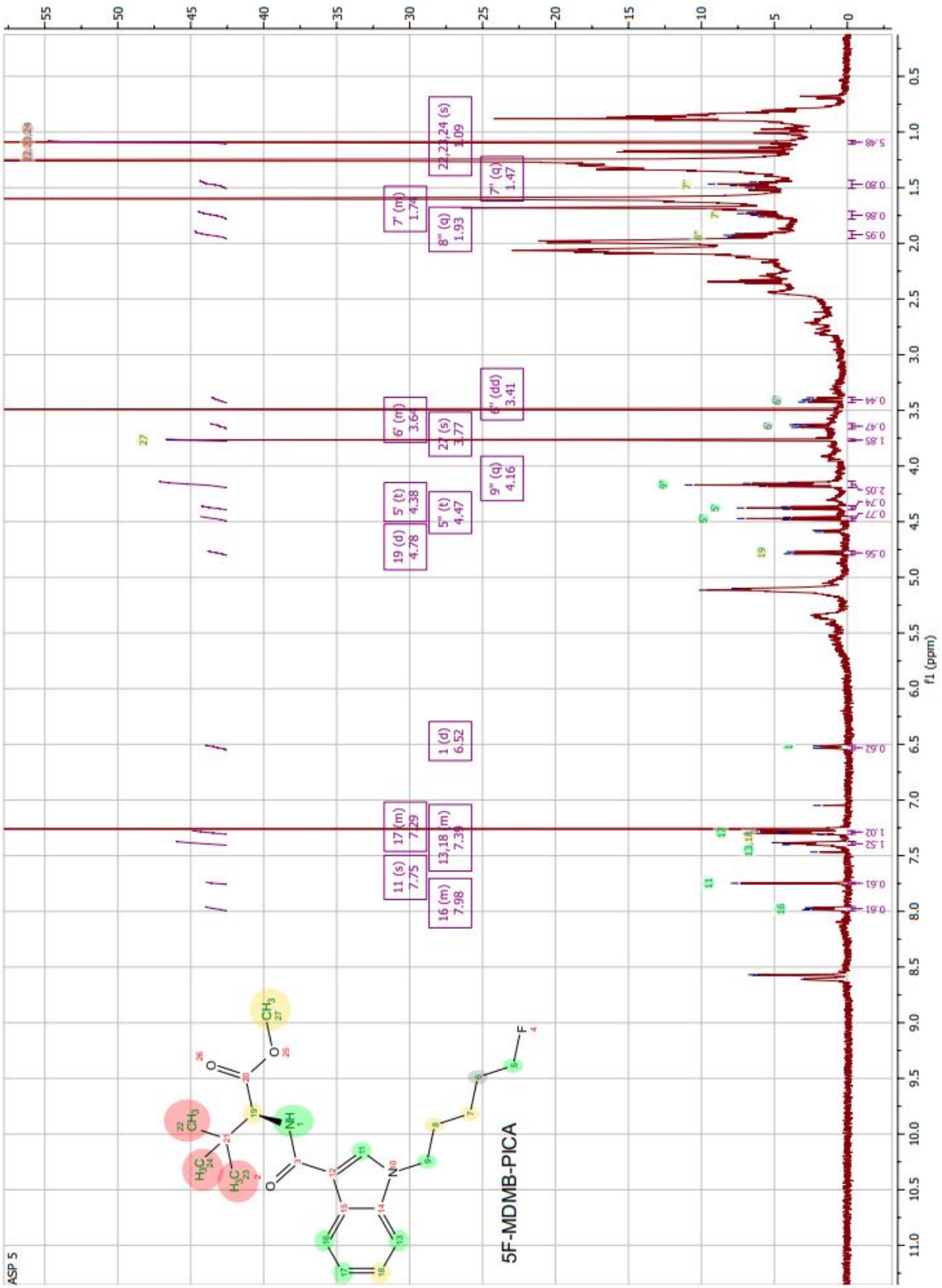



**Figure S11.** Labelled $^{1}H$ NMR of ASP5 in $CDCl_3$.

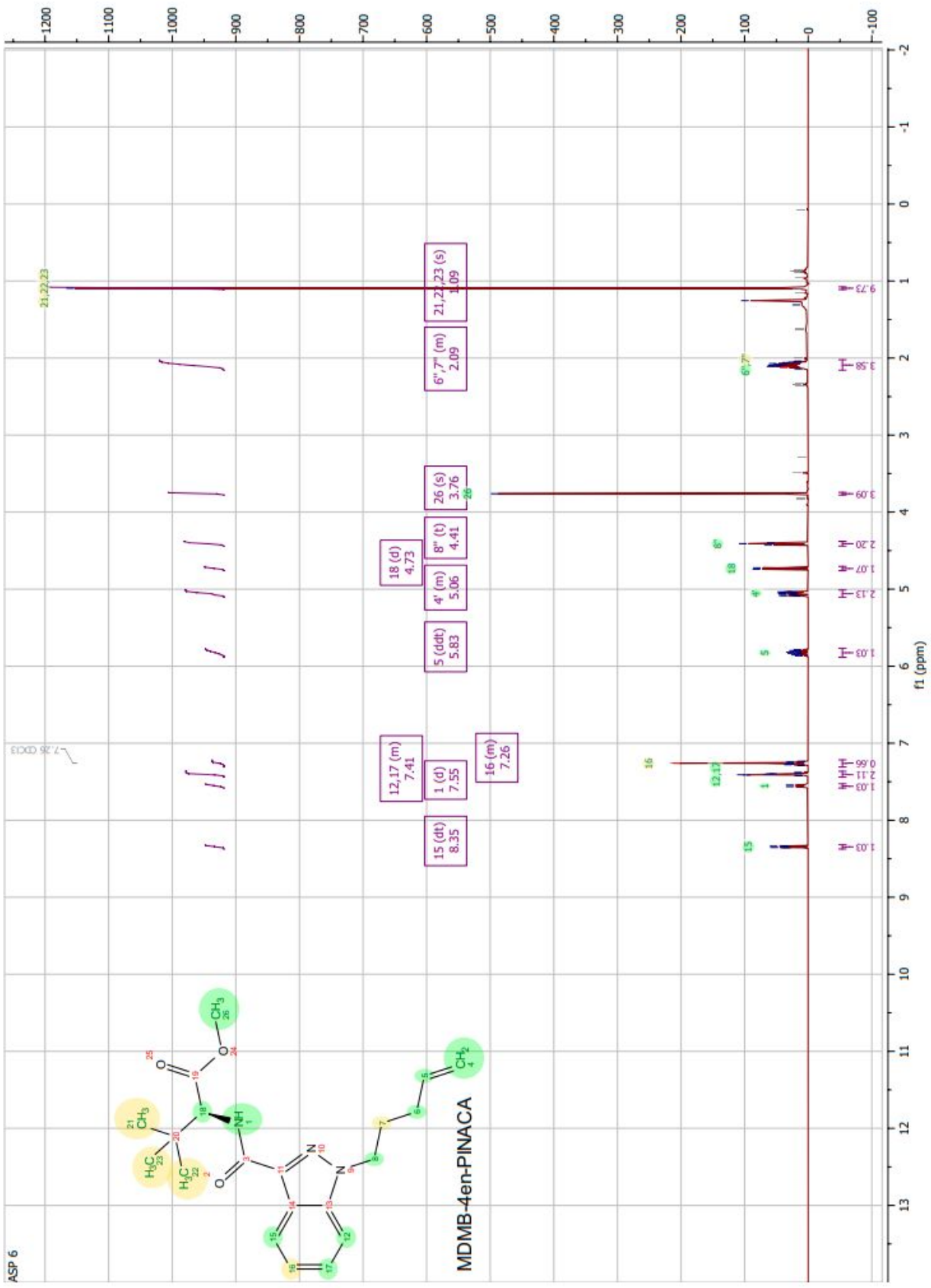



**Figure S12.** Labelled $^{1}H$ NMR of ASP6 in $CDCl_3$.

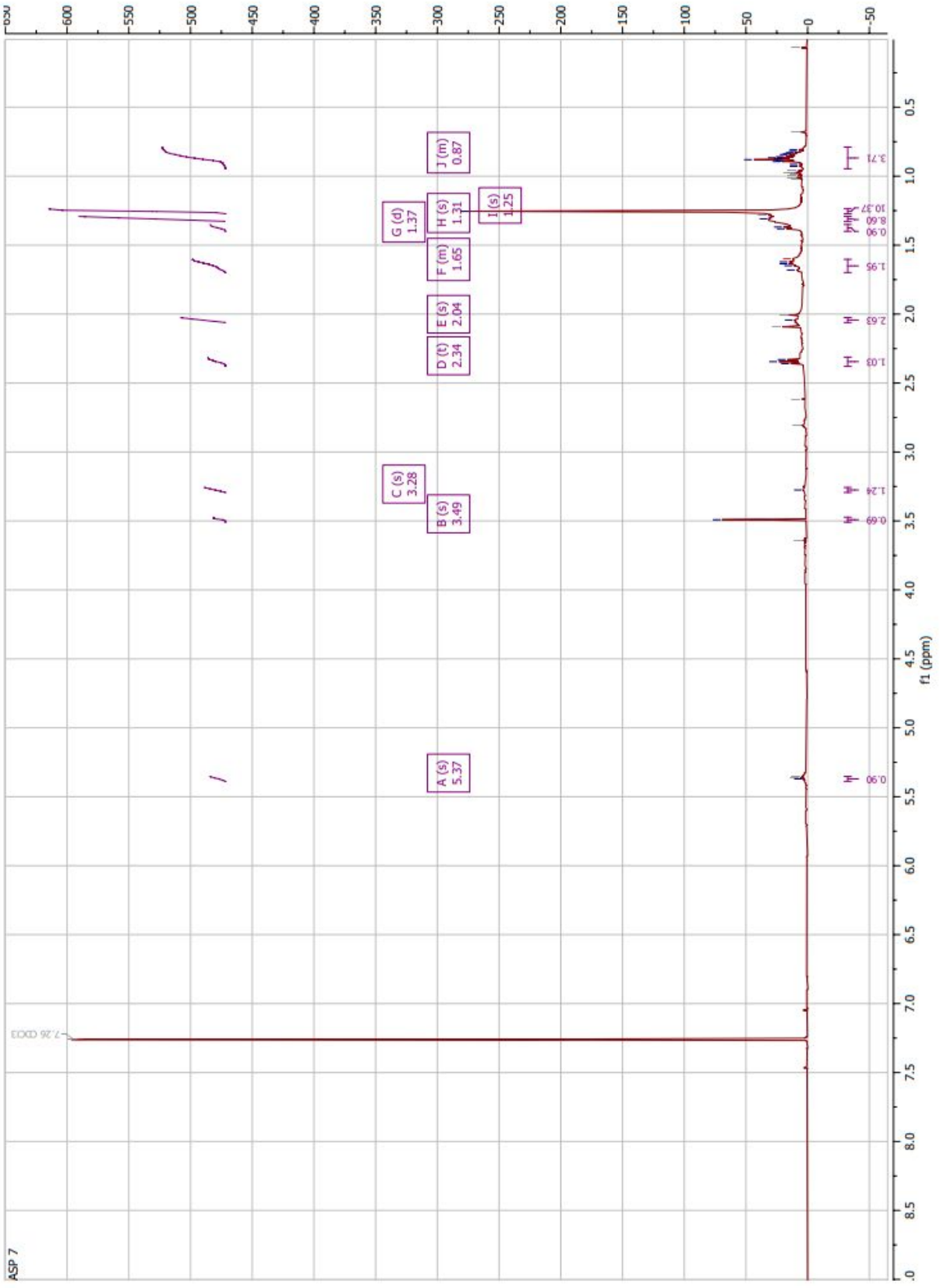



**Figure S13.** Labelled $^{1}H$ NMR of ASP7 in $CDCl_3$.

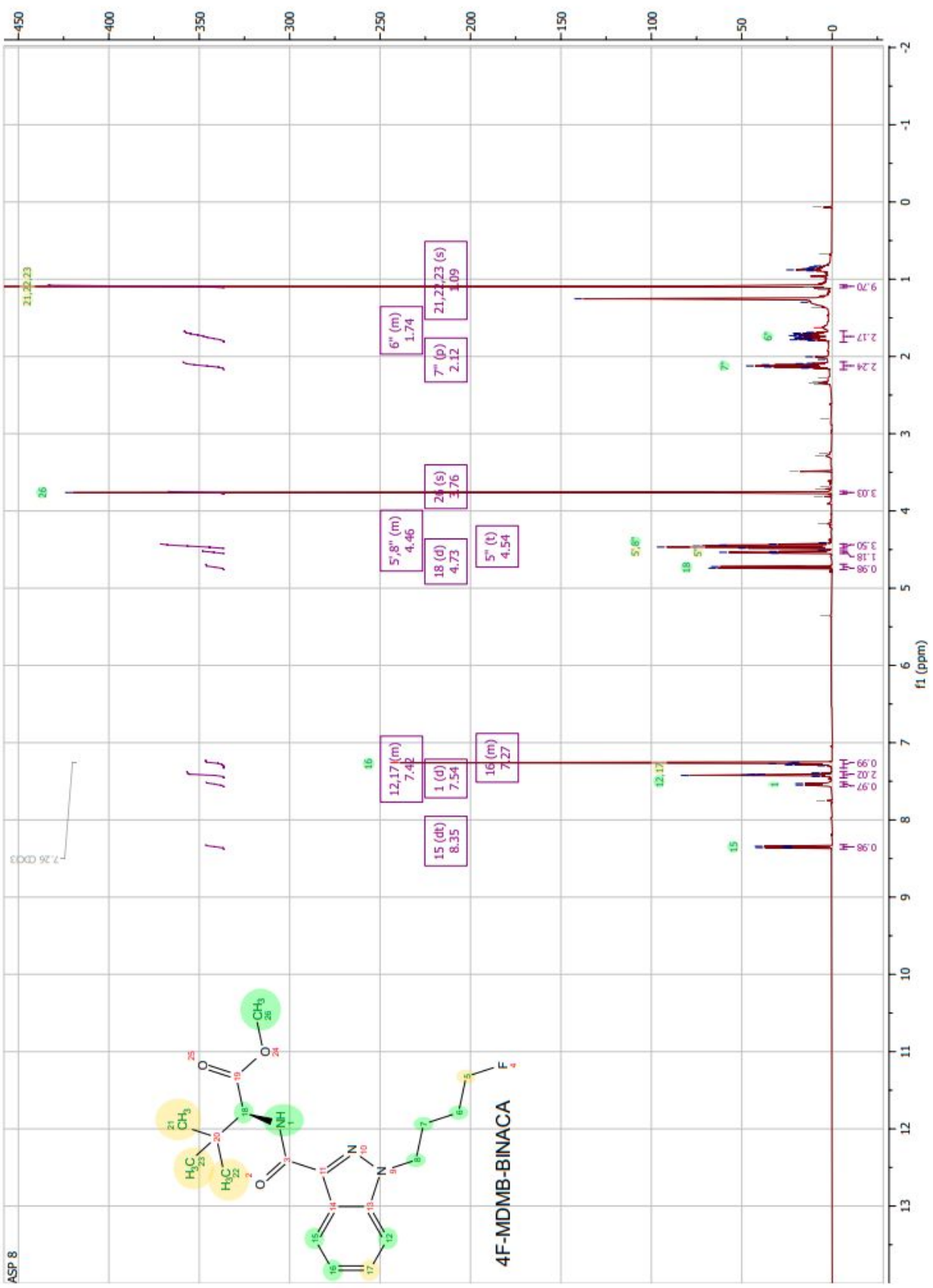



**Figure S14.** Labelled $^{1}H$ NMR of ASP8 in $CDCl_3$.

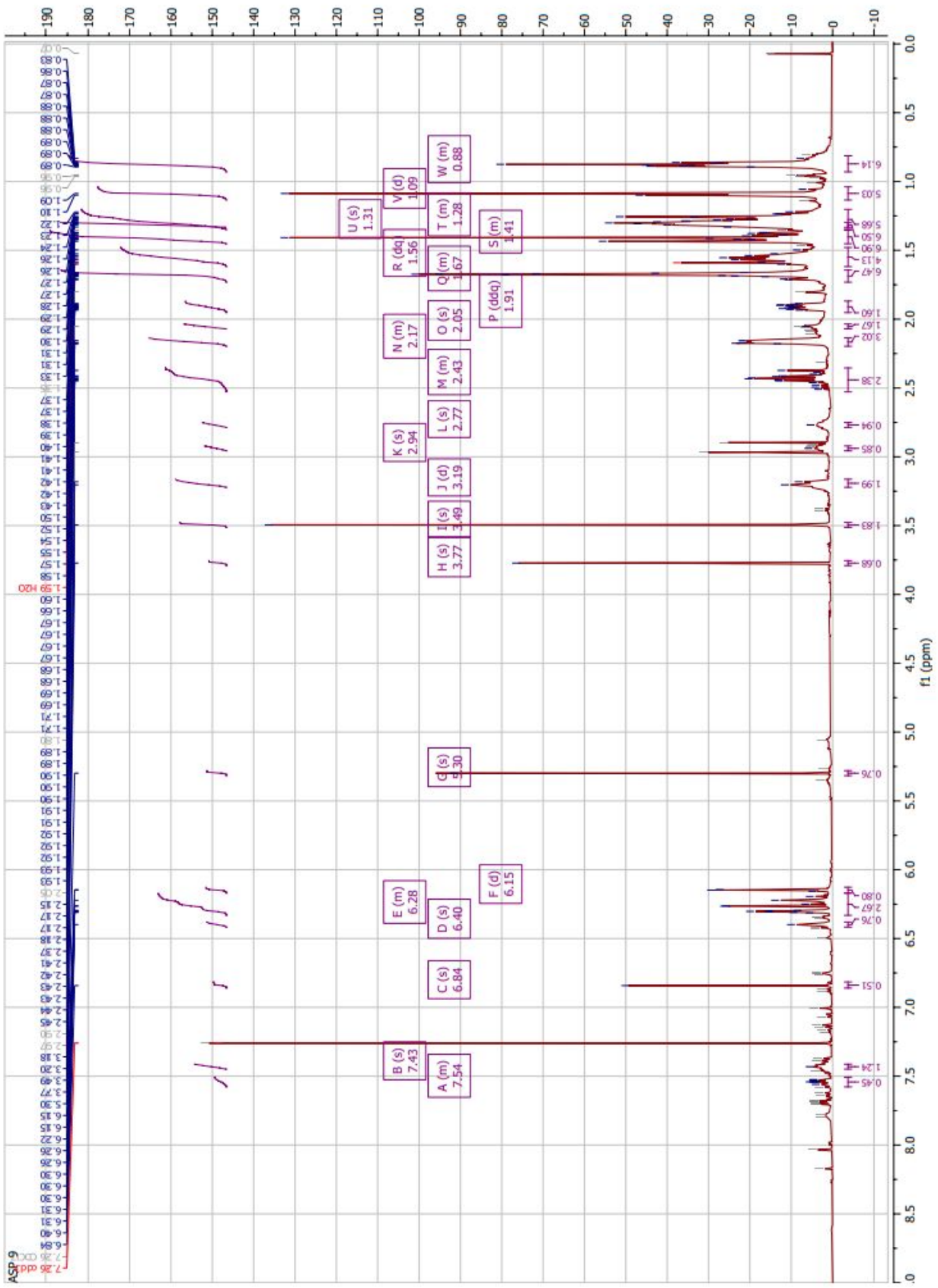



**Figure S15.** Labelled $^{1}H$ NMR of ASP9 in $CDCl_3$.

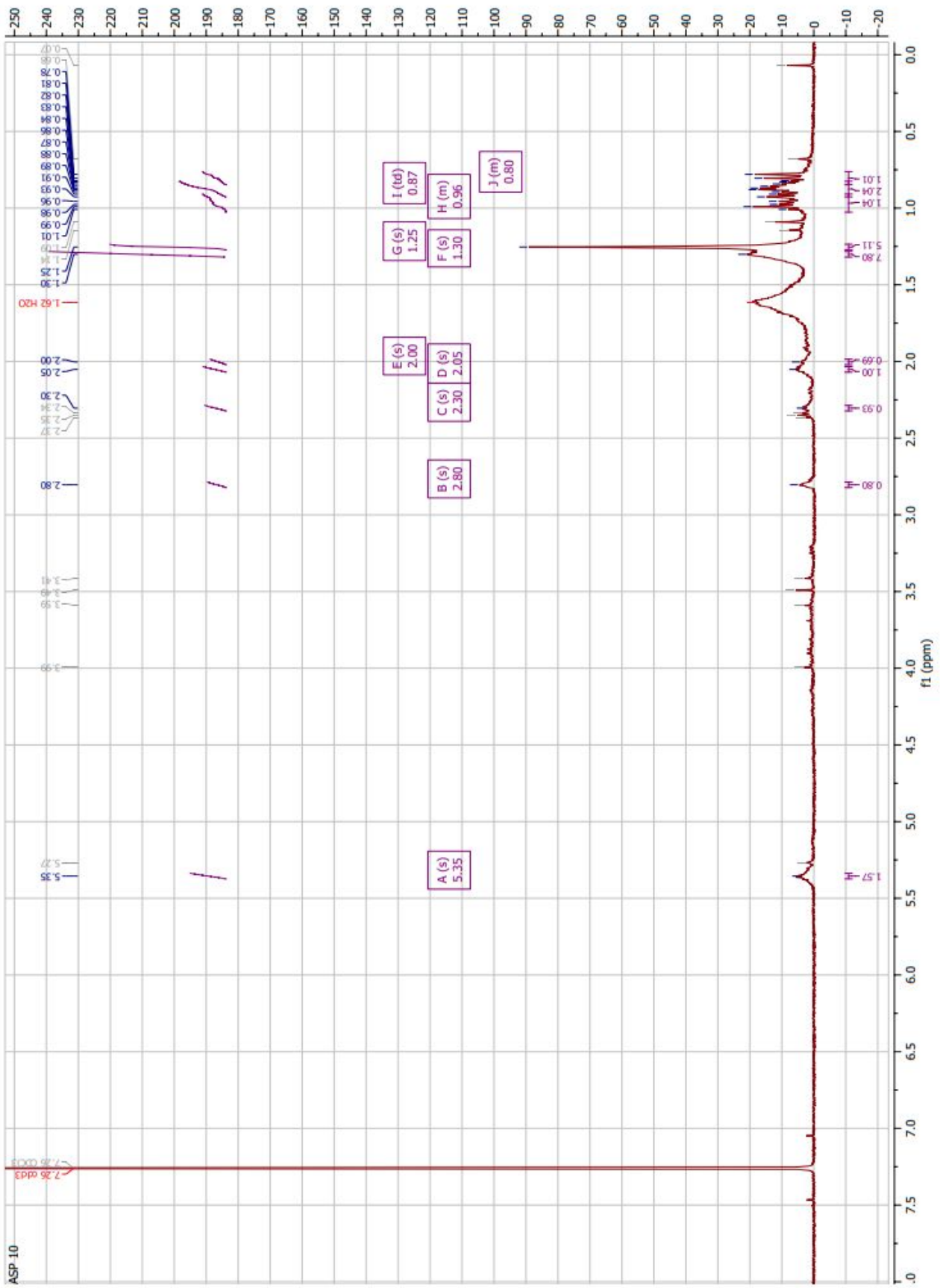



**Figure S16.** Labelled $^{1}H$ NMR of ASP10 in $CDCl_3$.

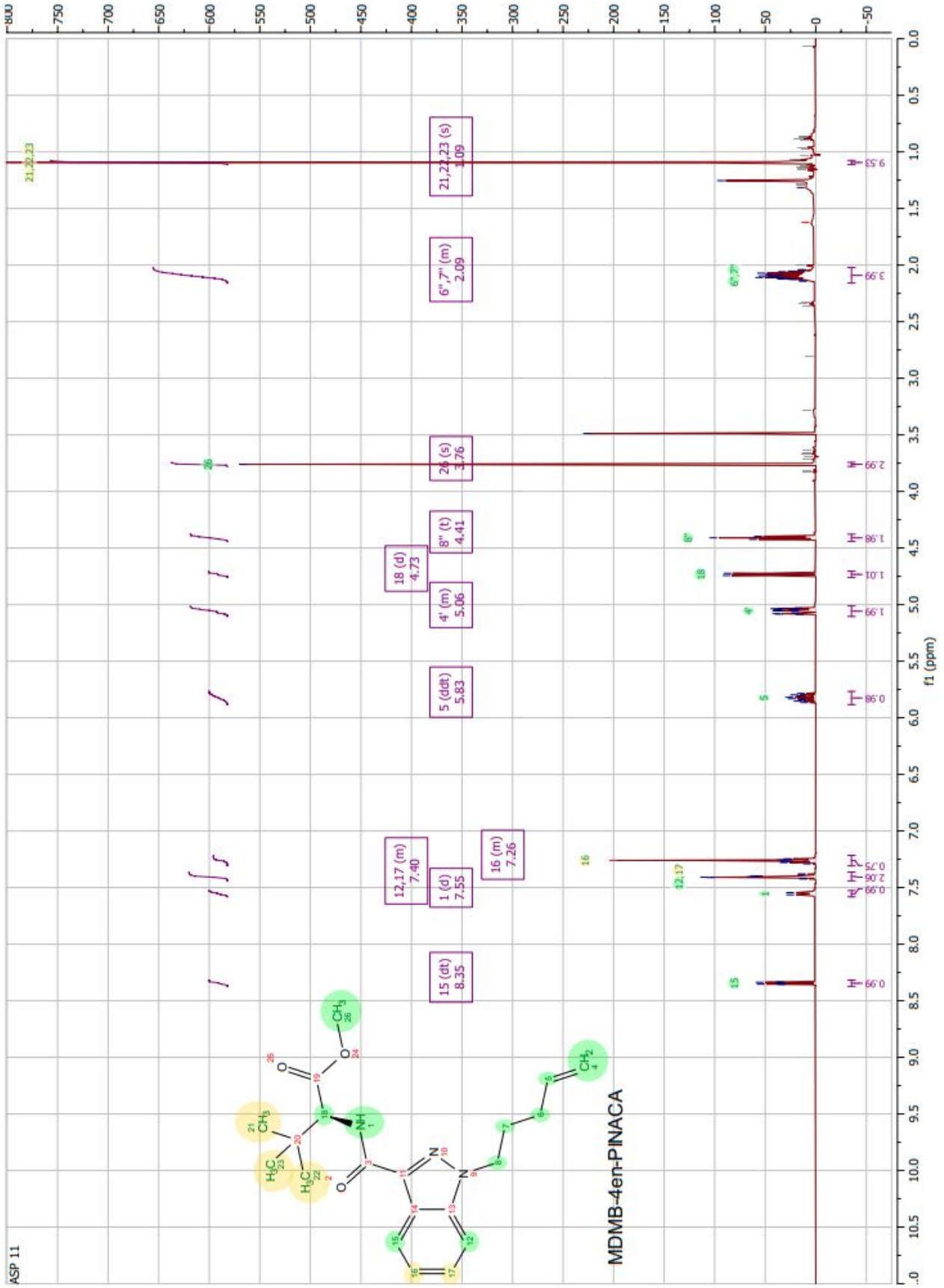



