Supplementary Information

A New Strategy for the Synthesis of Nonsymmetrical 3,3'-(Aryl/alkyl-methylene)bis-2-hydroxy-1,4-naphthoquinones and Their Cytotoxic Effects in PC3 Prostate Cancer Cells

Ruan Carlos B. Ribeiro,[#,a] Paula Priscilla de Freitas,[#,b] Caroline S. Moreira,[a] Leonardo G. C. de Moraes,[a] Matheus G. de Moraes,[a] Fernando de C. da Silva,[a] David R. Rocha,[*,a] Etel R. Pereira Gimba[*,a,c] and Vitor F. Ferreira[*,d]

[a]*Instituto de Química, Universidade Federal Fluminense, Campus do Valonguinho, 24020-150 Niterói-RJ, Brazil*

[b]*Coordenação de Pesquisa, Programa de Oncobiologia Celular e Molecular, Instituto Nacional de Câncer, 20231-050 Rio de Janeiro-RJ, Brazil*

[c]*Departamento de Tecnologia Farmacêutica, Faculdade de Farmácia, Universidade Federal Fluminense, Santa Rosa, 24241-002, Niterói-RJ, Brazil*

[d]*Departamento de Ciências da Natureza (RCN), Instituto de Humanidades e Saúde, Universidade Federal Fluminense, 28880-000 Rio de Janeiro-RJ, Brazil*

*e-mail: davidrrocha@uol.com.br; etelgimba@id.uff.br; vitorferreira@id.uff.br

[#]These authors equally contributed on performing the experiments described in this manuscript.

*These authors equally contributed to this work and are co-senior authors.