**Figure S17.** Labelled $^{1}H$ NMR of ASP11 in $CDCl_3$.

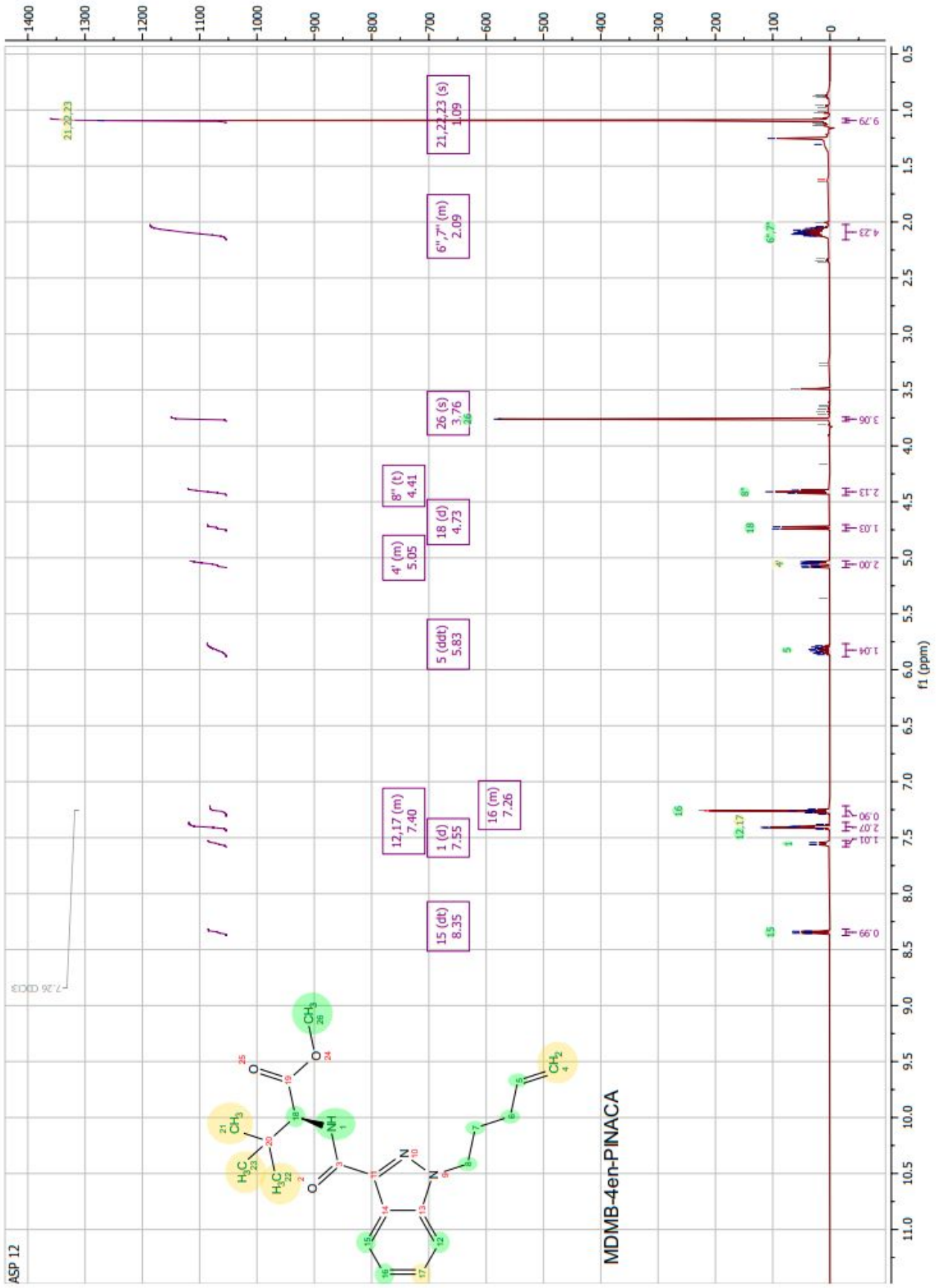



**Figure S18.** Labelled $^{1}H$ NMR of ASP12 in $CDCl_3$.

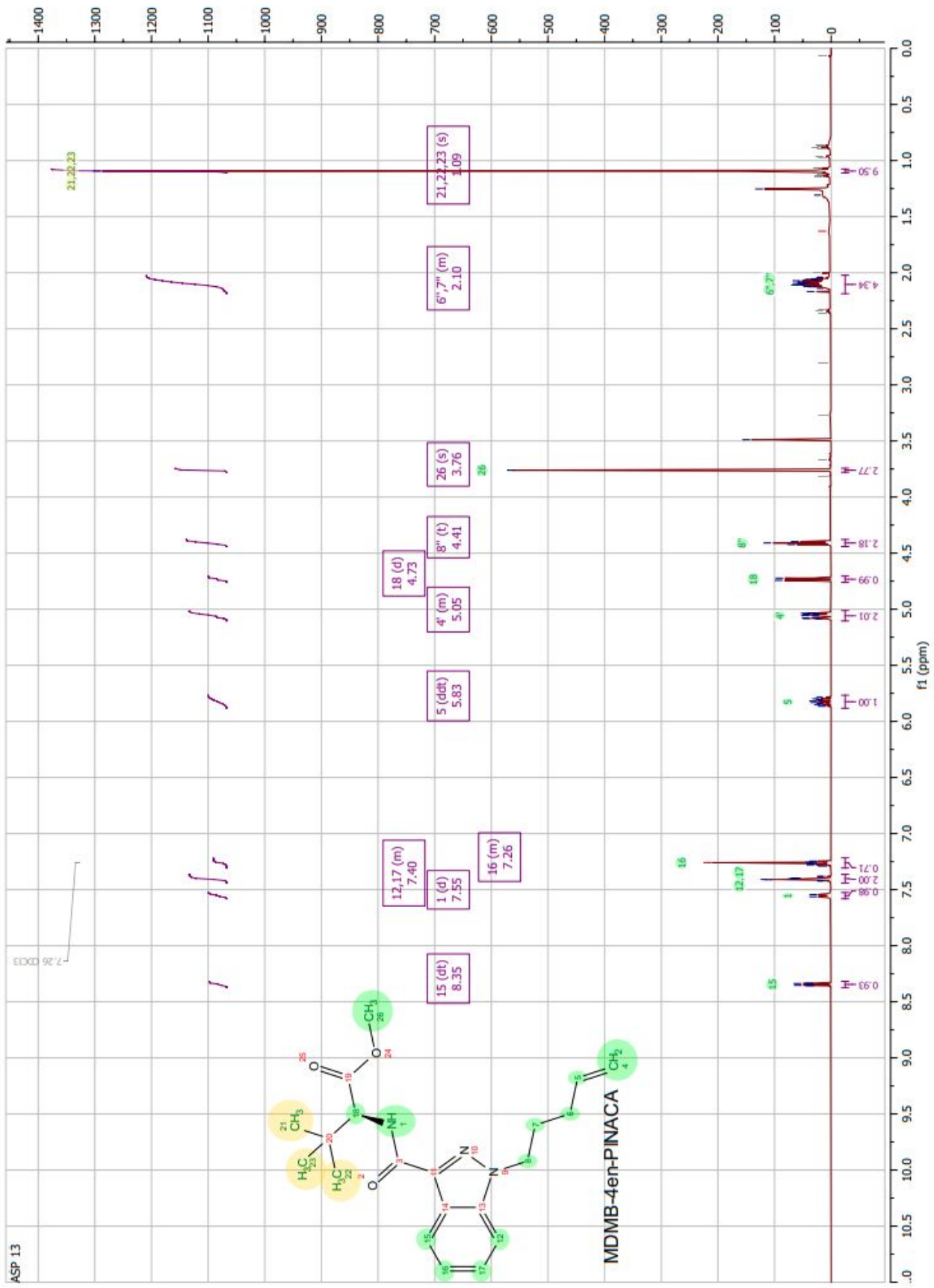



**Figure S19.** Labelled $^{1}H$ NMR of ASP13 in $CDCl_3$.

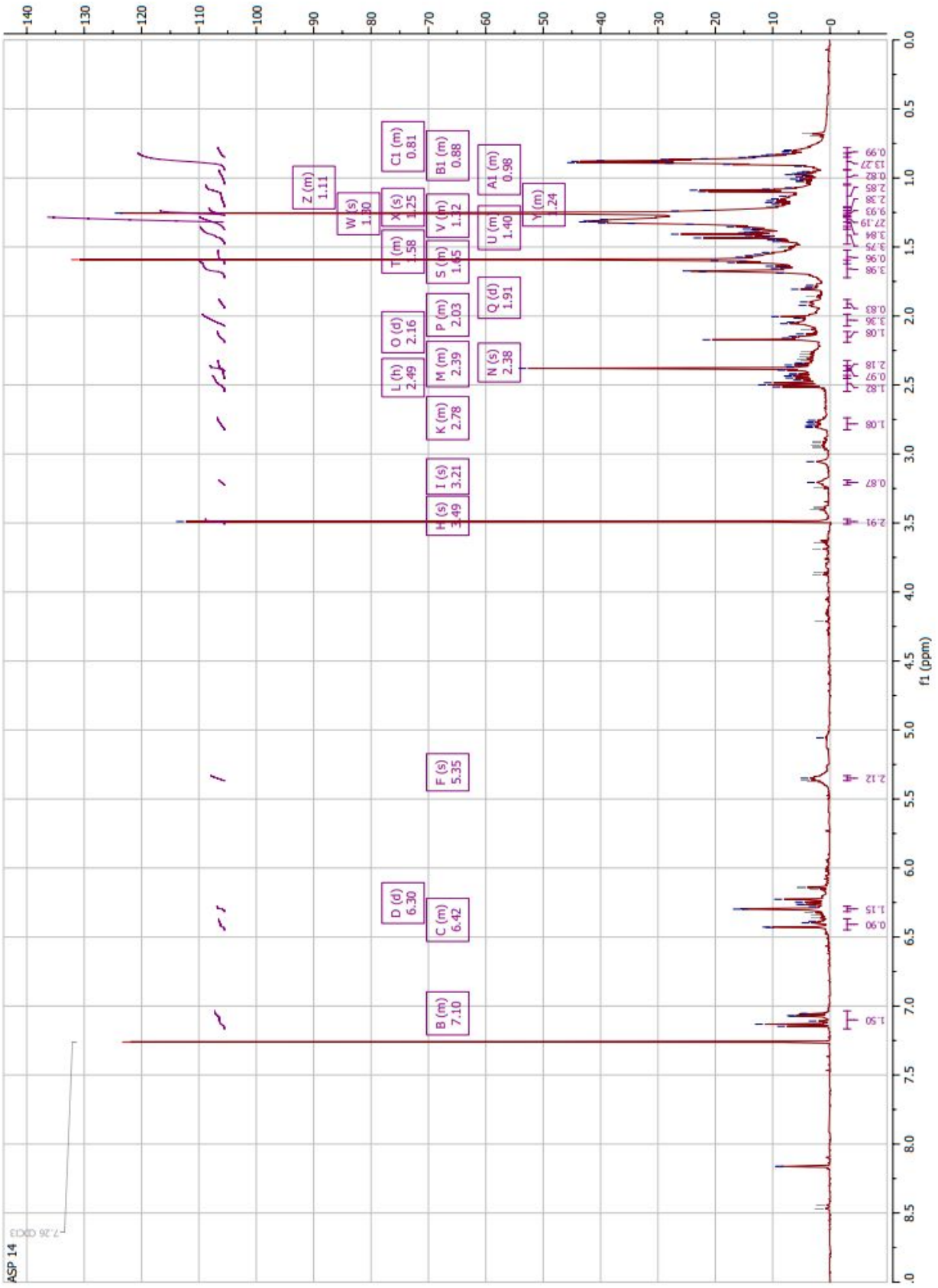



**Figure S20.** Labelled $^{1}H$ NMR of ASP14 in $CDCl_3$.


**Figure S21.** Labelled $^{1}H$ NMR of ASP15 in $CDCl_3$.

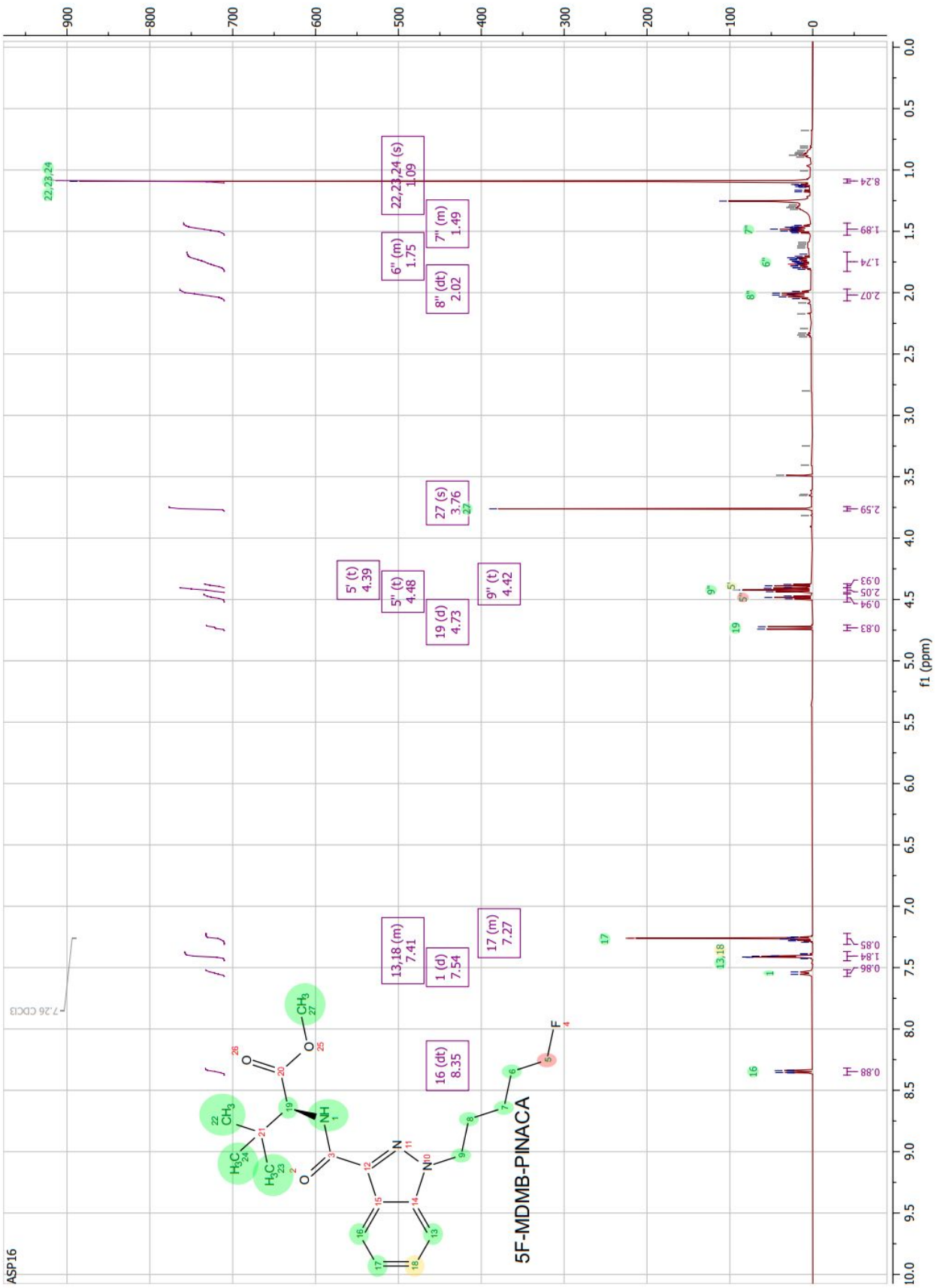



**Figure S22.** Labelled $^{1}H$ NMR of ASP16 in $CDCl_3$.

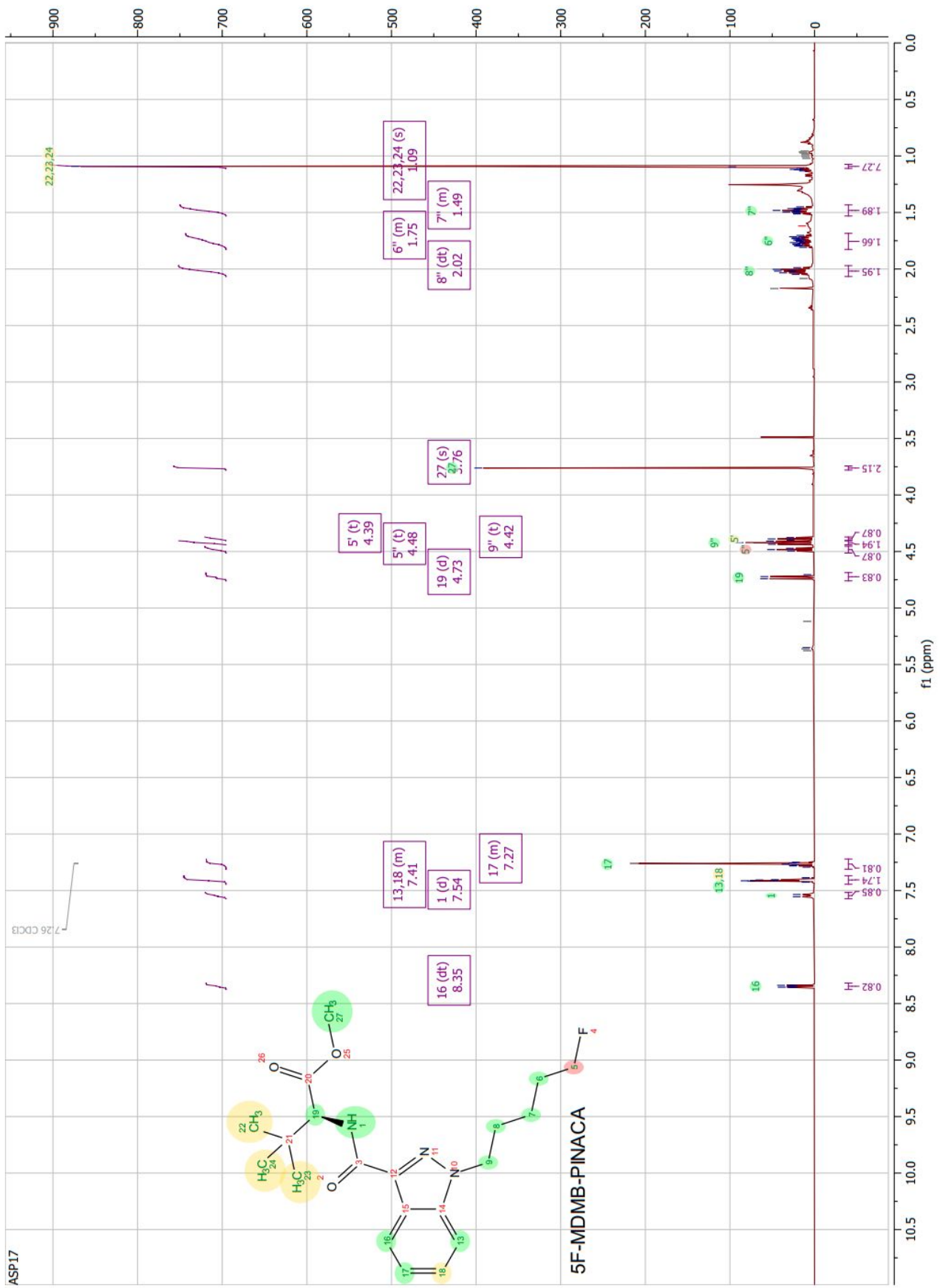



**Figure S23.** Labelled $^{1}H$ NMR of ASP17 in $CDCl_3$.

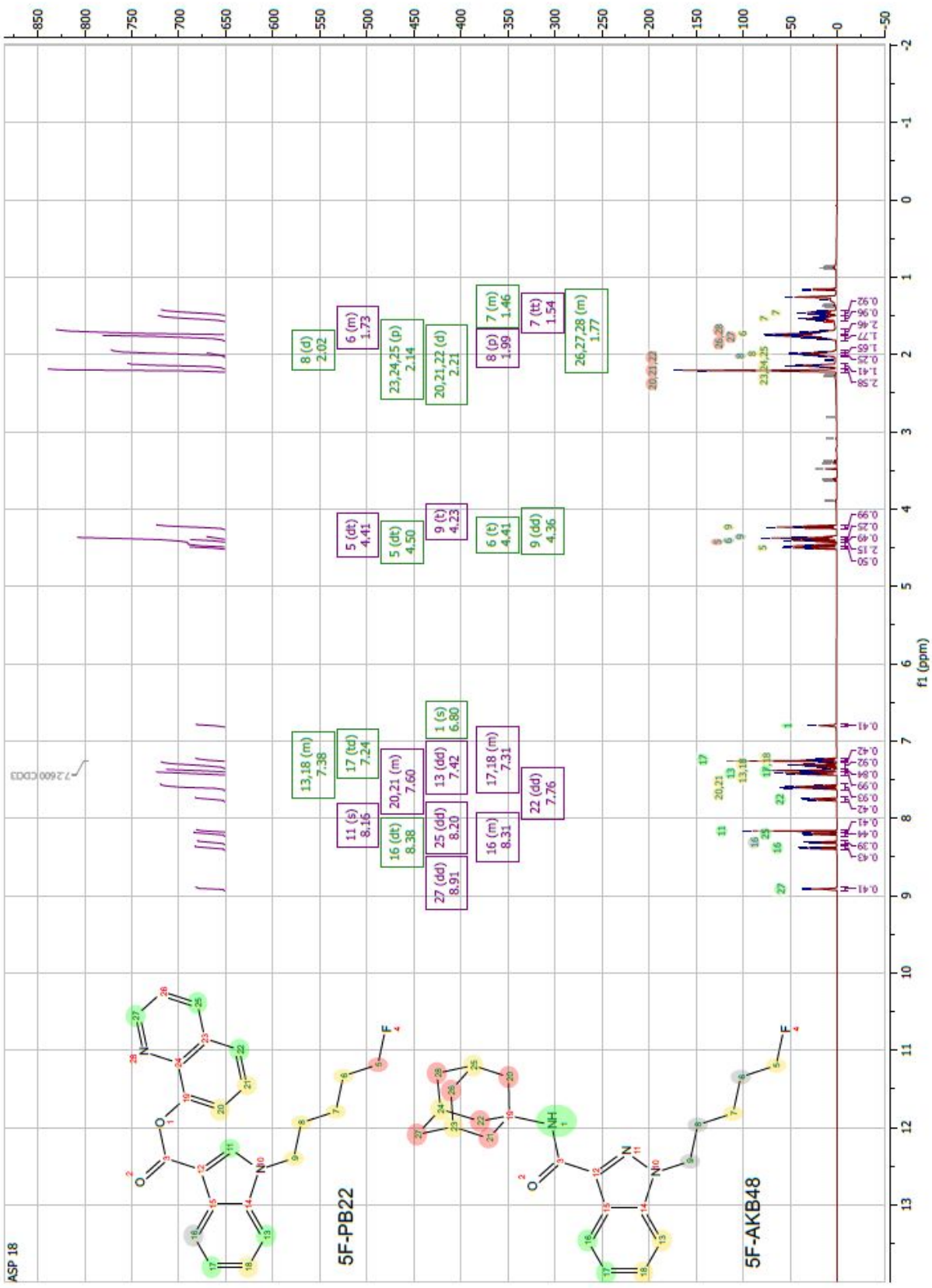



**Figure S24.** Labelled $^{1}H$ NMR of ASP18 in $CDCl_3$.

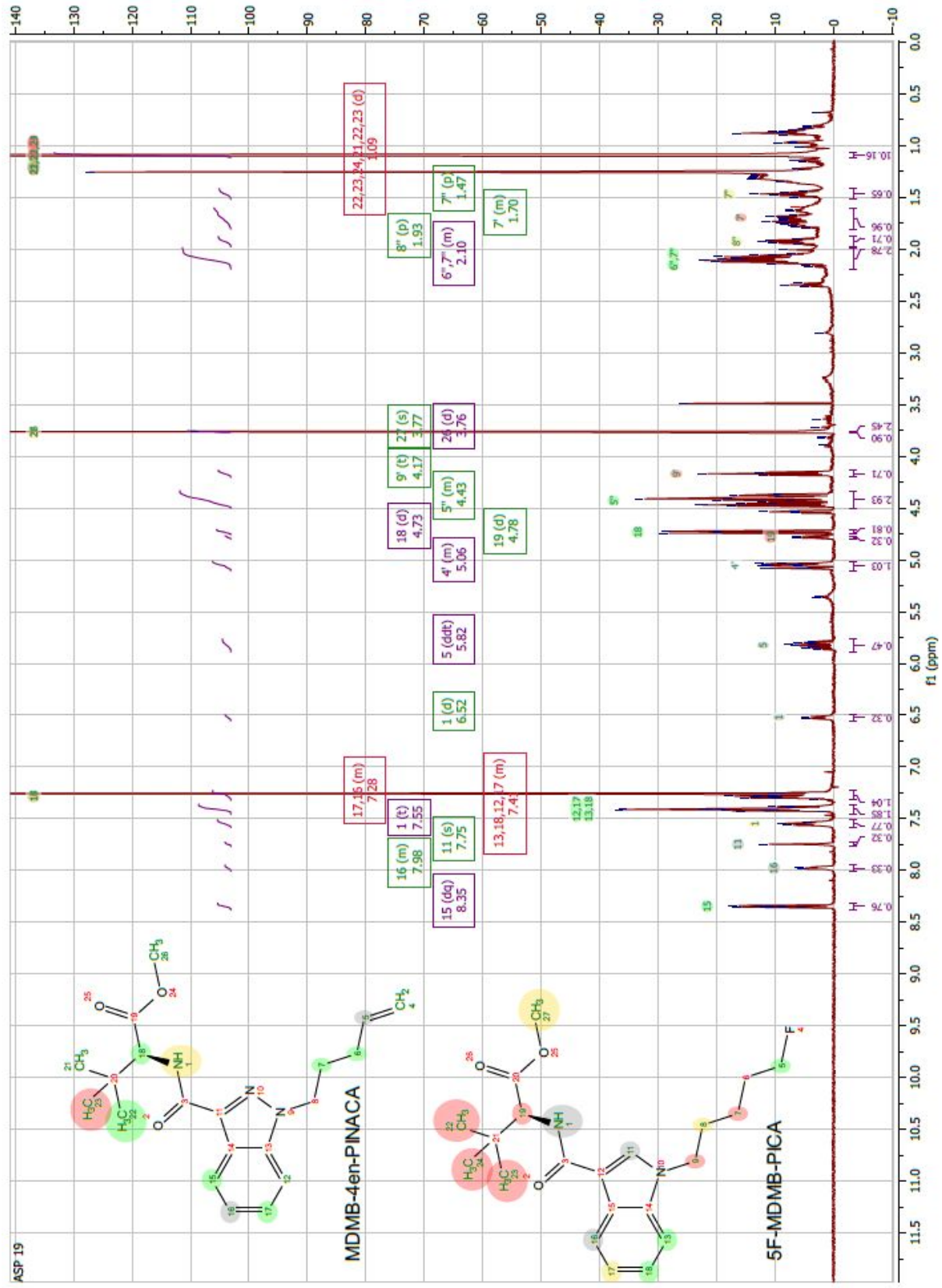



**Figure S25.** Labelled $^{1}H$ NMR of ASP19 in $CDCl_3$.

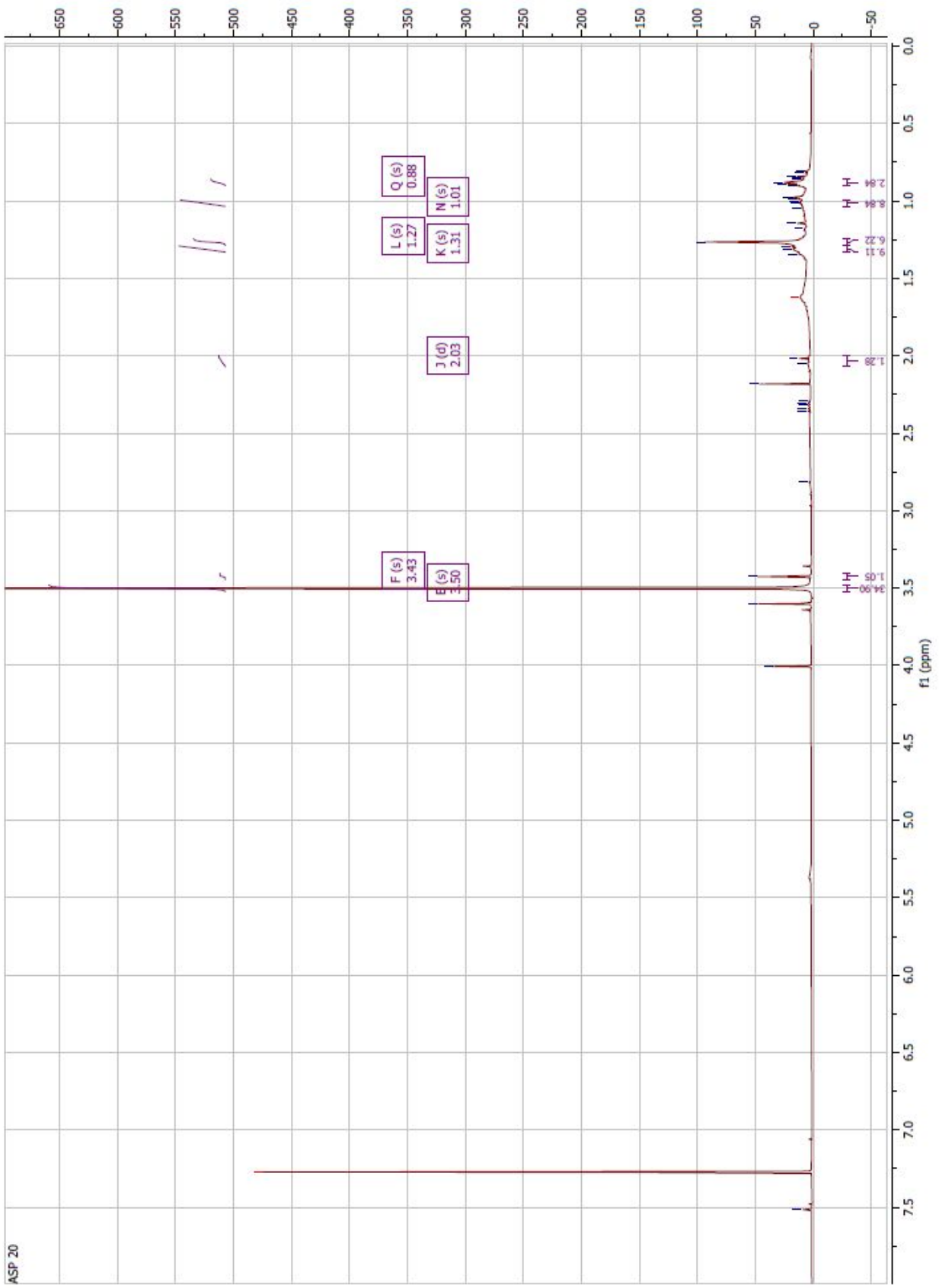



**Figure S26.** Labelled $^{1}H$ NMR of ASP20 in $CDCl_3$.

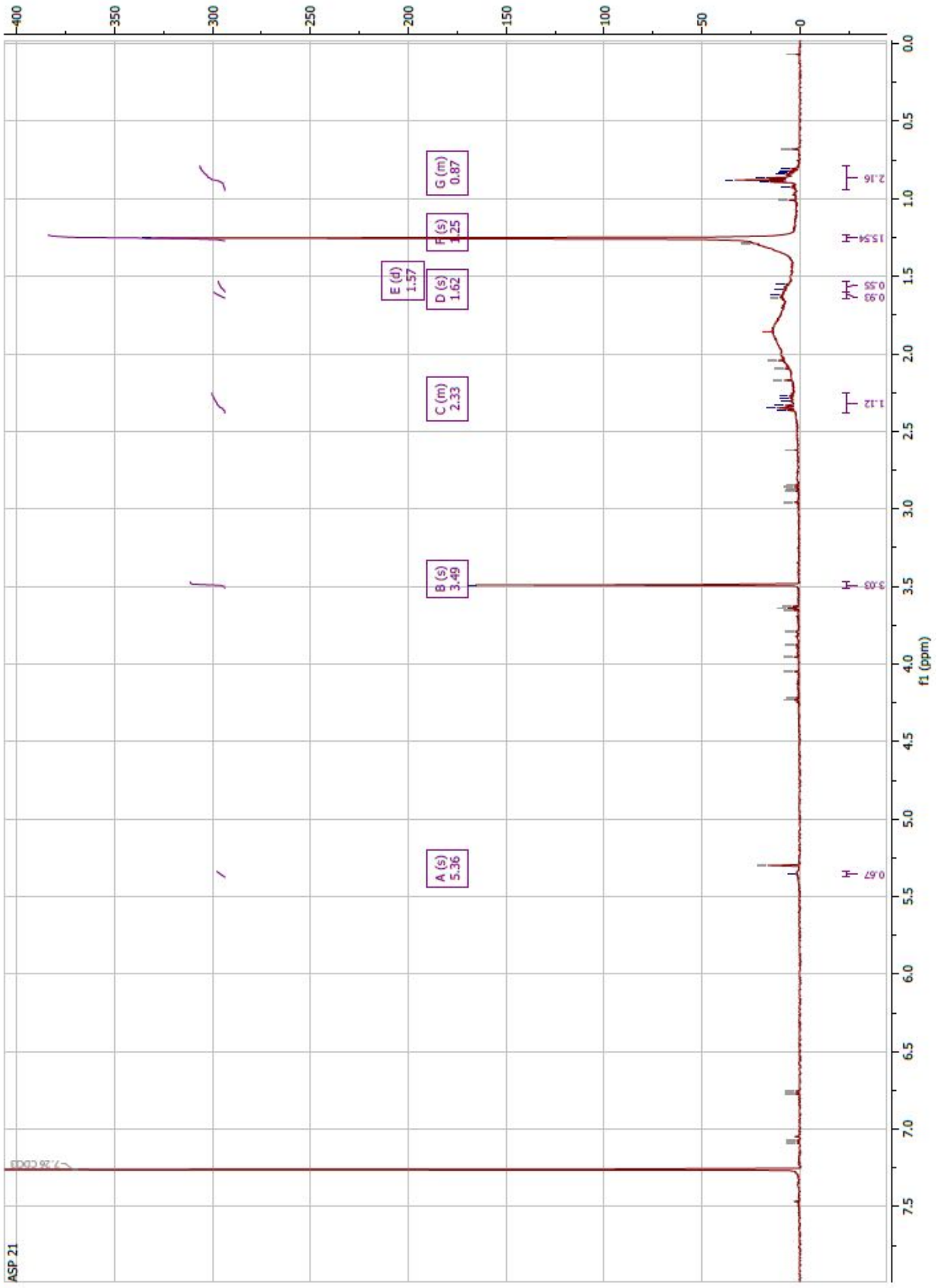



**Figure S27.** Labelled $^{1}H$ NMR of ASP21 in $CDCl_3$.

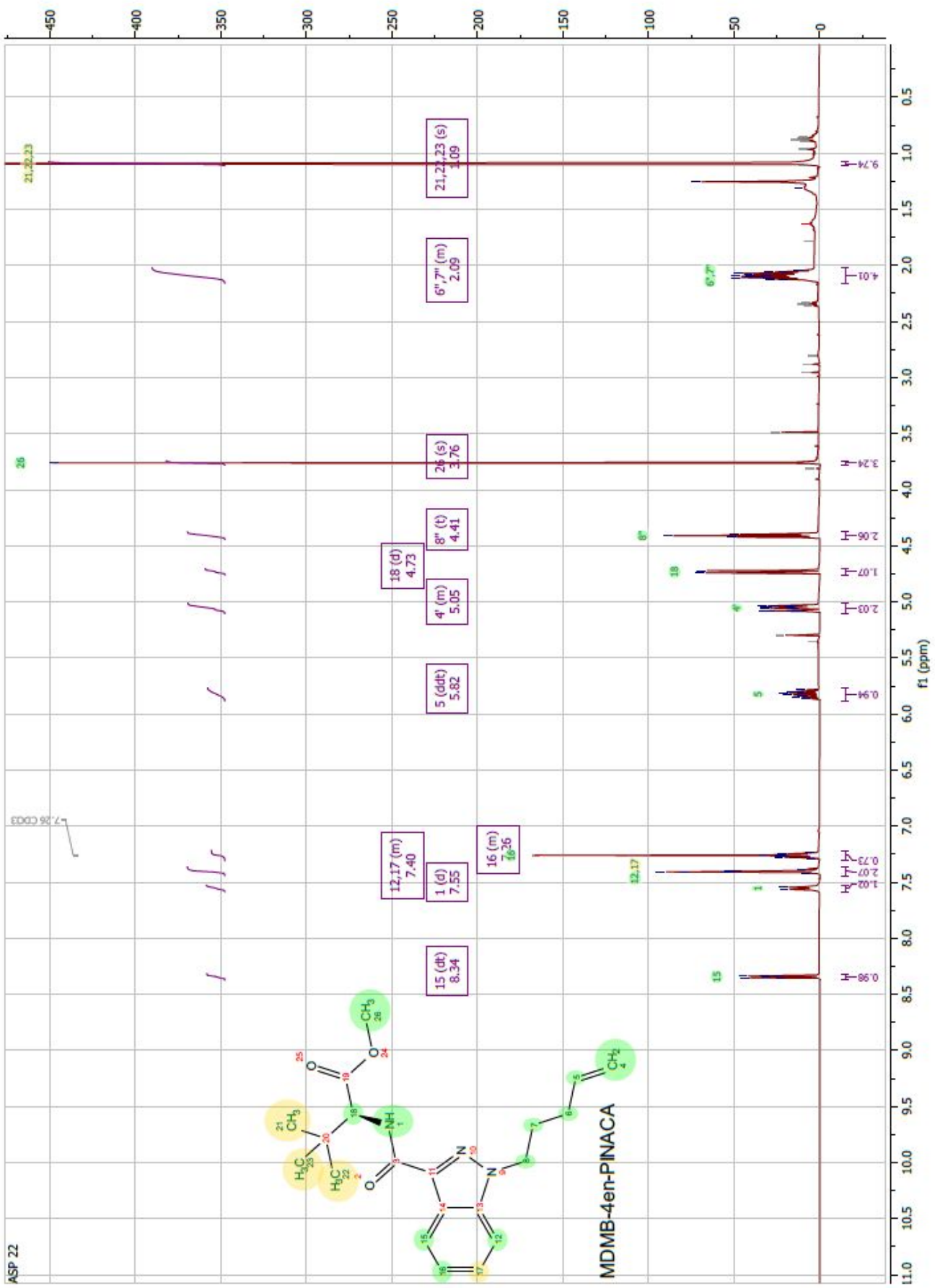



**Figure S28.** Labelled $^{1}H$ NMR of ASP22 in $CDCl_3$.

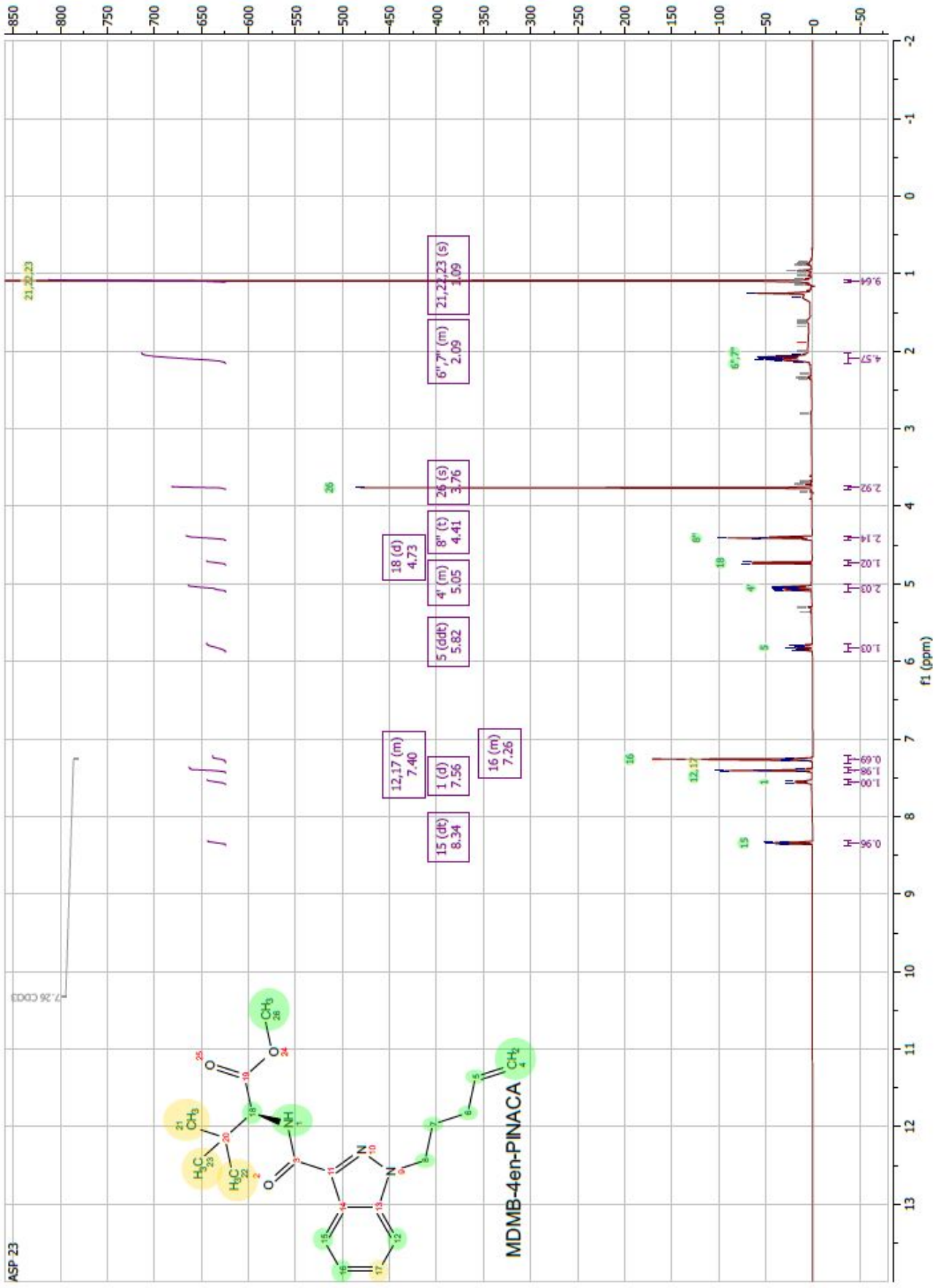