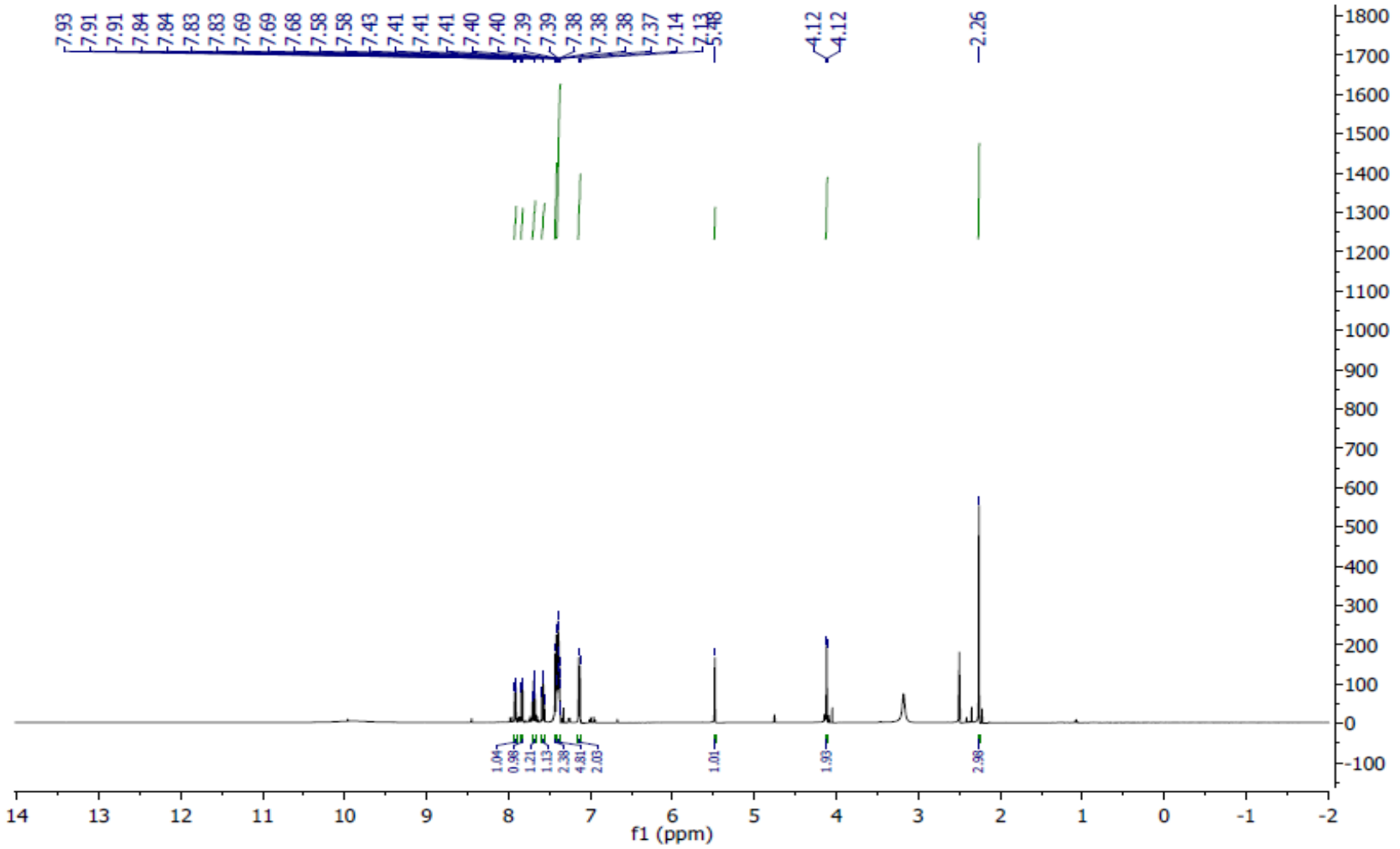

Figure S1. [1]H NMR spectrum (500 MHz, DMSO-d_6) of compound **13b**.

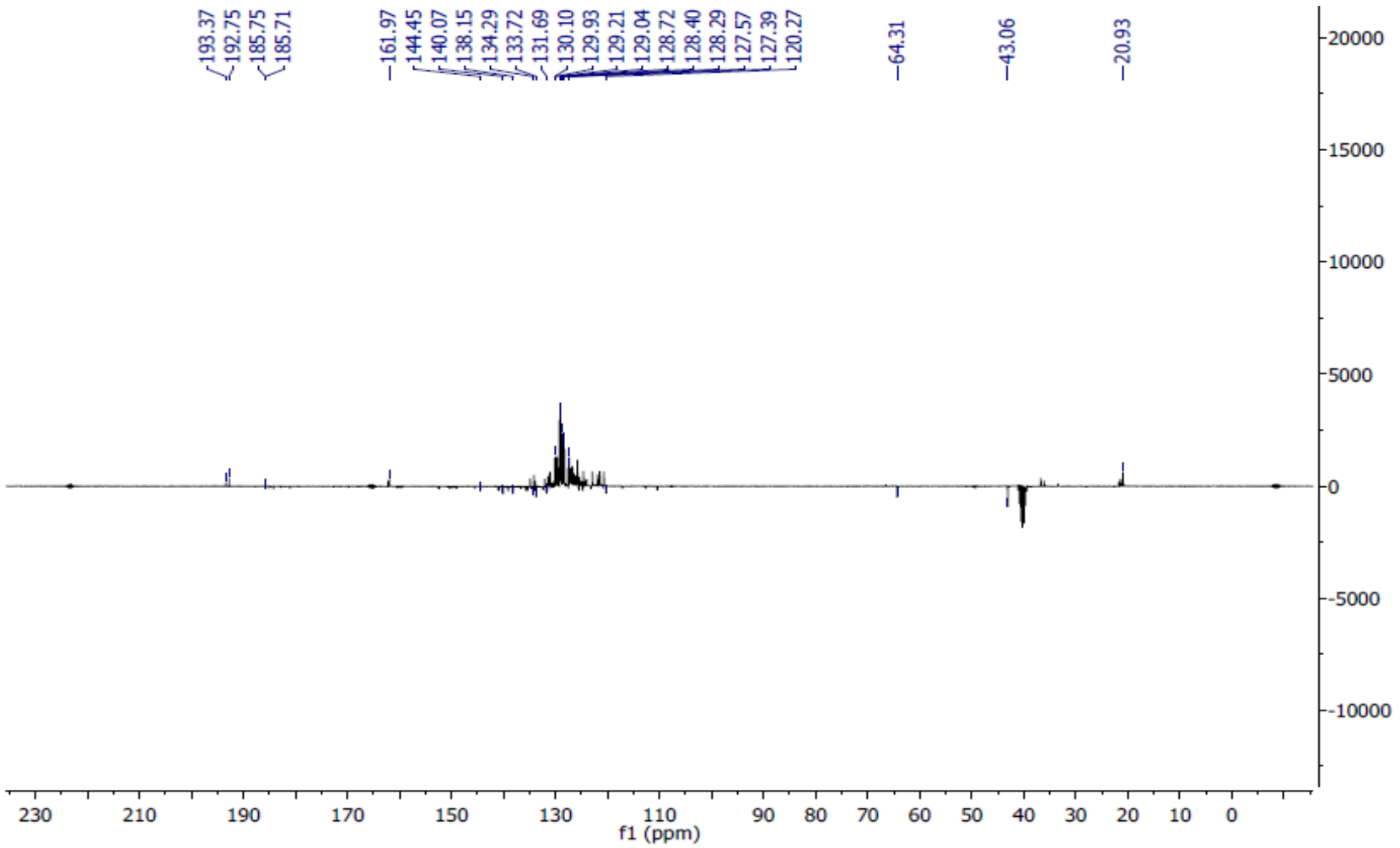

Figure S2. ^{13}C NMR spectrum (75 MHz, DMSO-d_6) of compound **13b**.