**Figure S29.** Labelled $^{1}H$ NMR of ASP23 in $CDCl_3$.

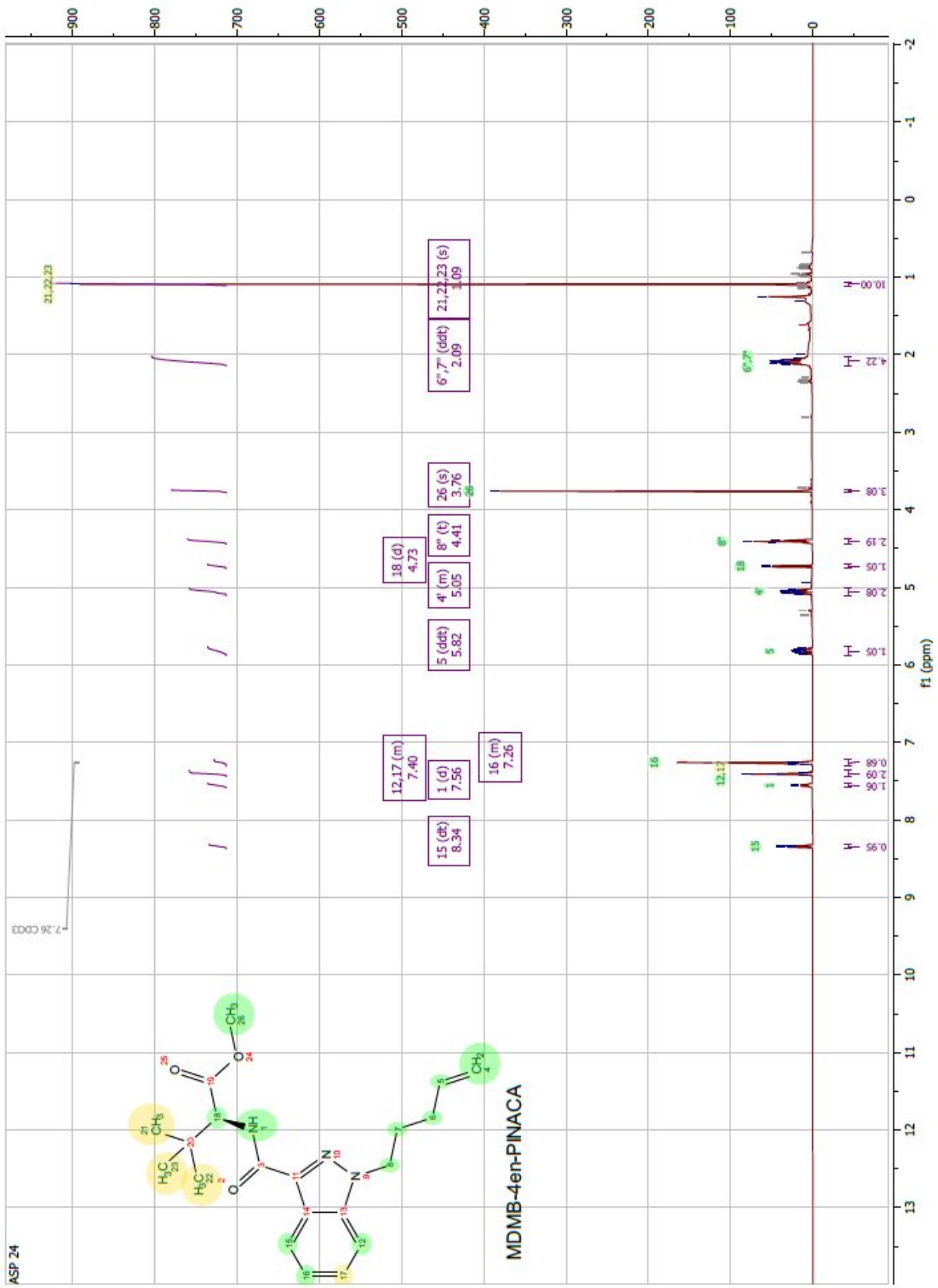



**Figure S30.** Labelled $^{1}H$ NMR of ASP24 in $CDCl_3$.

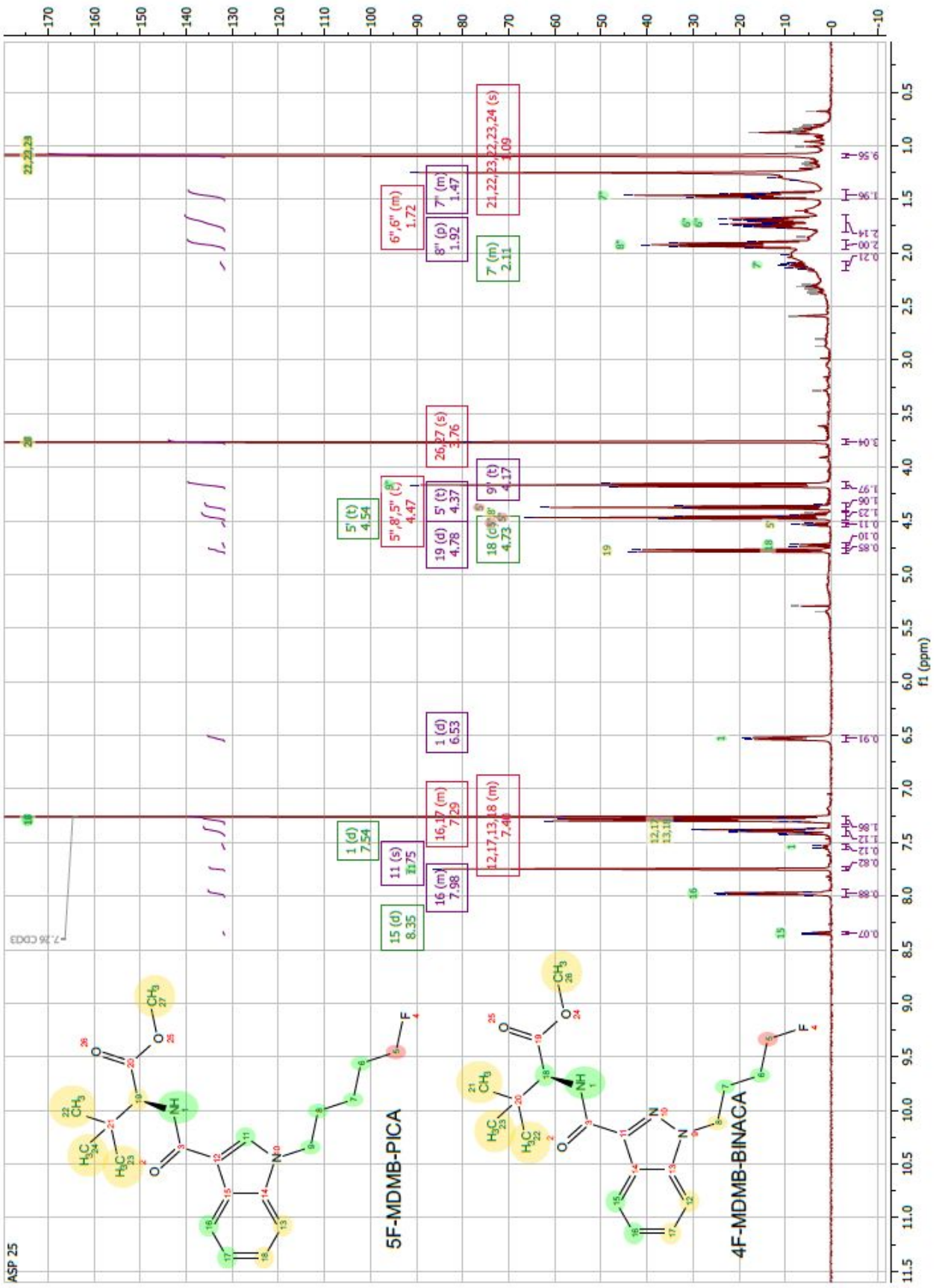



**Figure S31.** Labelled $^{1}H$ NMR of ASP25 in $CDCl_3$.

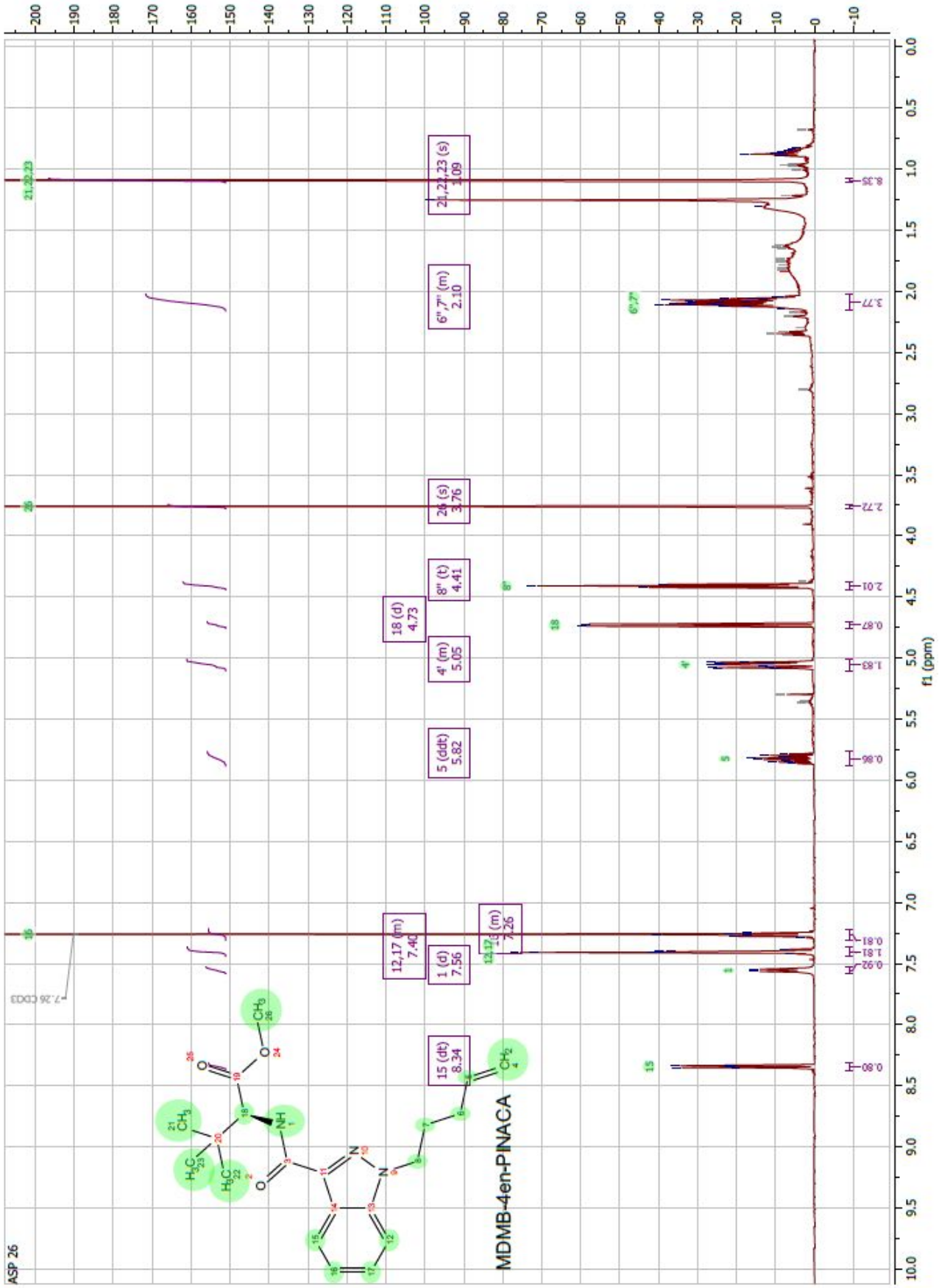



**Figure S32.** Labelled $^{1}H$ NMR of ASP26 in $CDCl_3$.

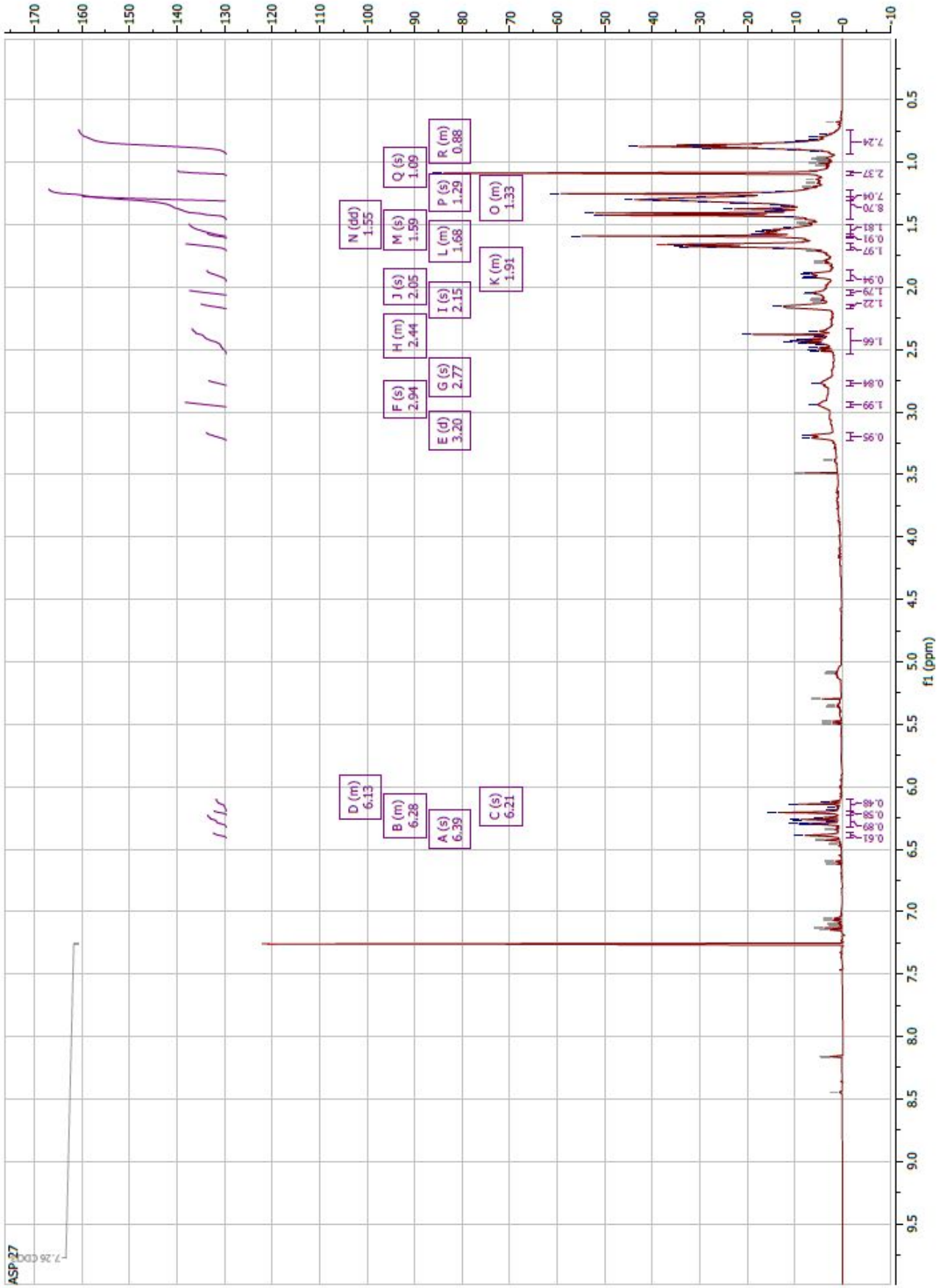



**Figure S33.** Labelled $^{1}H$ NMR of ASP27 in $CDCl_3$.

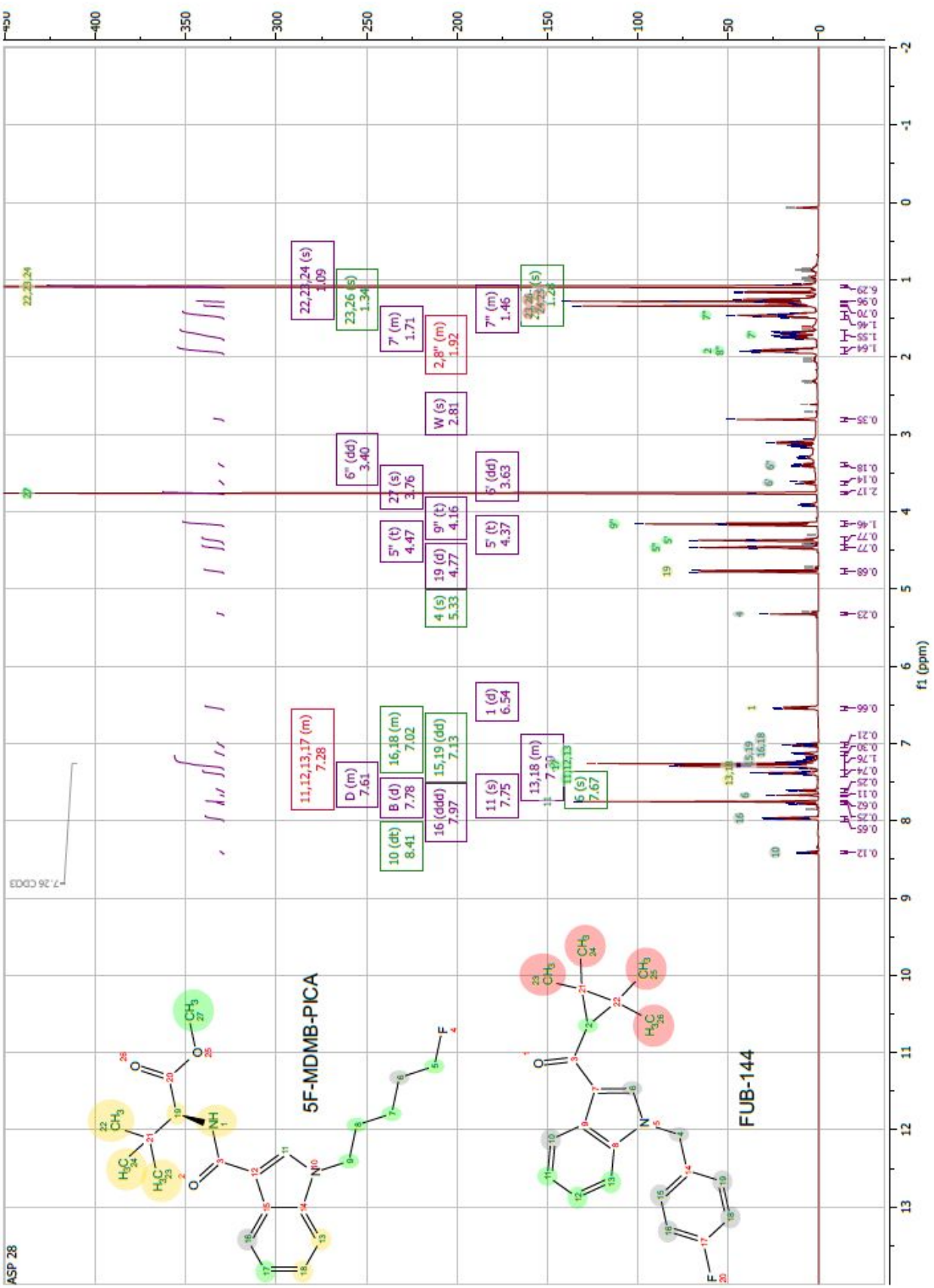



**Figure S34.** Labelled $^{1}H$ NMR of ASP28 in $CDCl_3$.

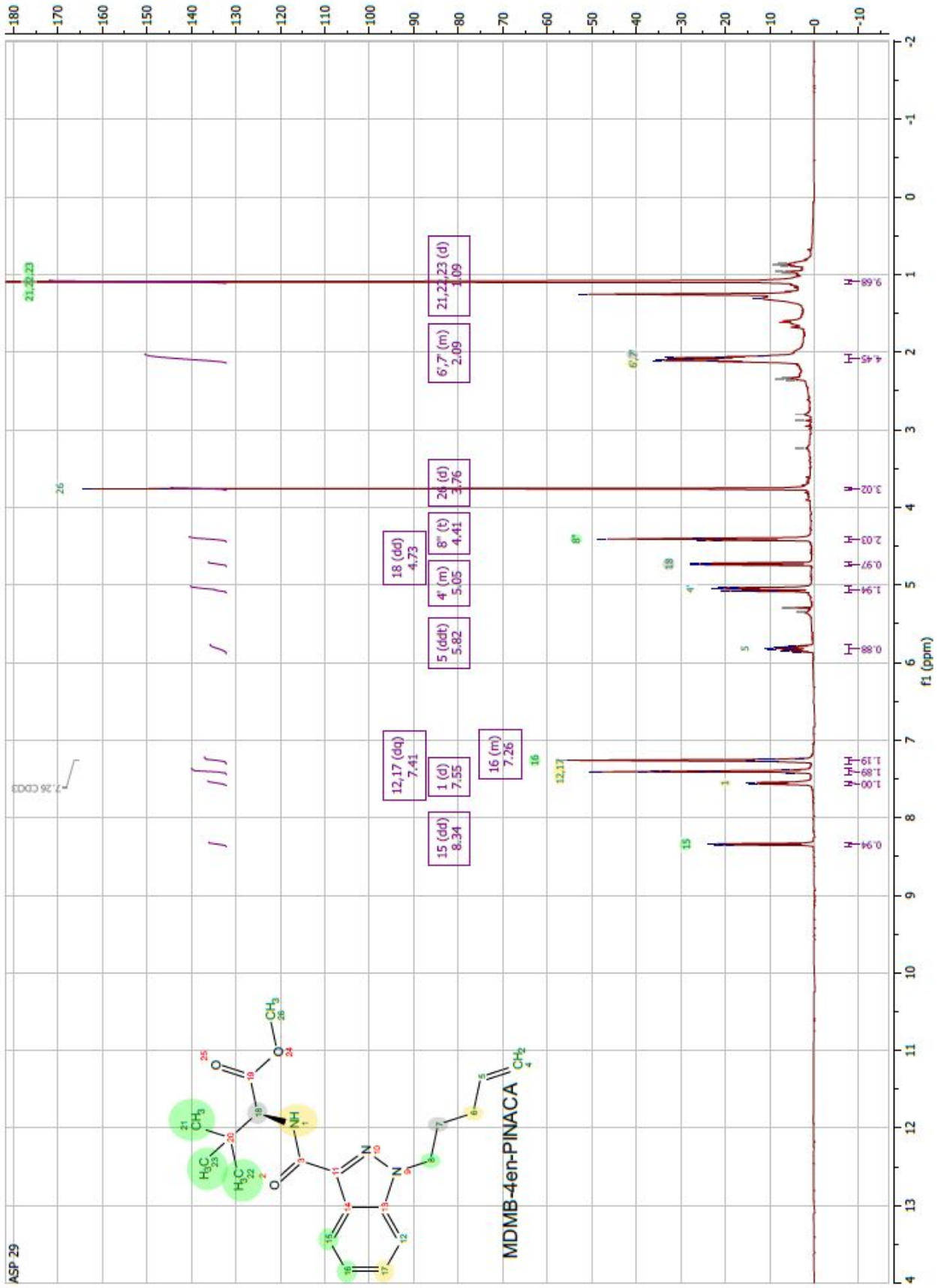



**Figure S35.** Labelled $^{1}H$ NMR of ASP29 in $CDCl_3$.

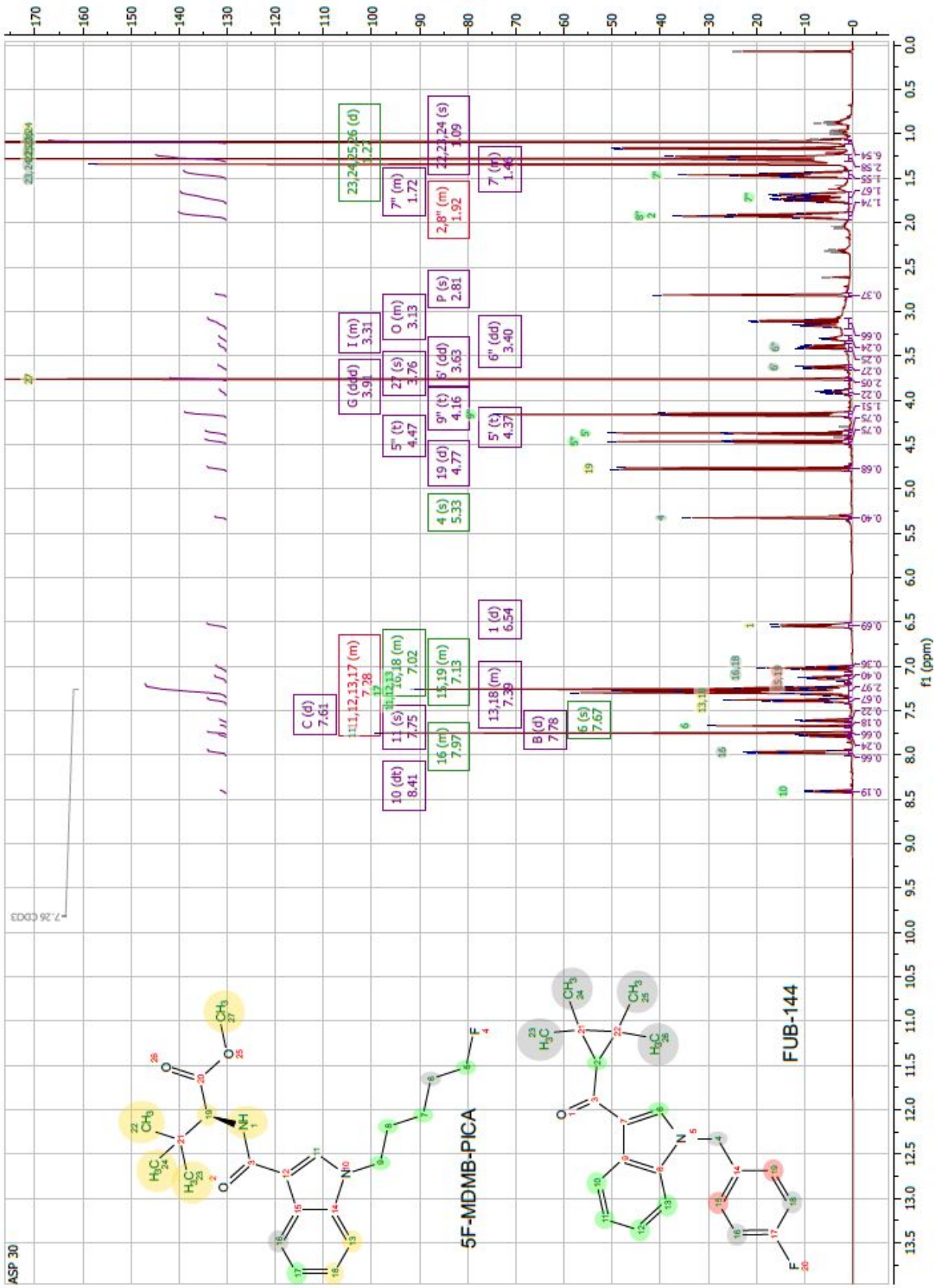



**Figure S36.** Labelled $^{1}H$ NMR of ASP30 in $CDCl_3$.


**Figure S37.** Labelled $^{1}H$ NMR of ASP31 in $CD_3OD$.


**Figure S38.** Labelled $^{1}H$ NMR of ASP32 in $CD_3OD$.

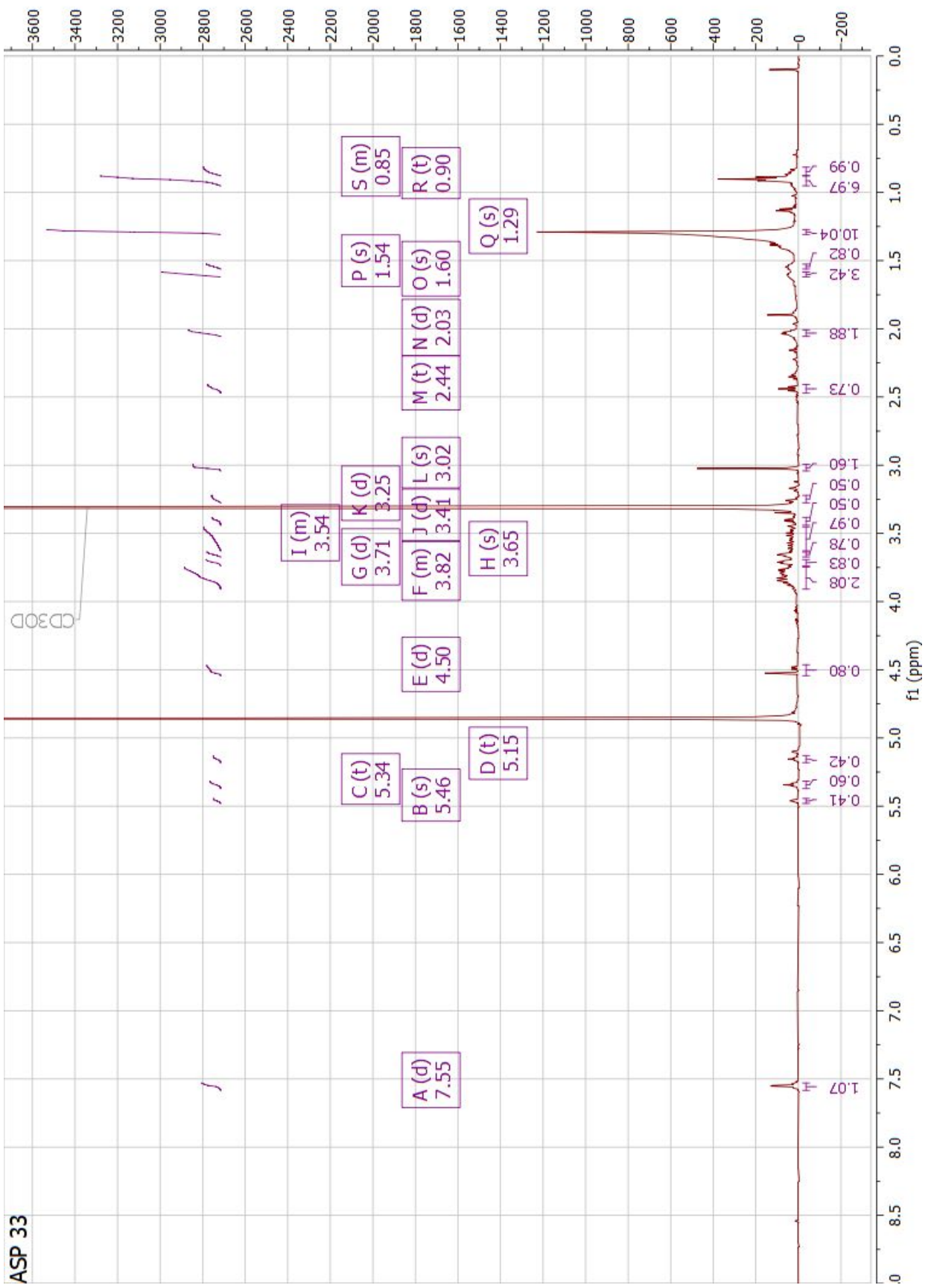



**Figure S39.** Labelled $^{1}H$ NMR of ASP33 in $CD_3OD$.

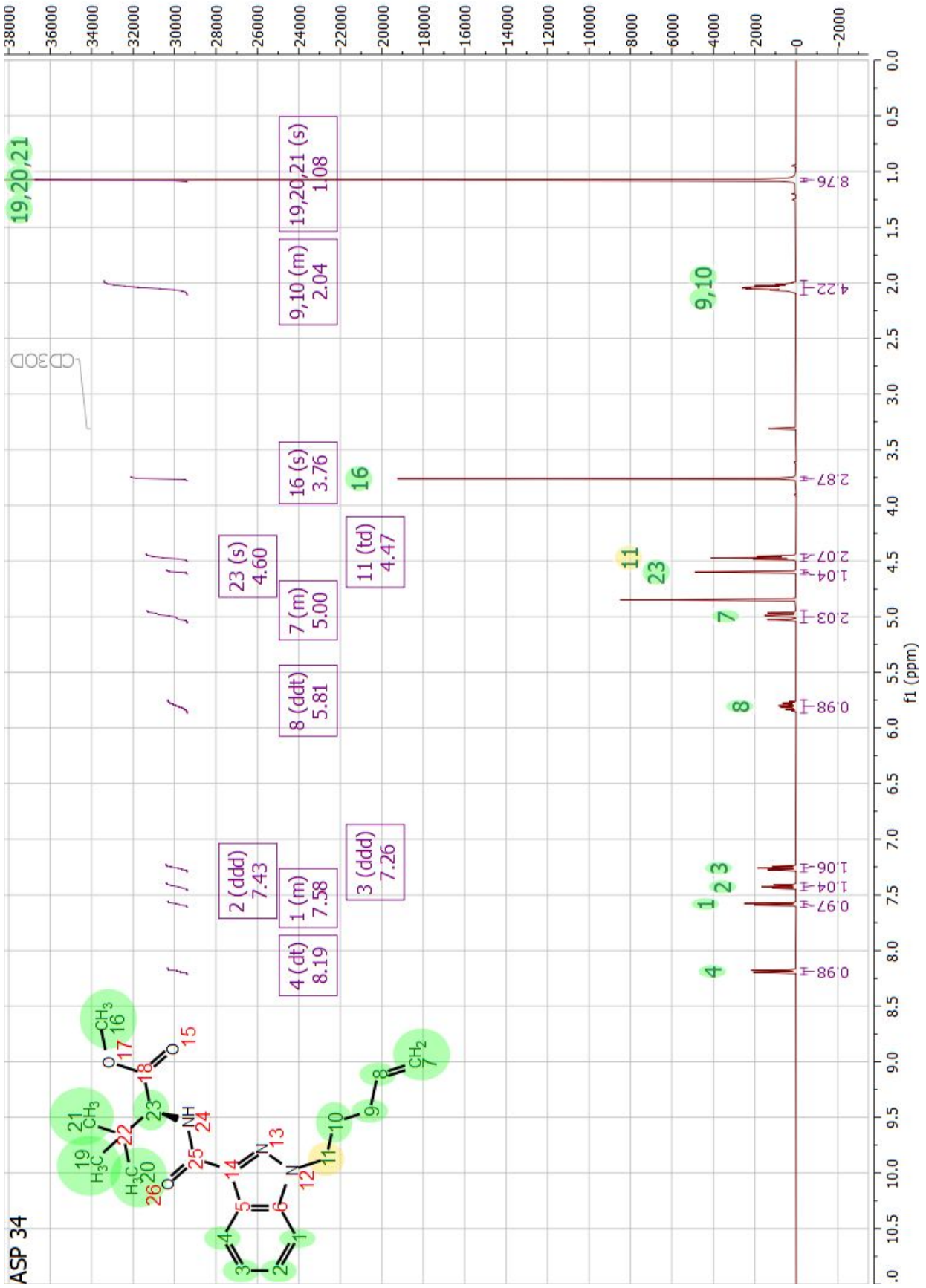



**Figure S40.** Labelled $^{1}H$ NMR of ASP34 in $CD_3OD$.

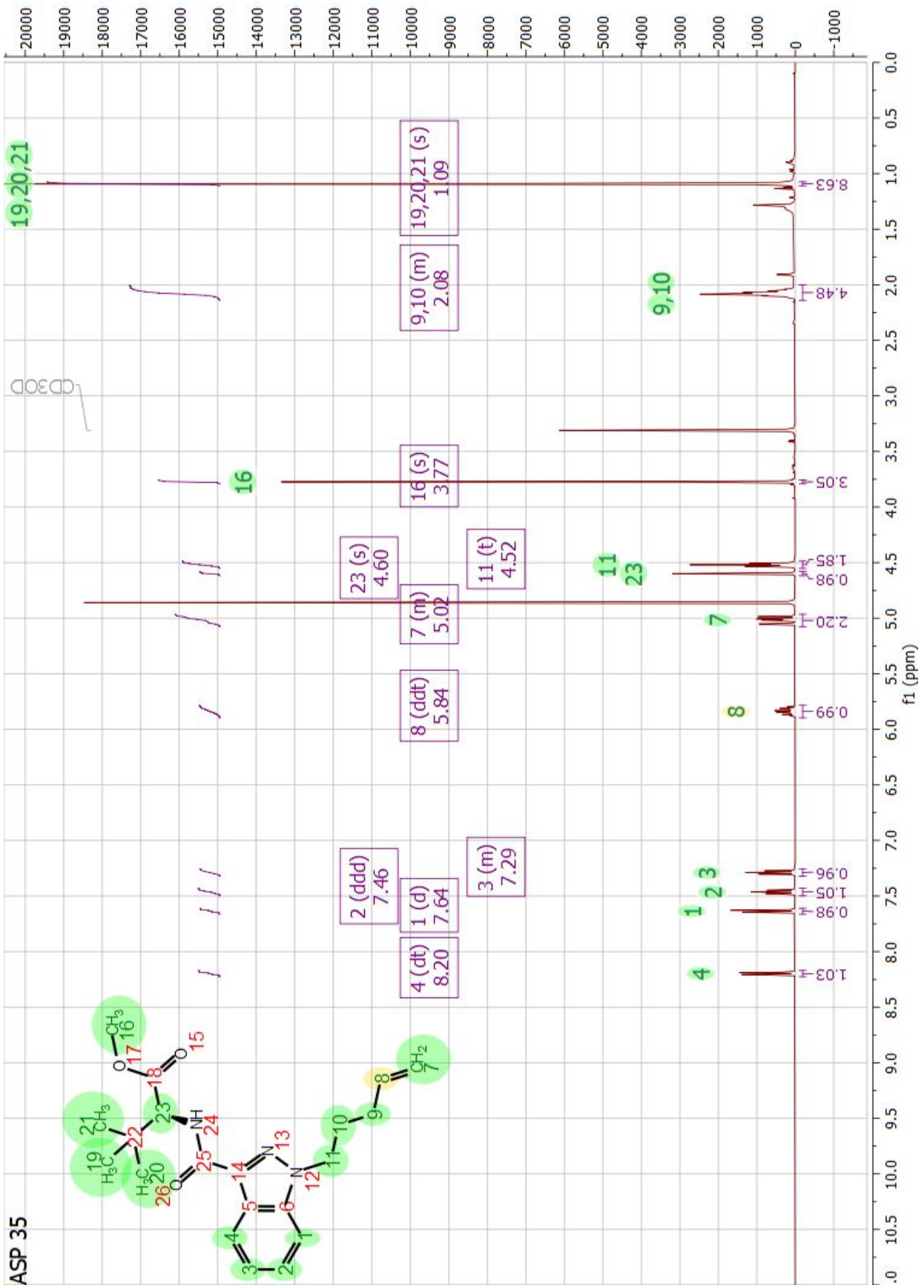



**Figure S41.** Labelled $^{1}H$ NMR of ASP35 in $CD_3OD$.

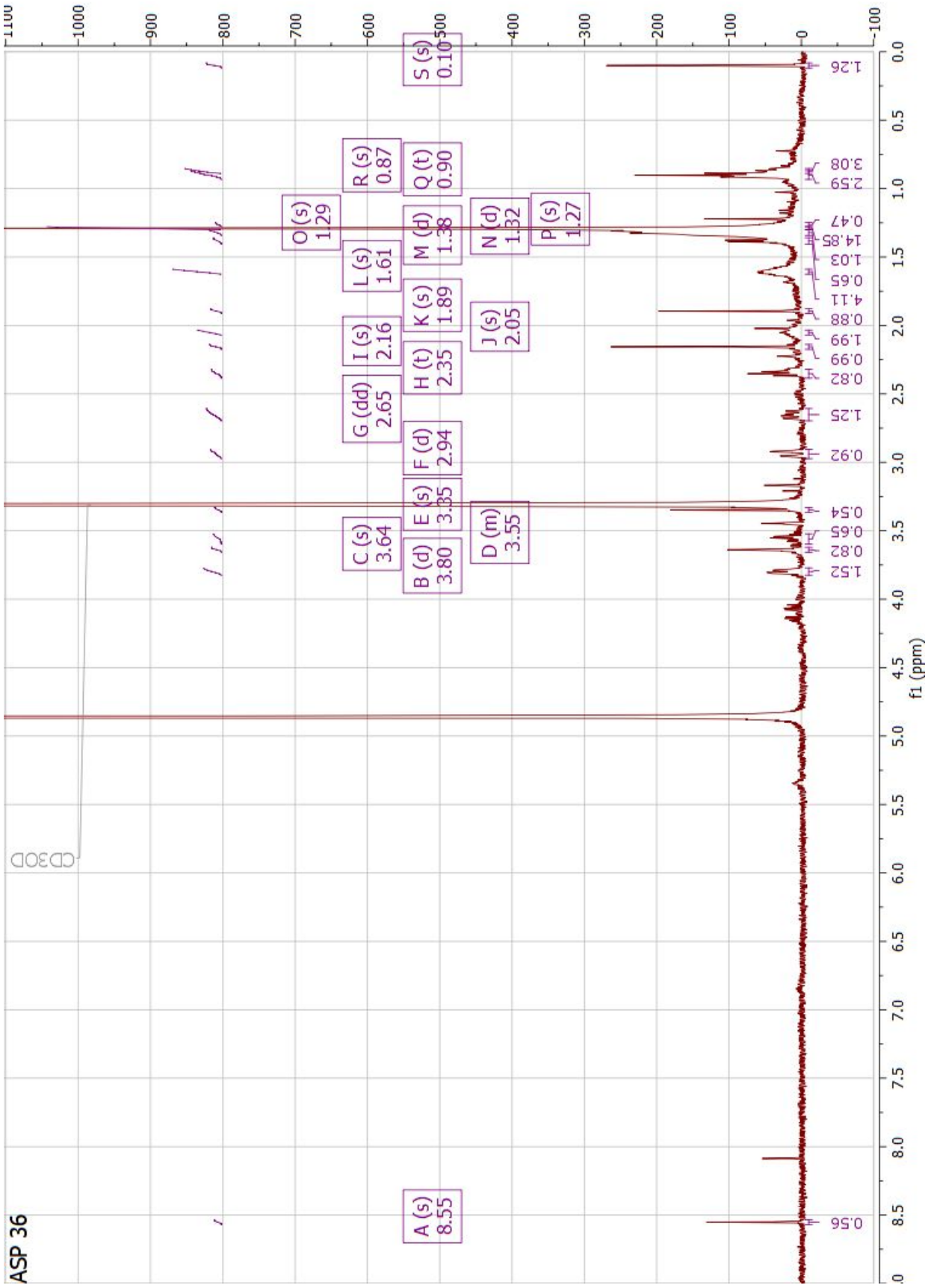



**Figure S42.** Labelled $^{1}H$ NMR of ASP36 in $CD_3OD$.

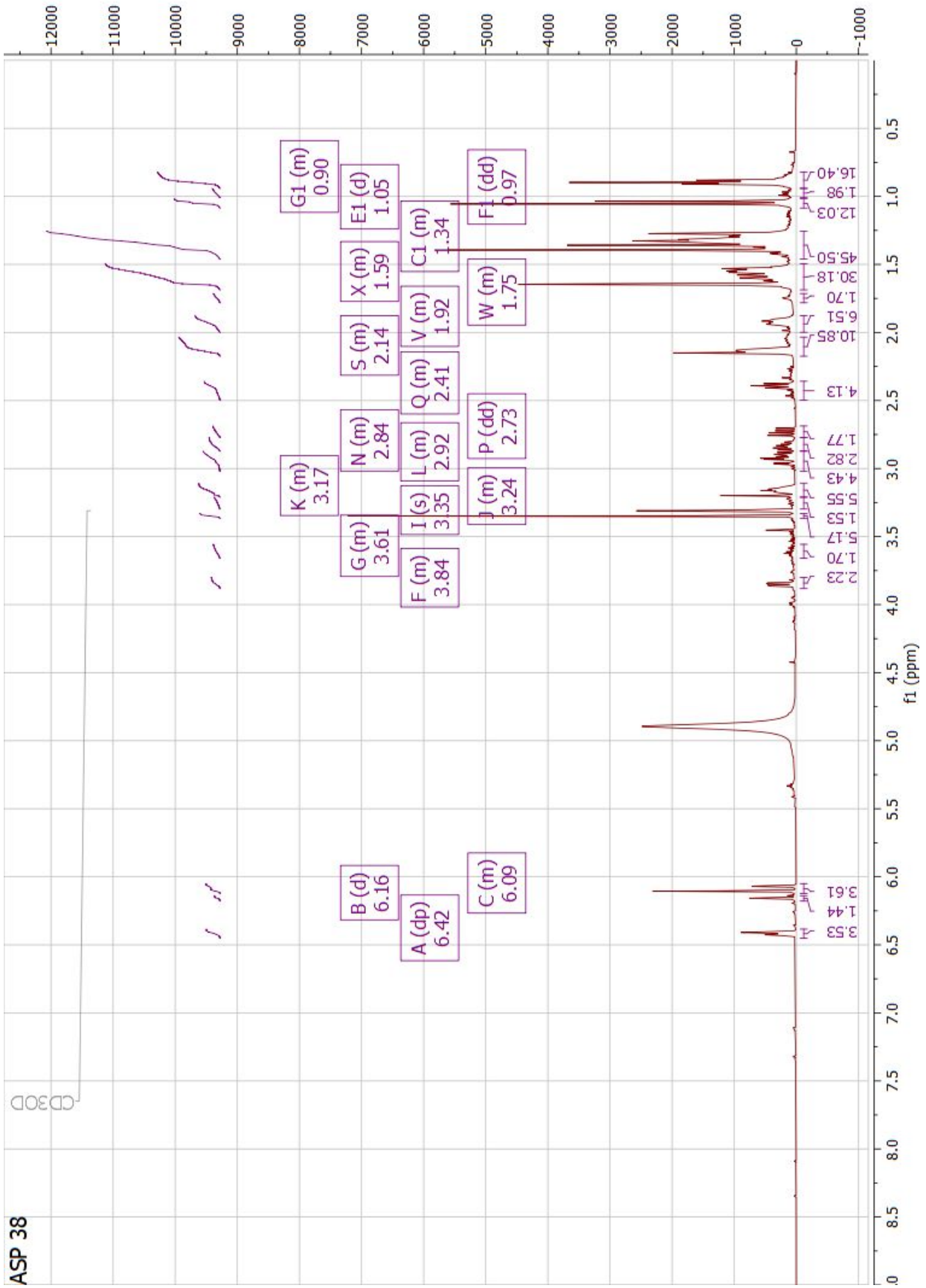



**Figure S43.** Labelled $^{1}H$ NMR of ASP38 in $CD_3OD$.

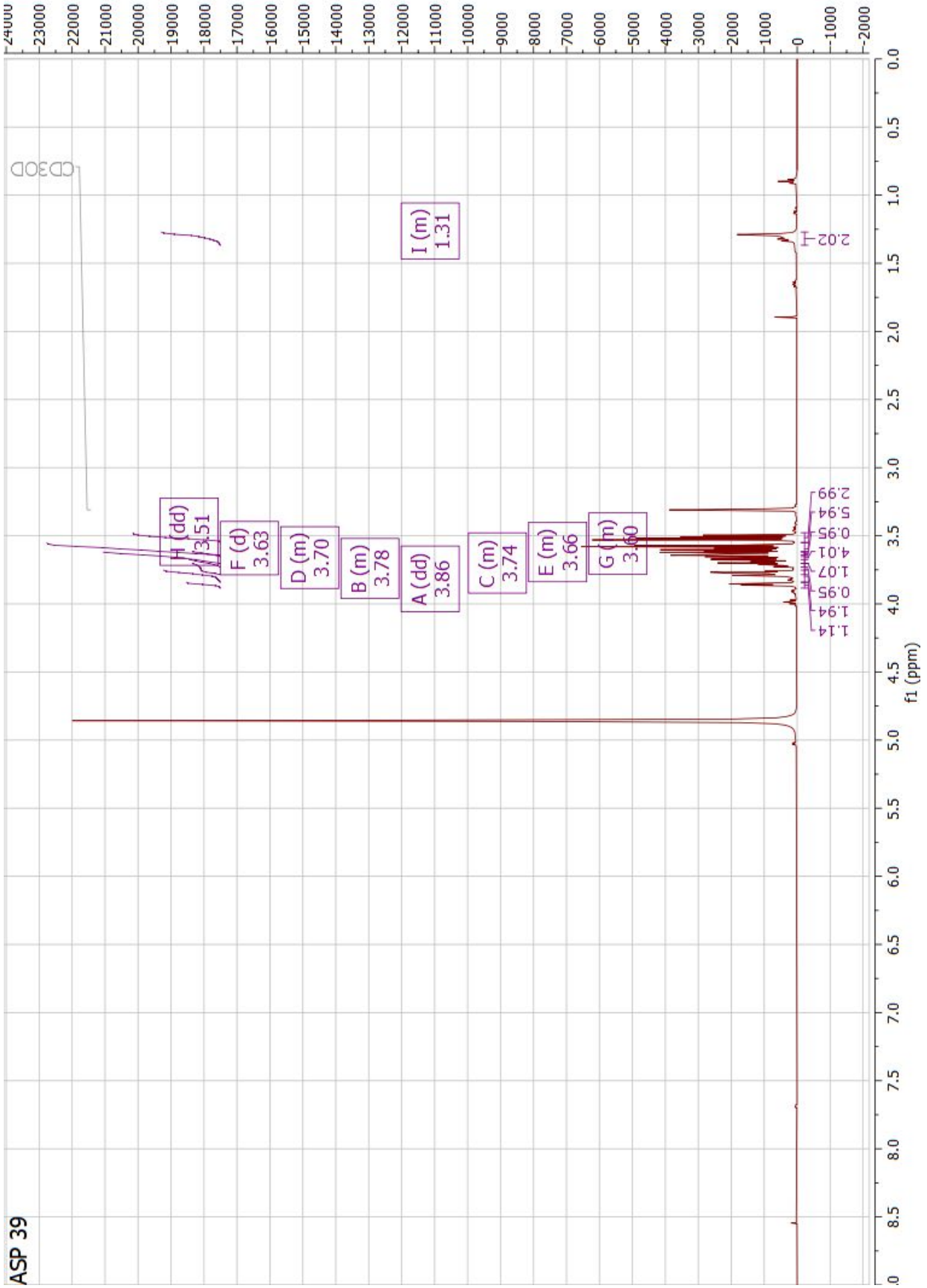



**Figure S44.** Labelled $^{1}H$ NMR of ASP39 in $CD_3OD$.

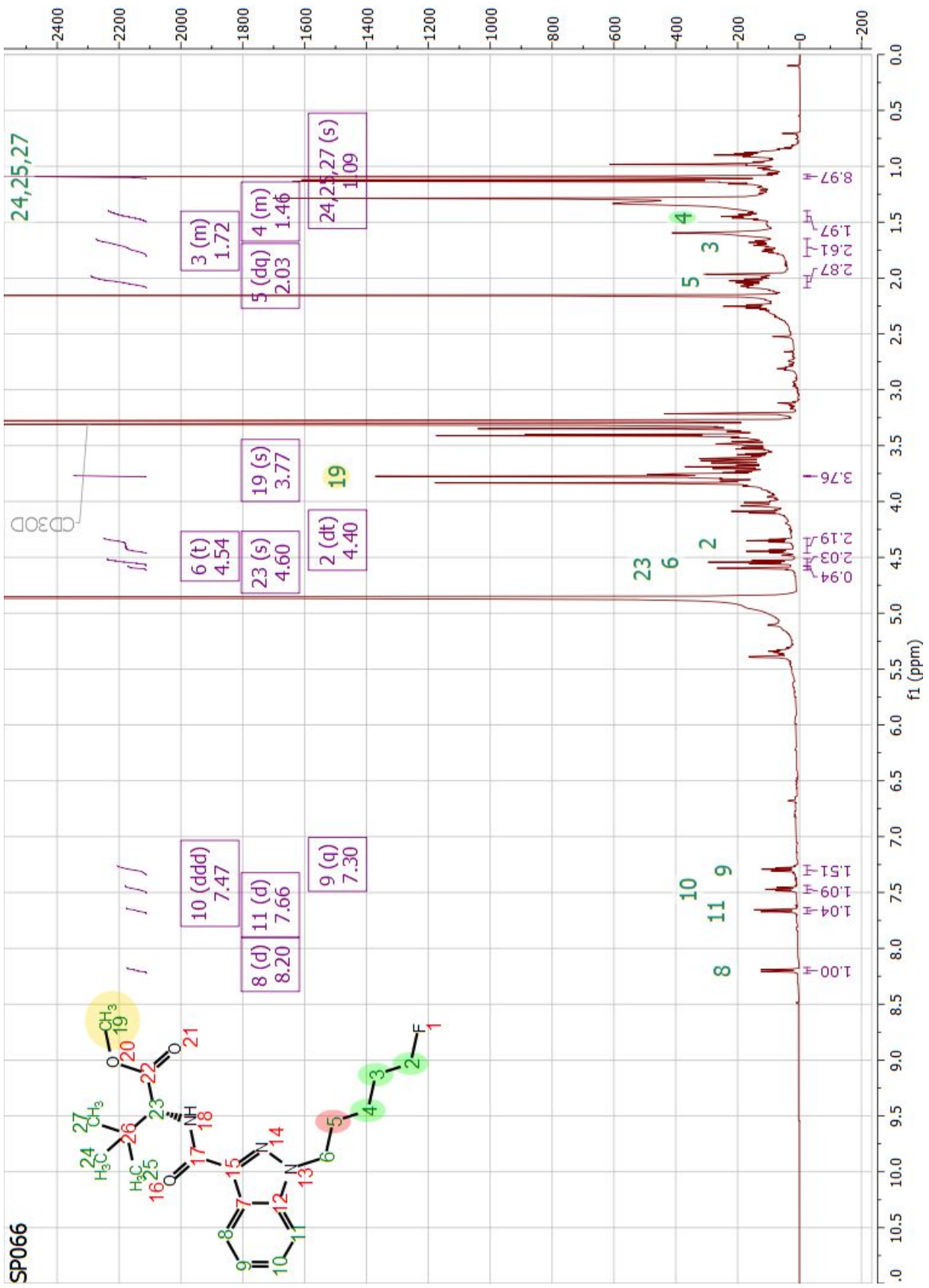



**Figure S45.** Labelled $^{1}H$ NMR of SP066 in $CD_3OD$.

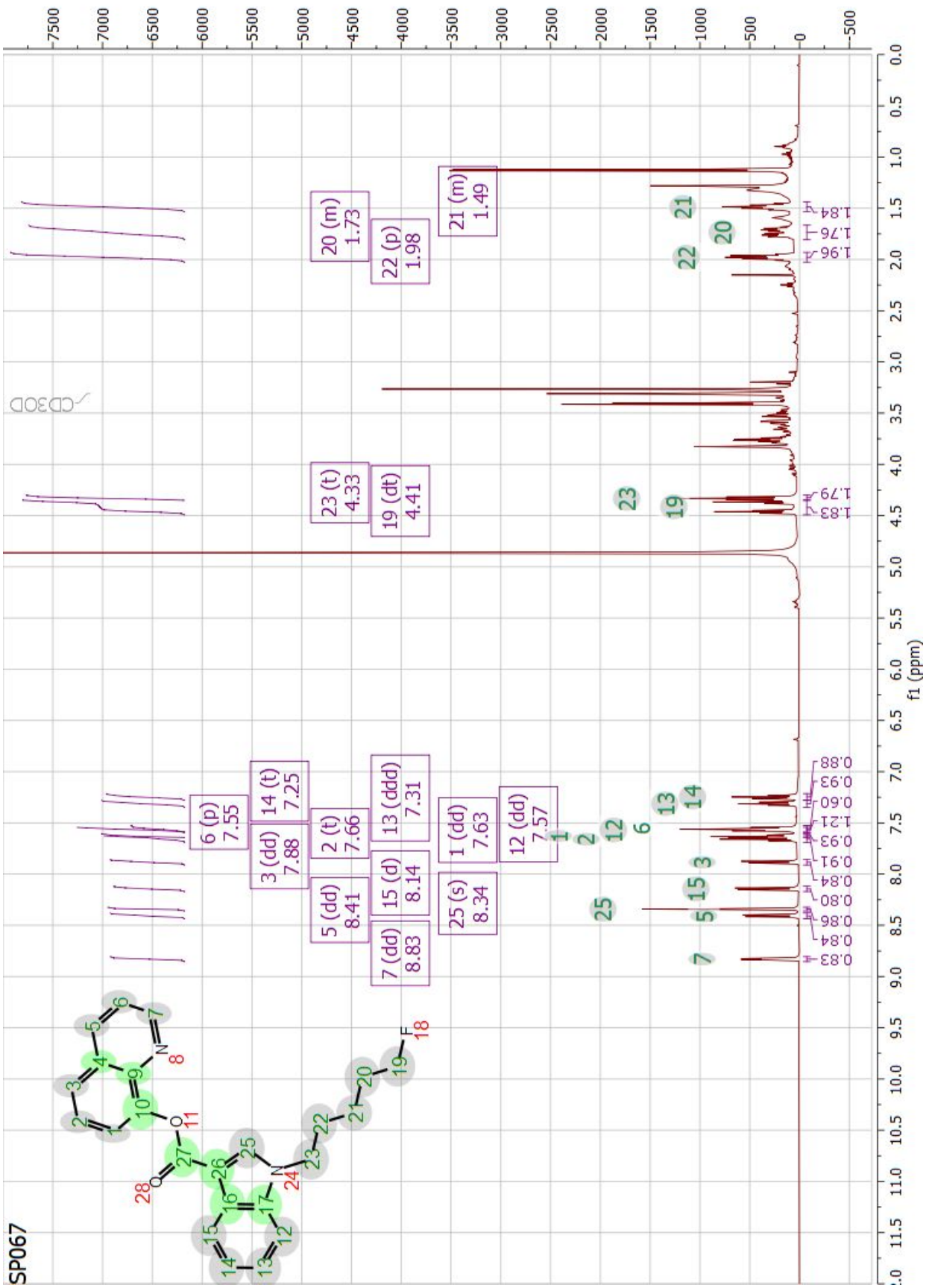



**Figure S46.** Labelled $^{1}H$ NMR of SP067 in $CD_3OD$.

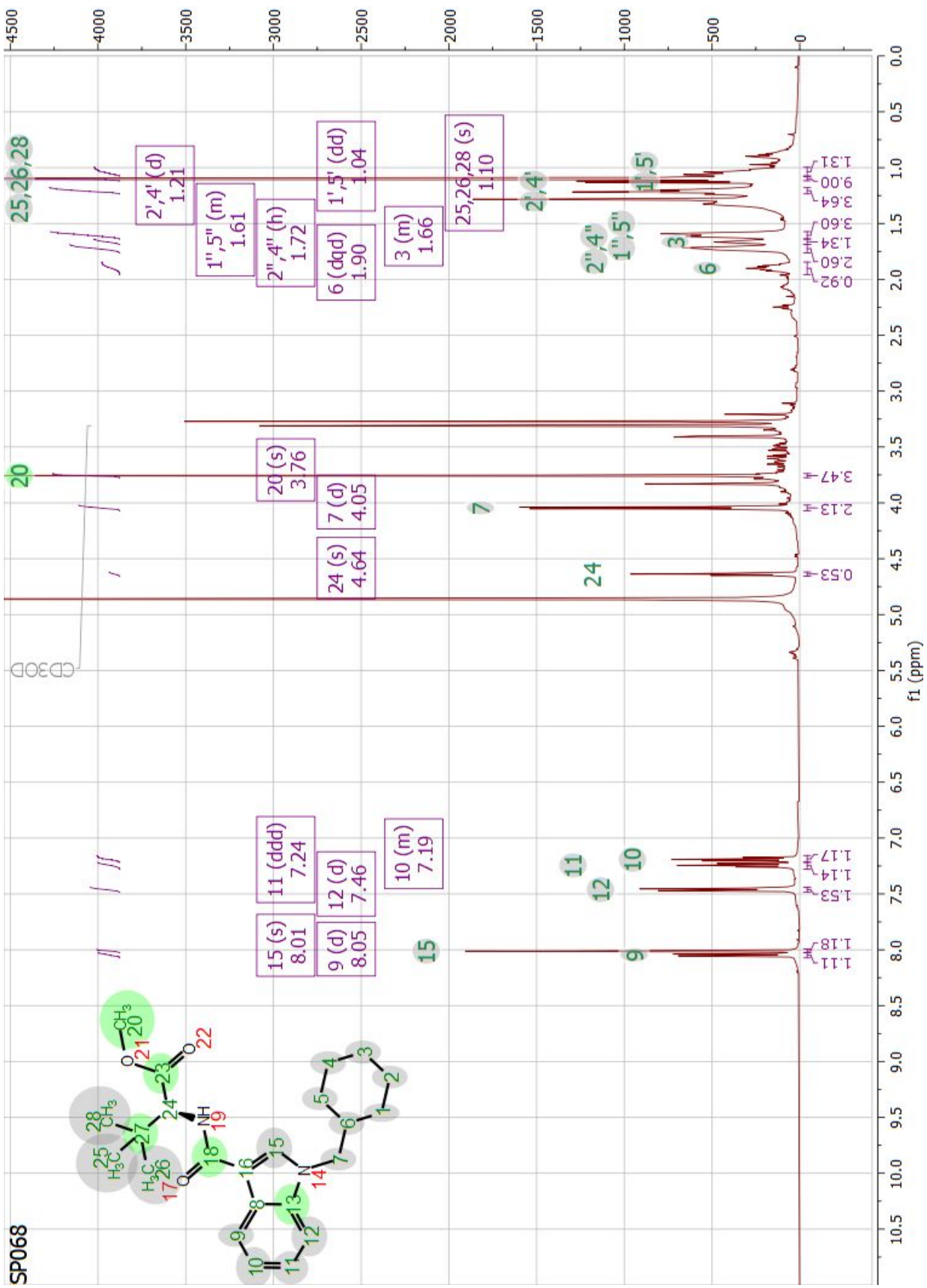



**Figure S47.** Labelled $^{1}H$ NMR of SP068 in $CD_3OD$.

**ASP2:** 5F-MDMB-PINACA

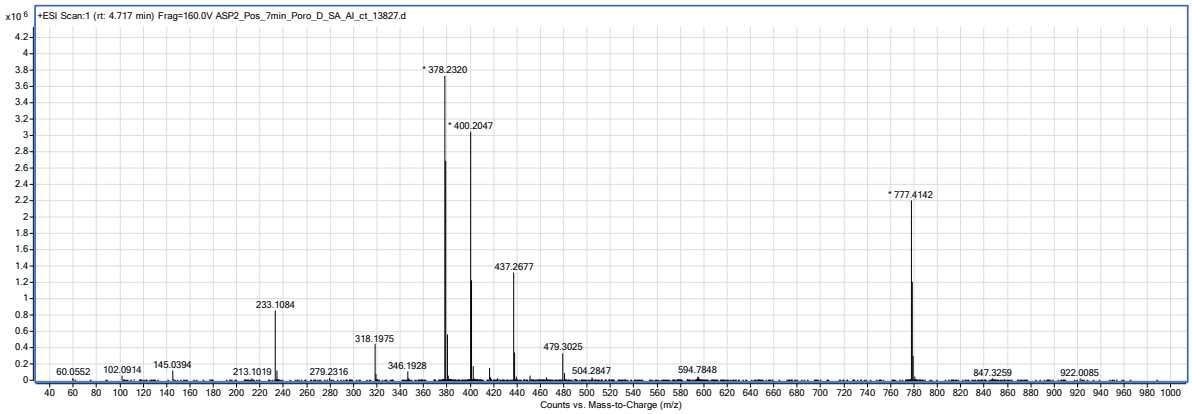
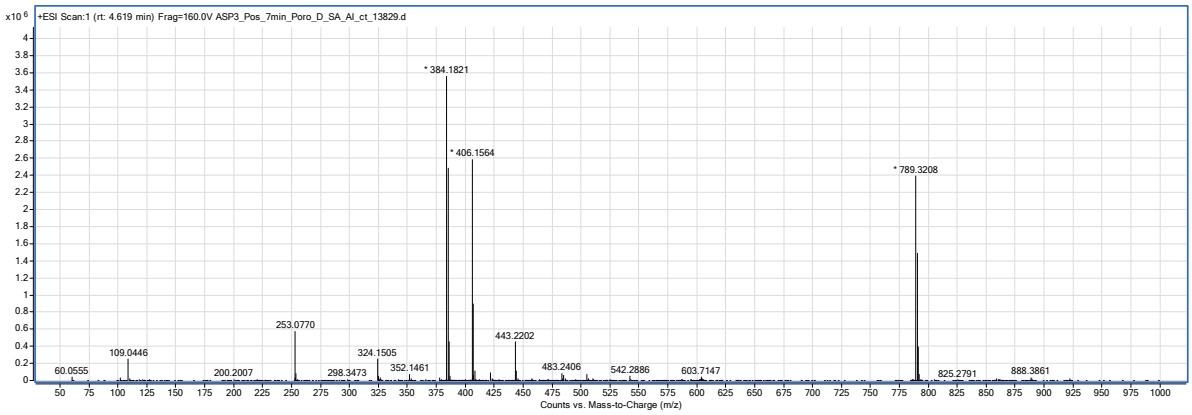



**Figure S48.** Extracted Mass Spectra from LC-MS Analysis for ASP2.

**ASP3:** AMB-FUBINACA




5F-MDMB-PINACA

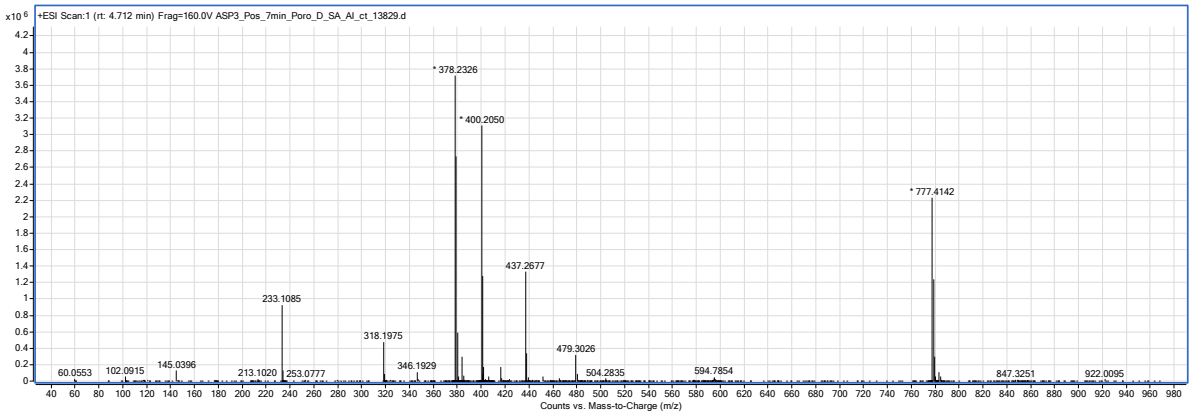



**Figure S49.** Extracted Mass Spectra from LC-MS Analysis for ASP3.

**ASP4:** MDMB-4en-PINACA

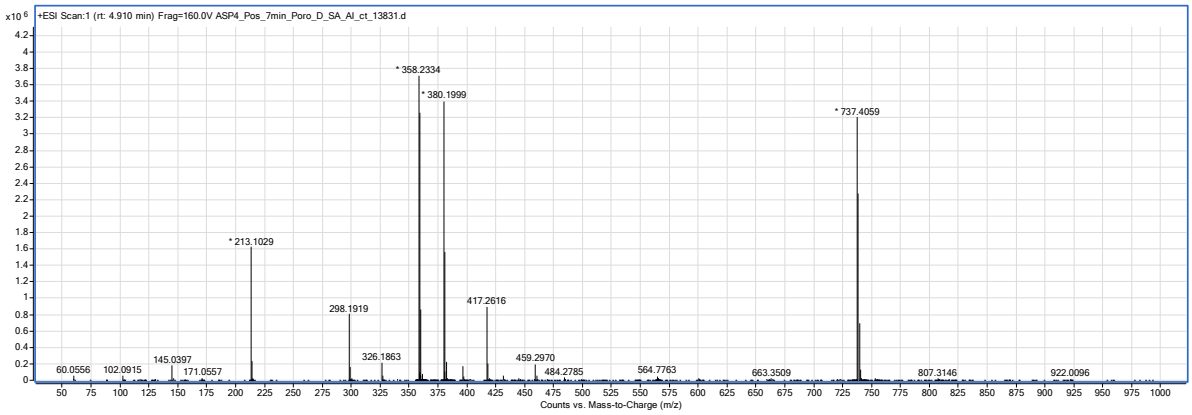



**Figure S50.** Extracted Mass Spectra from LC-MS Analysis for ASP4.

**ASP5:** 5F-MDMB-PICA

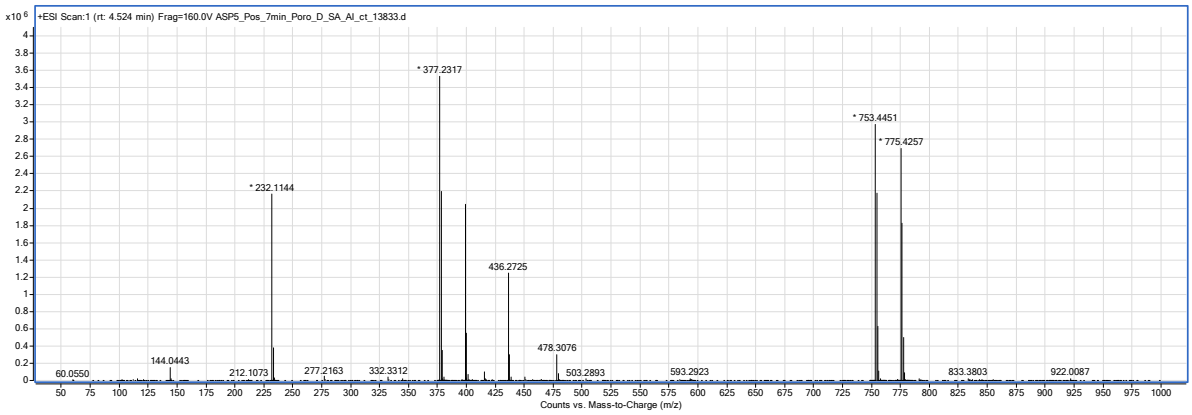



**Figure S51.** Extracted Mass Spectra from LC-MS Analysis for ASP5.

**ASP6:** MDMB-4en-PINACA

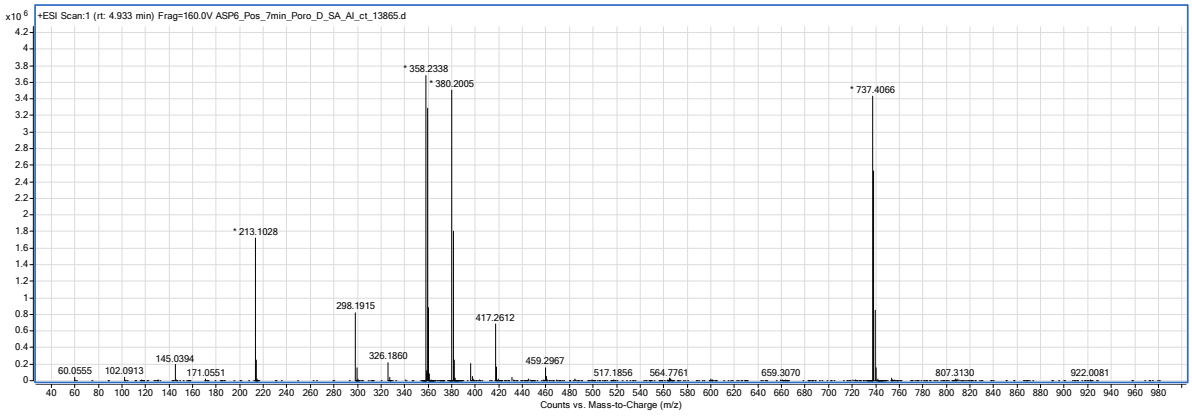



**Figure S52.** Extracted Mass Spectra from LC-MS Analysis for ASP6.

**ASP8:** 4F-MDMB-BINACA

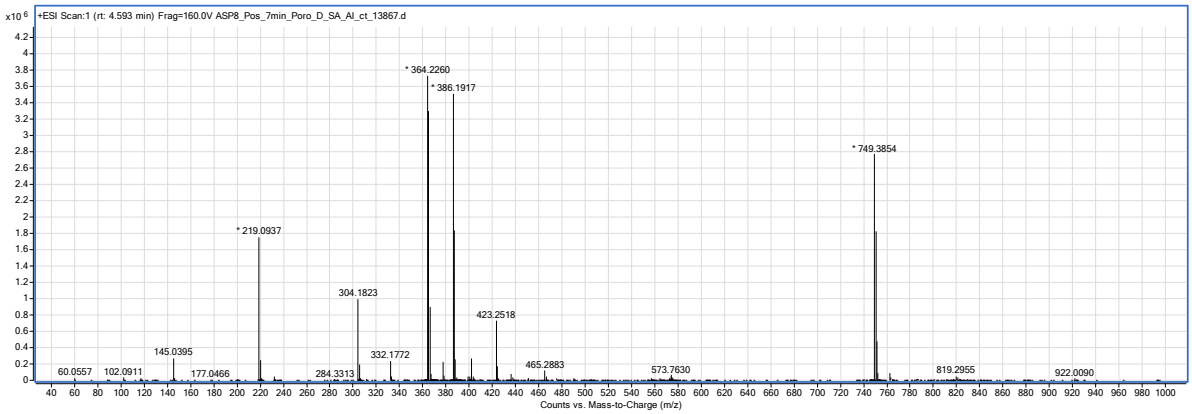



**Figure S53.** Extracted Mass Spectra from LC-MS Analysis for ASP8.

**ASP11:** MDMB-4en-PINACA

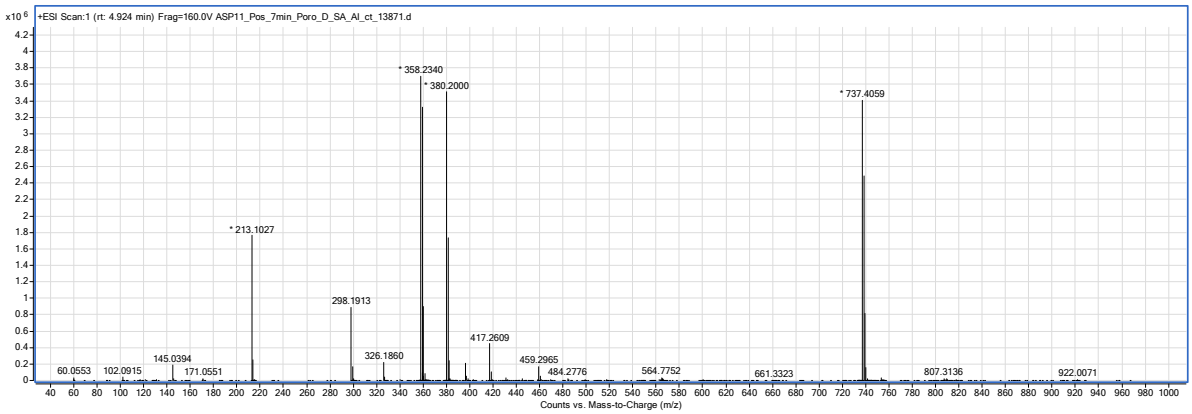



**Figure S54.** Extracted Mass Spectra from LC-MS Analysis for ASP11.

**ASP12:** MDMB-4en-PINACA

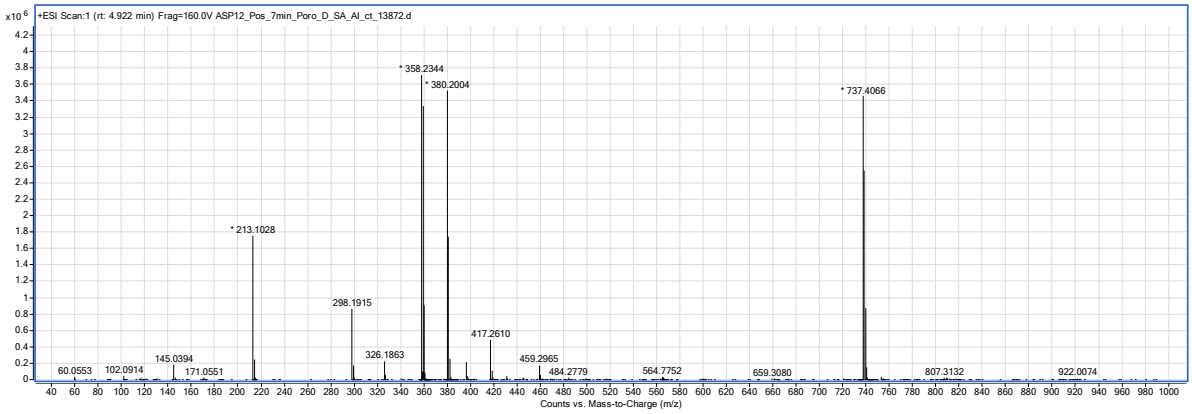



**Figure S55.** Extracted Mass Spectra from LC-MS Analysis for ASP12.

**ASP13:** MDMB-4en-PINACA

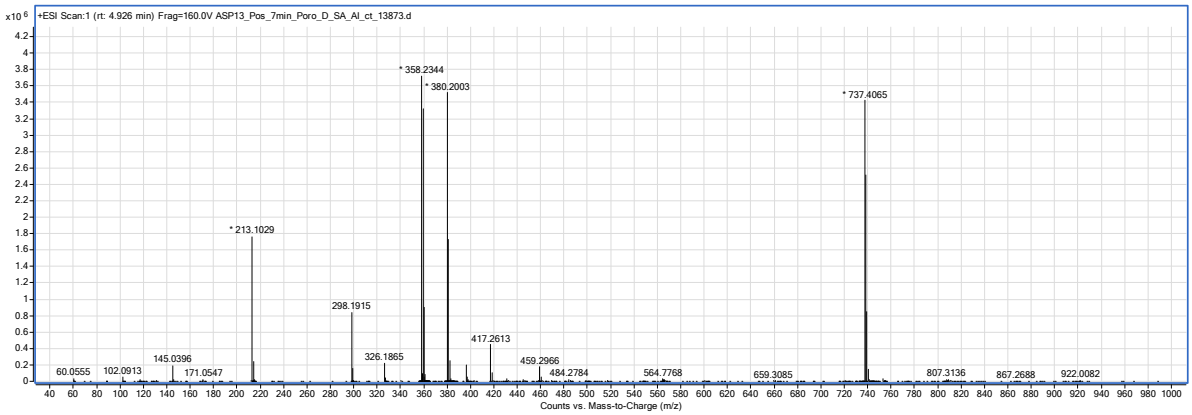



**Figure S56.** Extracted Mass Spectra from LC-MS Analysis for ASP13.

**ASP14:** 5F-MDMB-PINACA

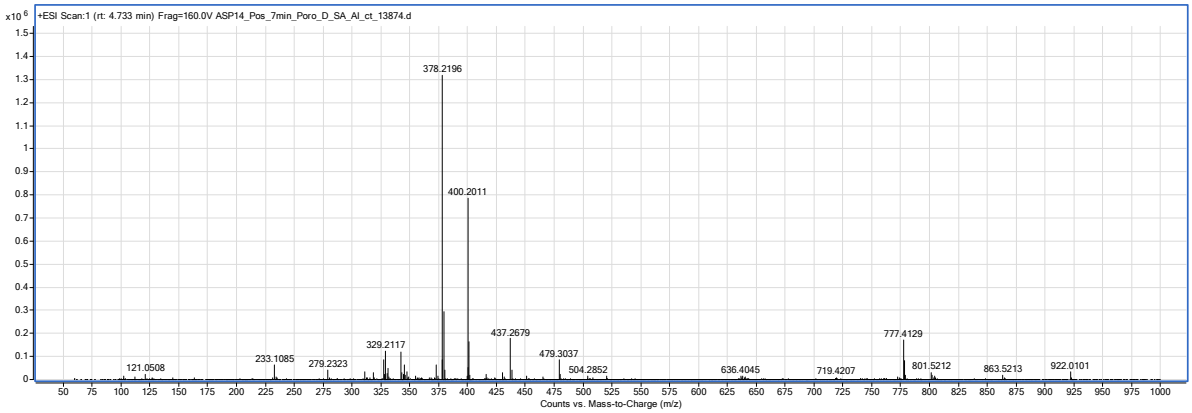



**Figure S57.** Extracted Mass Spectra from LC-MS Analysis for ASP14.

**ASP15:** 5F-MDMB-PINACA

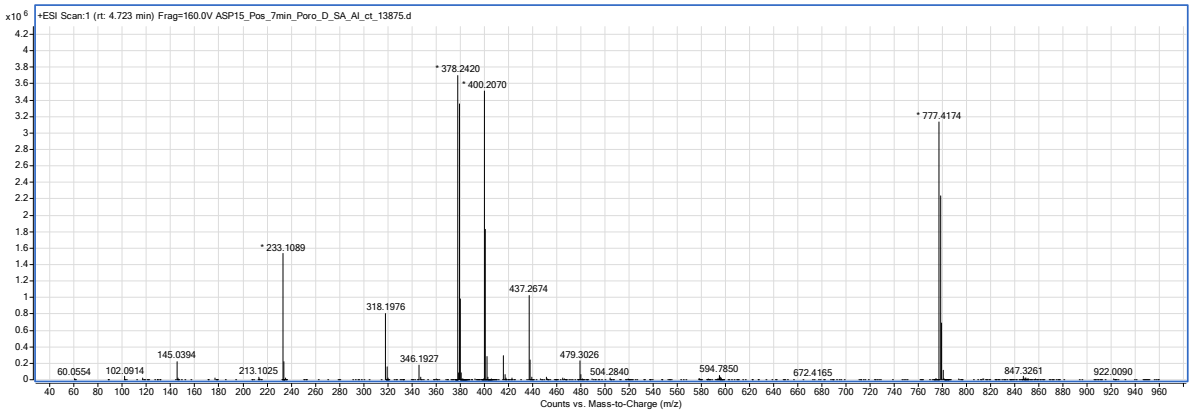



**Figure S58.** Extracted Mass Spectra from LC-MS Analysis for ASP15.

**ASP16:** 5F-MDMB-PINACA

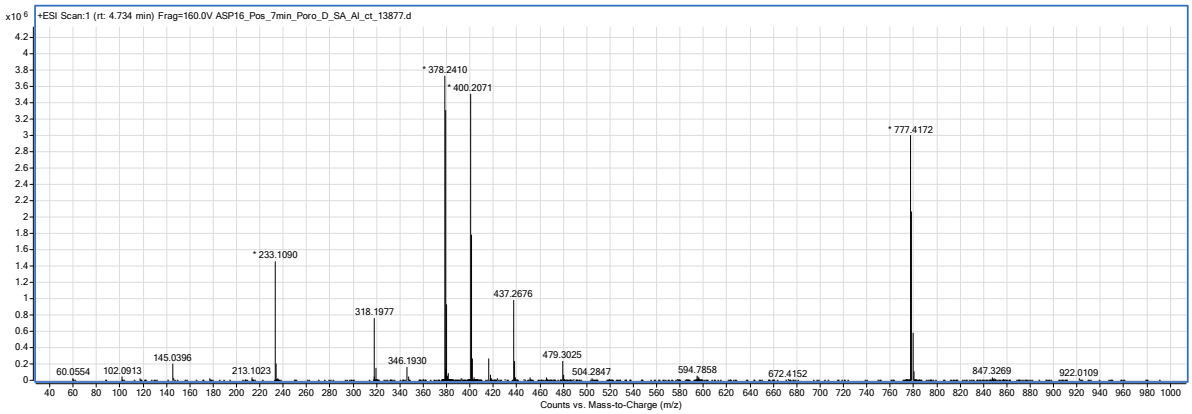



**Figure S59.** Extracted Mass Spectra from LC-MS Analysis for ASP16.

**ASP17:** 5F-MDMB-PINACA

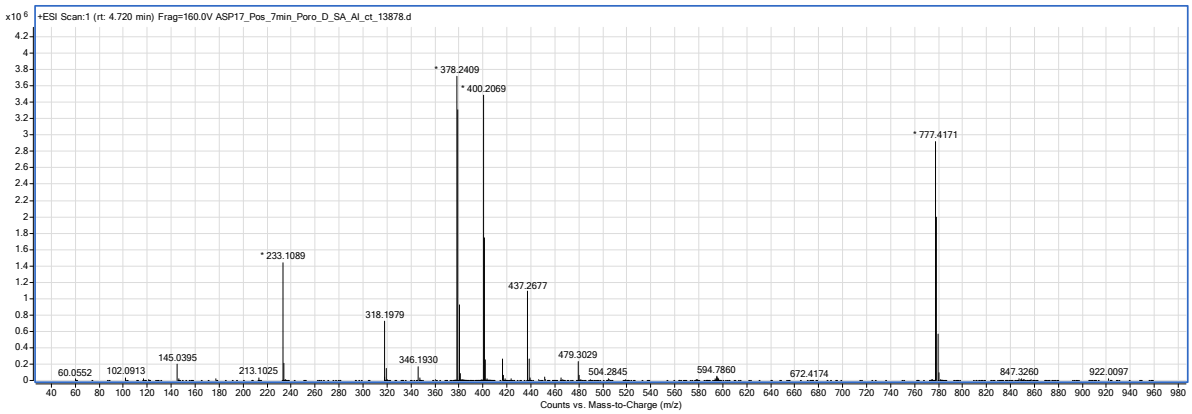
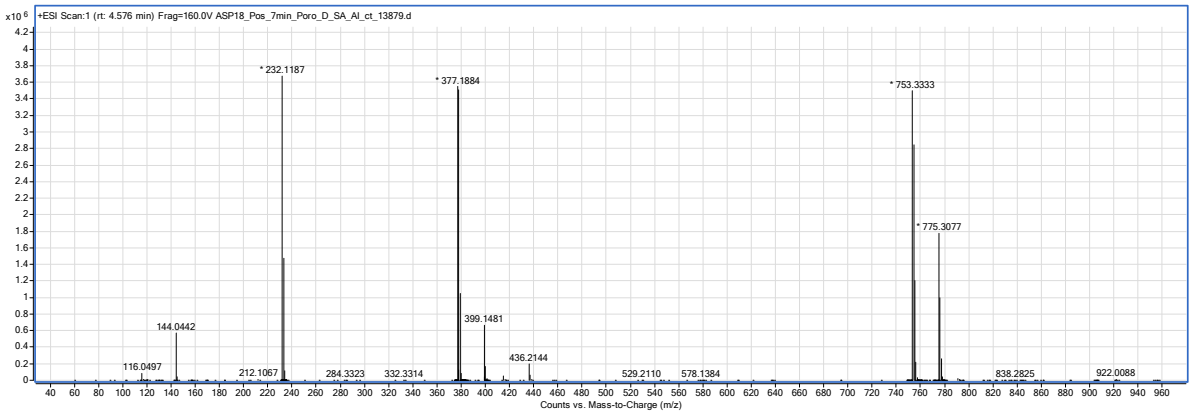



**Figure S60.** Extracted Mass Spectra from LC-MS Analysis for ASP17.

**ASP18:** 5F-PB-22




5F-AKB-48

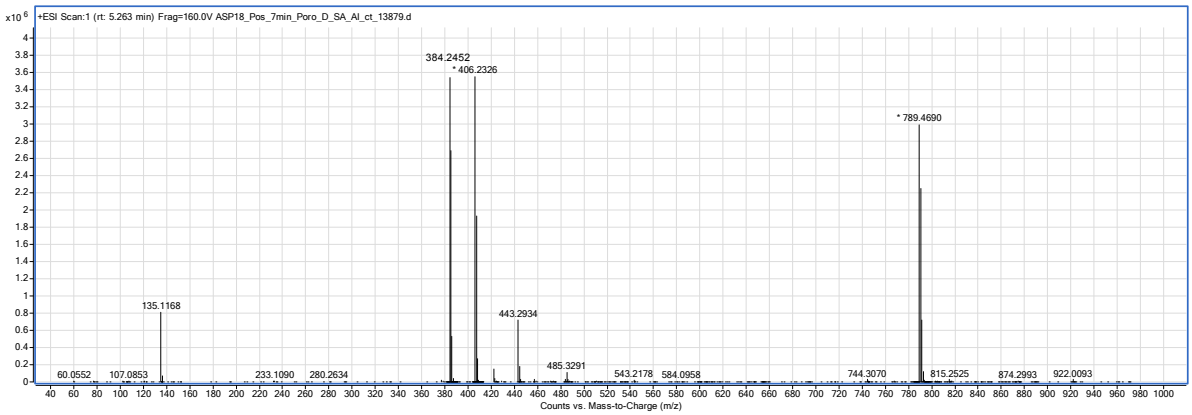
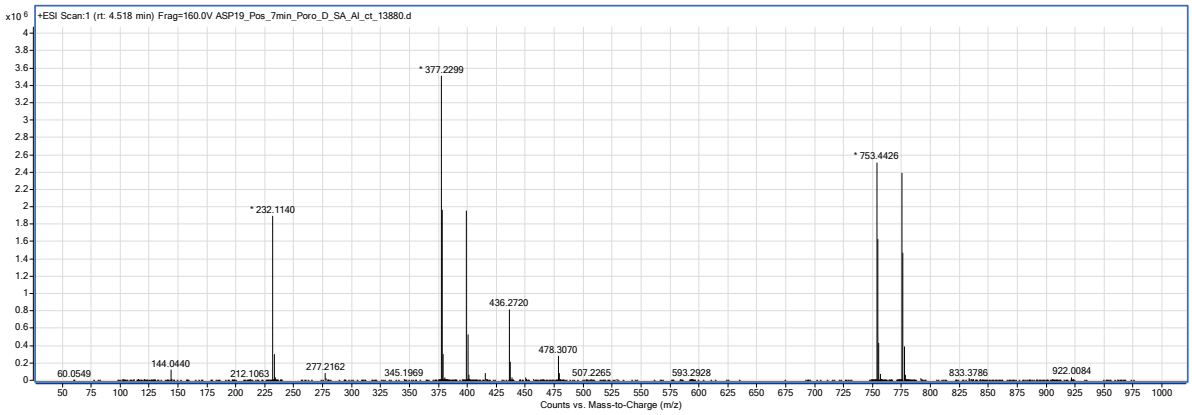
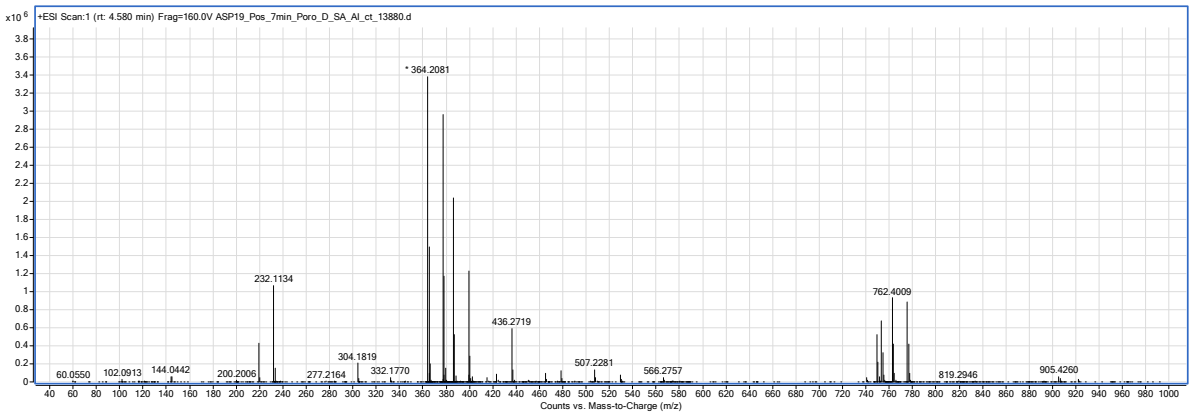



**Figure S61.** Extracted Mass Spectra from LC-MS Analysis for ASP18.

**ASP19:** 5F-MDMB-PICA




5F-AMB-PINACA




MDMB-4en-PINACA

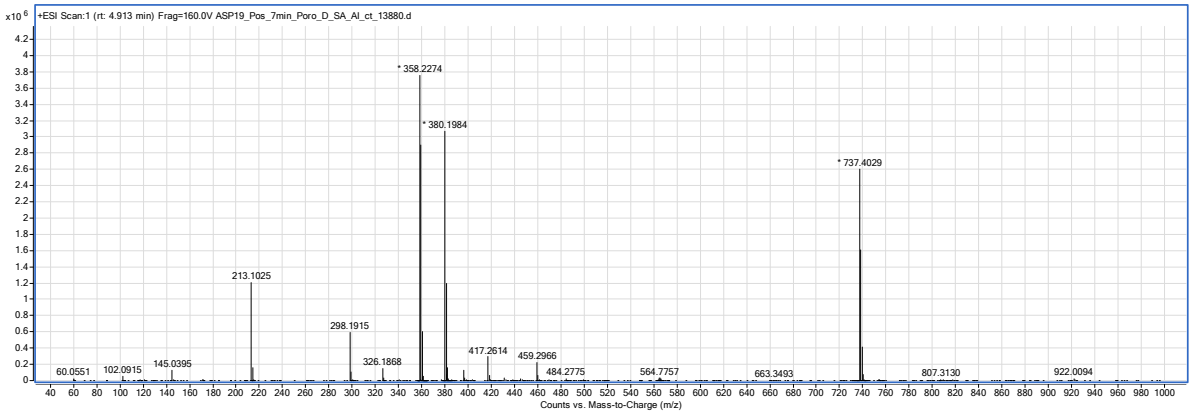



**Figure S62.** Extracted Mass Spectra from LC-MS Analysis for ASP19.

**ASP22:** MDMB-4en-PINACA

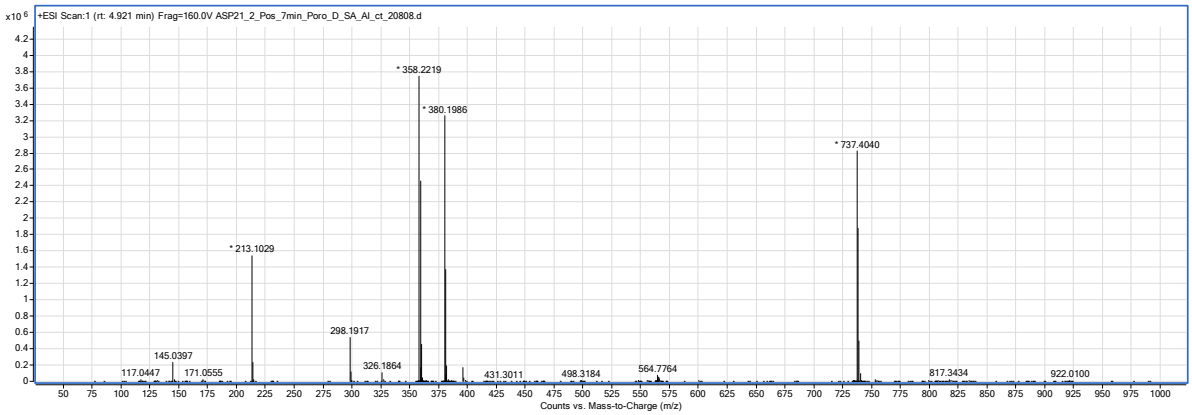



**Figure S63.** Extracted Mass Spectra from LC-MS Analysis for ASP22.

**ASP23:** MDMB-4en-PINACA

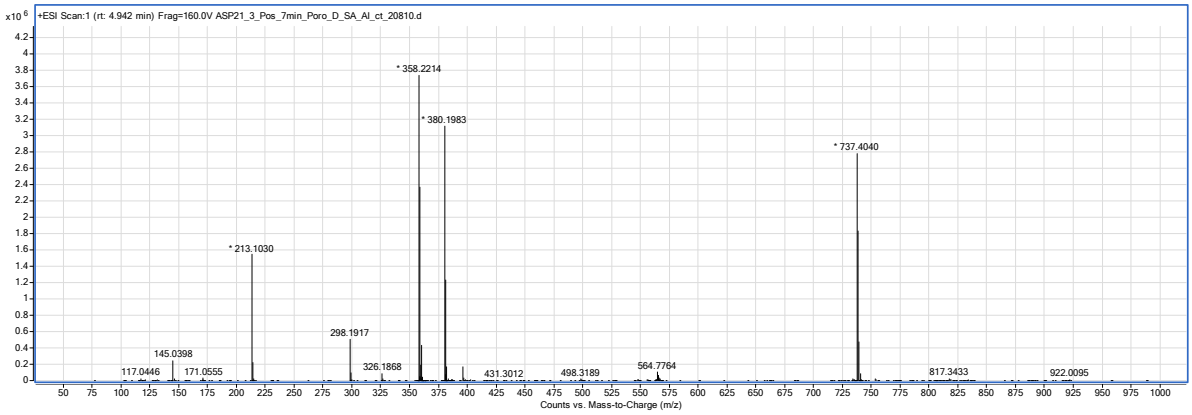



**Figure S64.** Extracted Mass Spectra from LC-MS Analysis for ASP23.

**ASP24:** MDMB-4en-PINACA

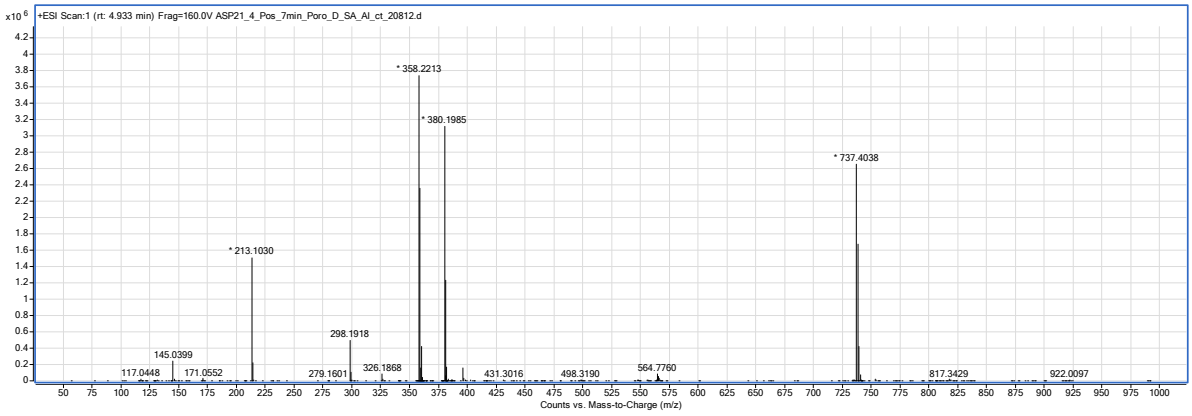
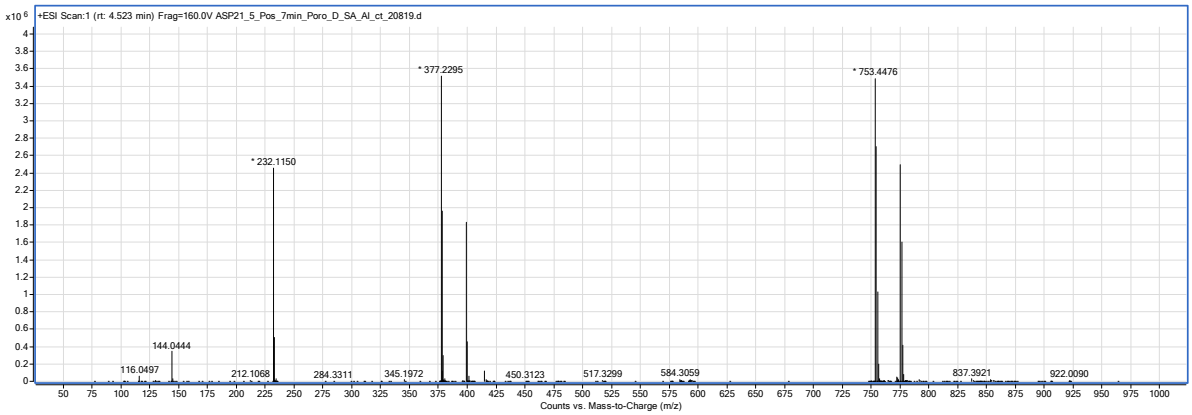



**Figure S65.** Extracted Mass Spectra from LC-MS Analysis for ASP24.

**ASP25:** 5F-MDMB-PICA




4F-MDMB-BINACA

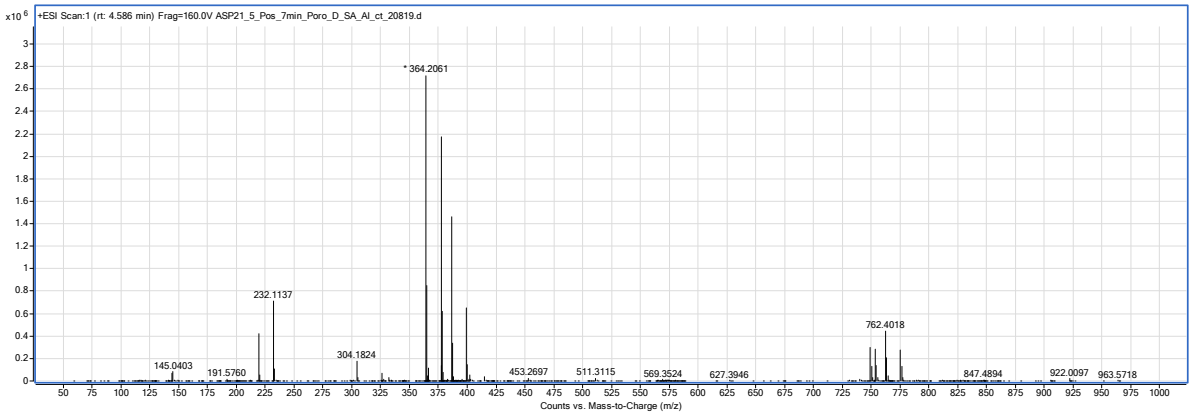



**Figure S66.** Extracted Mass Spectra from LC-MS Analysis for ASP25.

**ASP26:** MDMB-4en-PINACA

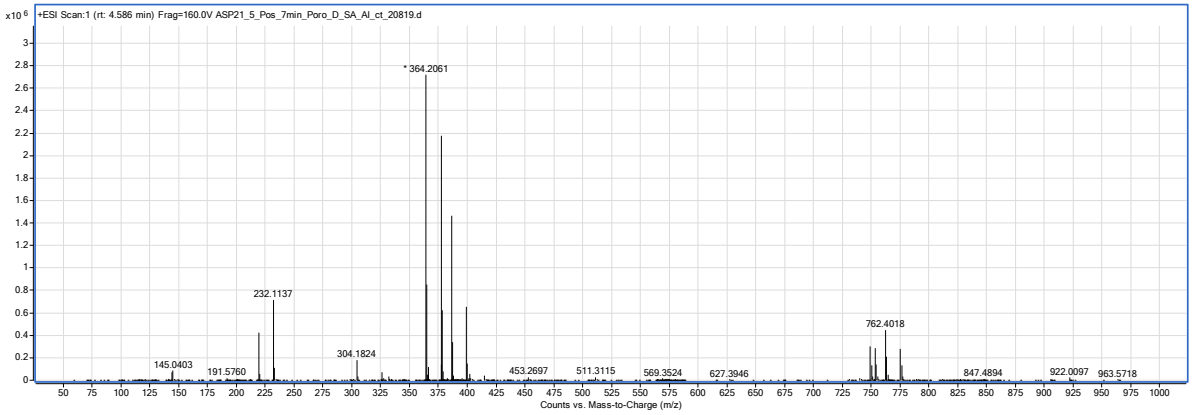
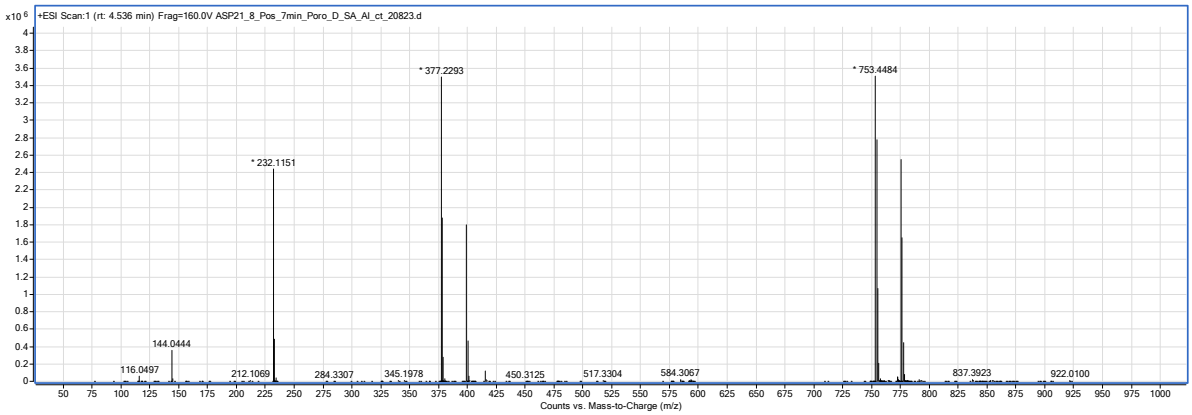
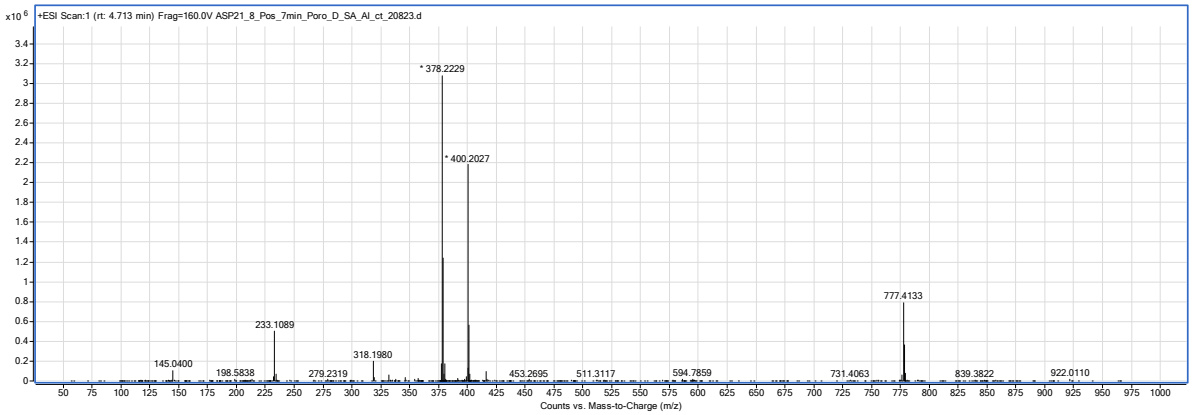



**Figure S67.** Extracted Mass Spectra from LC-MS Analysis for ASP26.

**ASP28:** 5F-MDMB-PICA




5F-MDMB-PINACA




FUB-144

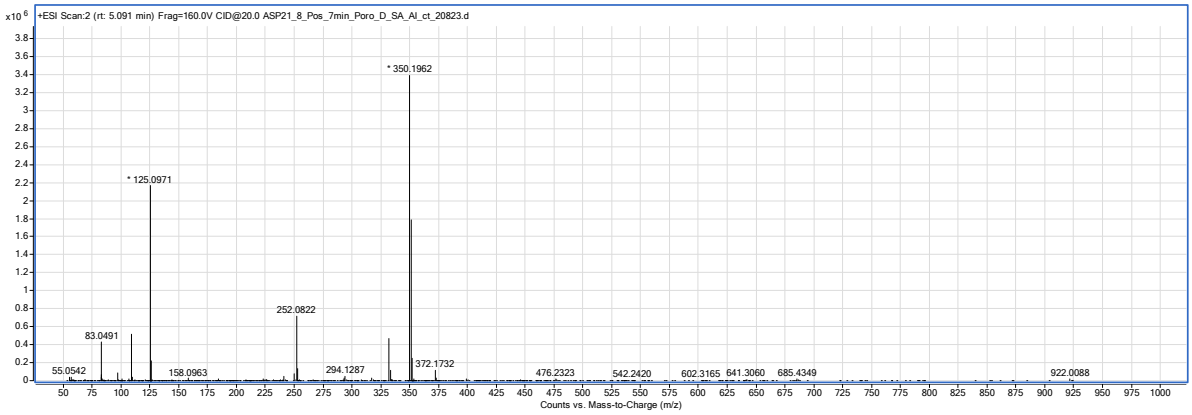



**Figure S68.** Extracted Mass Spectra from LC-MS Analysis for ASP28.

**ASP29:** MDMB-4en-PINACA

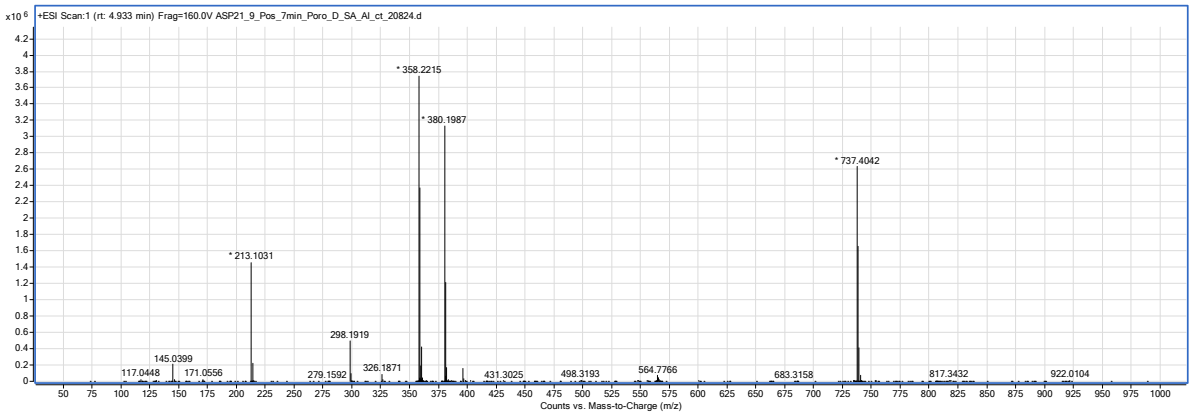
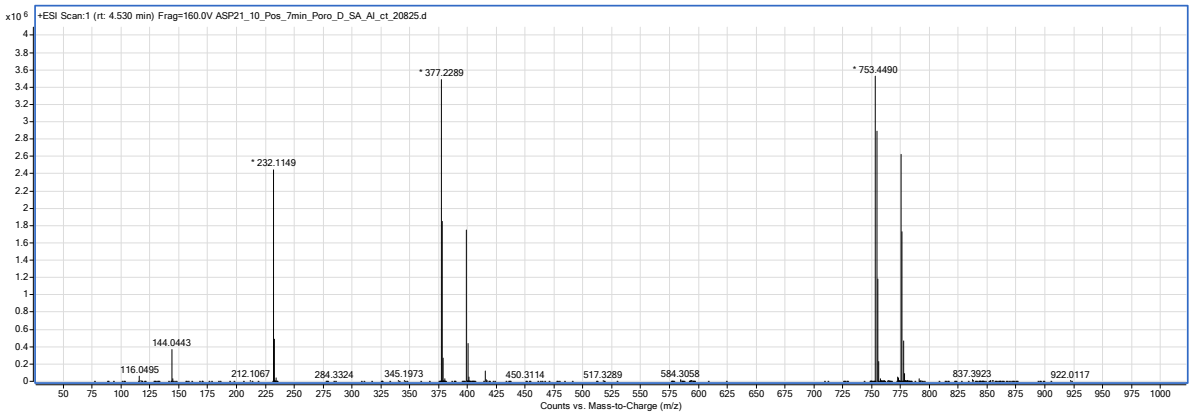
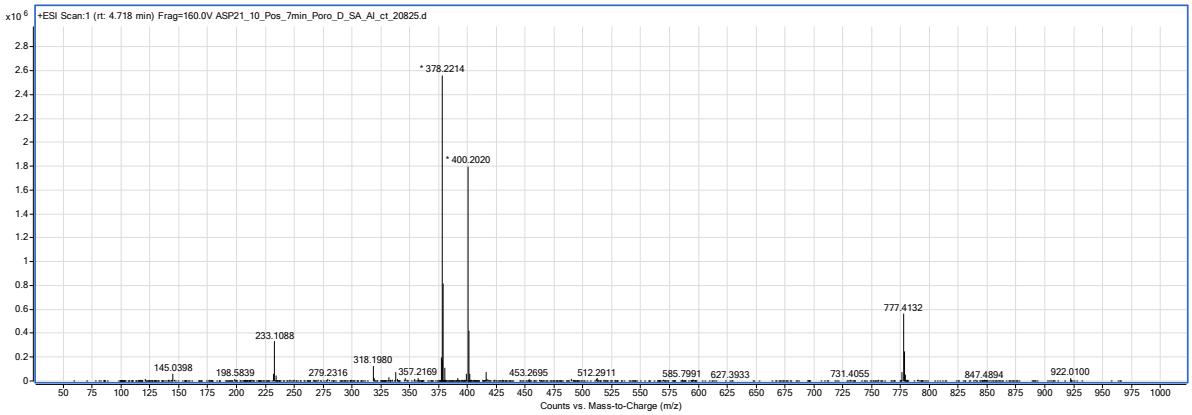



**Figure S69.** Extracted Mass Spectra from LC-MS Analysis for ASP29.

**ASP30:** 5F-MDMB-PICA




5F-MDMB-PINACA




FUB-144

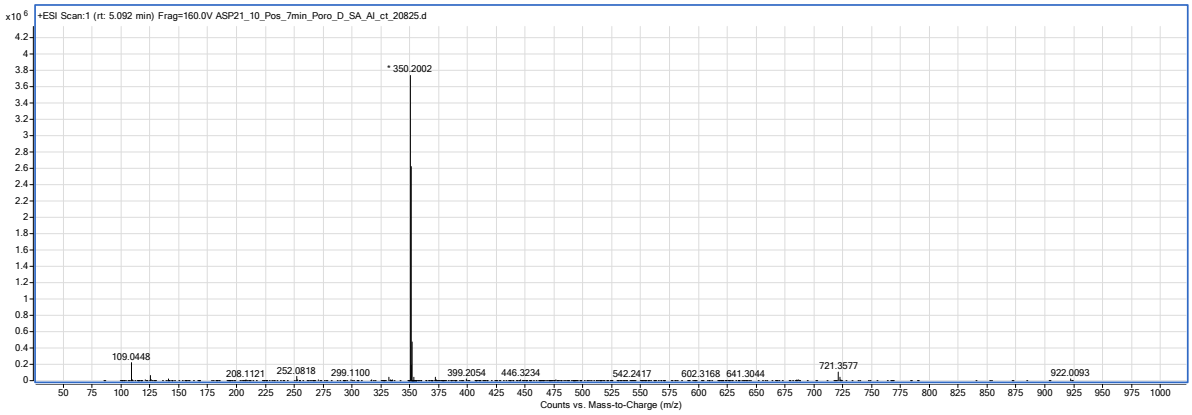



**Figure S70.** Extracted Mass Spectra from LC-MS Analysis for ASP30.

## Tables

**Table S1.** Summary results for the confirmatory analysis using the combined TLC, NMR and LC-MS workflow. Only controlled substances are listed. Compounds that were detected in LC-MS but not identified in the NMR have been indicated with an Asterix (*).

| Sample | Workflow Results |
|---|---|
| ASP 1 | -- |
| ASP 2 | 5F-MDMB-PINACA |
| ASP 3 | 5F-MDMB-PINACA, AMB-FUBINACA |
| ASP 4 | MDMB-4en-PINACA |
| ASP 5 | 5F-MDMB-PICA |
| ASP 6 | MDMB-4en-PINACA |
| ASP 7 | -- |
| ASP 8 | 4F-MDMB-BINACA |
| ASP 9 | Cannabis* |
| ASP 10 | -- |
| ASP 11 | MDMB-4en-PINACA |
| ASP 12 | MDMB-4en-PINACA |
| ASP 13 | MDMB-4en-PINACA |
| ASP 14 | Cannabis*, 5F-MDMB-PINACA* |
| ASP 15 | 5F-MDMB-PINACA |
| ASP 16 | 5F-MDMB-PINACA |
| ASP 17 | 5F-MDMB-PINACA |
| ASP 18 | 5F-PB-22, 5F-AKB48 |
| ASP 19 | MDMB-4en-PINACA, 5F-MDMB-PICA, 5F-AMB-PINACA* |
| ASP 20 | -- |
| ASP 21 | -- |
| ASP 22 | MDMB-4en-PINACA |
| ASP 23 | MDMB-4en-PINACA |
| ASP 24 | MDMB-4en-PINACA |
| ASP 25 | 5F-MDMB-PICA, 4F-MDMB-BINACA |
| ASP 26 | MDMB-4en-PINACA |

| | |
|---|---|
| **ASP 27** | -- |
| **ASP 28** | 5F-MDMB-PICA, FUB-144, 5F-MDMB-PINACA* |
| **ASP 29** | MDMB-4en-PINACA |
| **ASP 30** | 5F-MDMB-PICA, FUB-144, 5F-MDMB-PINACA* |
| **SP066** | 5F-ADB |
| **SP067** | 5F-PB-22 |
| **SP068** | MDMB-CHMICA |
| **ASP 31** | -- |
| **ASP 32** | -- |
| **ASP 33** | -- |
| **ASP 34** | MDMB-4en-PINACA |
| **ASP 35** | MDMB-4en-PINACA |
| **ASP 36** | -- |
| **ASP 38** | -- |
| **ASP 39** | -- |

**Table S2.** Results of trial of 181 paper (letters, cards etc.) samples seized from prisons highlighting the effect of changing detection threshold.

| | High Sensitivity Threshold (~12% false positive threshold) | High Specificity Threshold (~6% false positive threshold) |
|---|---|---|
| Positive | 50 | 47 |
| False Negative | 14 | 17 |
| Negative | 103 | 110 |
| False Positive | 14 | 7 |