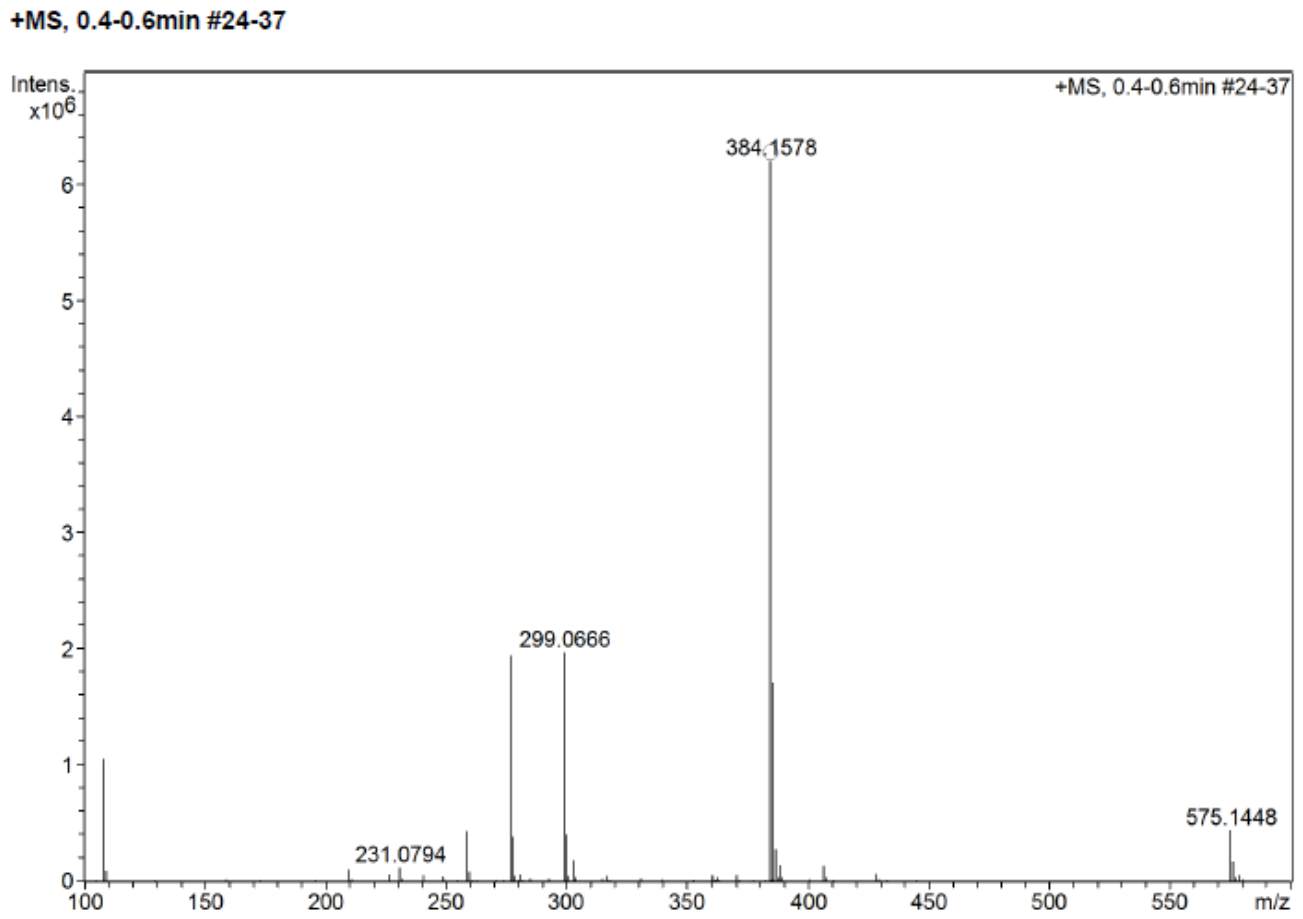

Figure S3. Mass spectrum of compound **13b**.

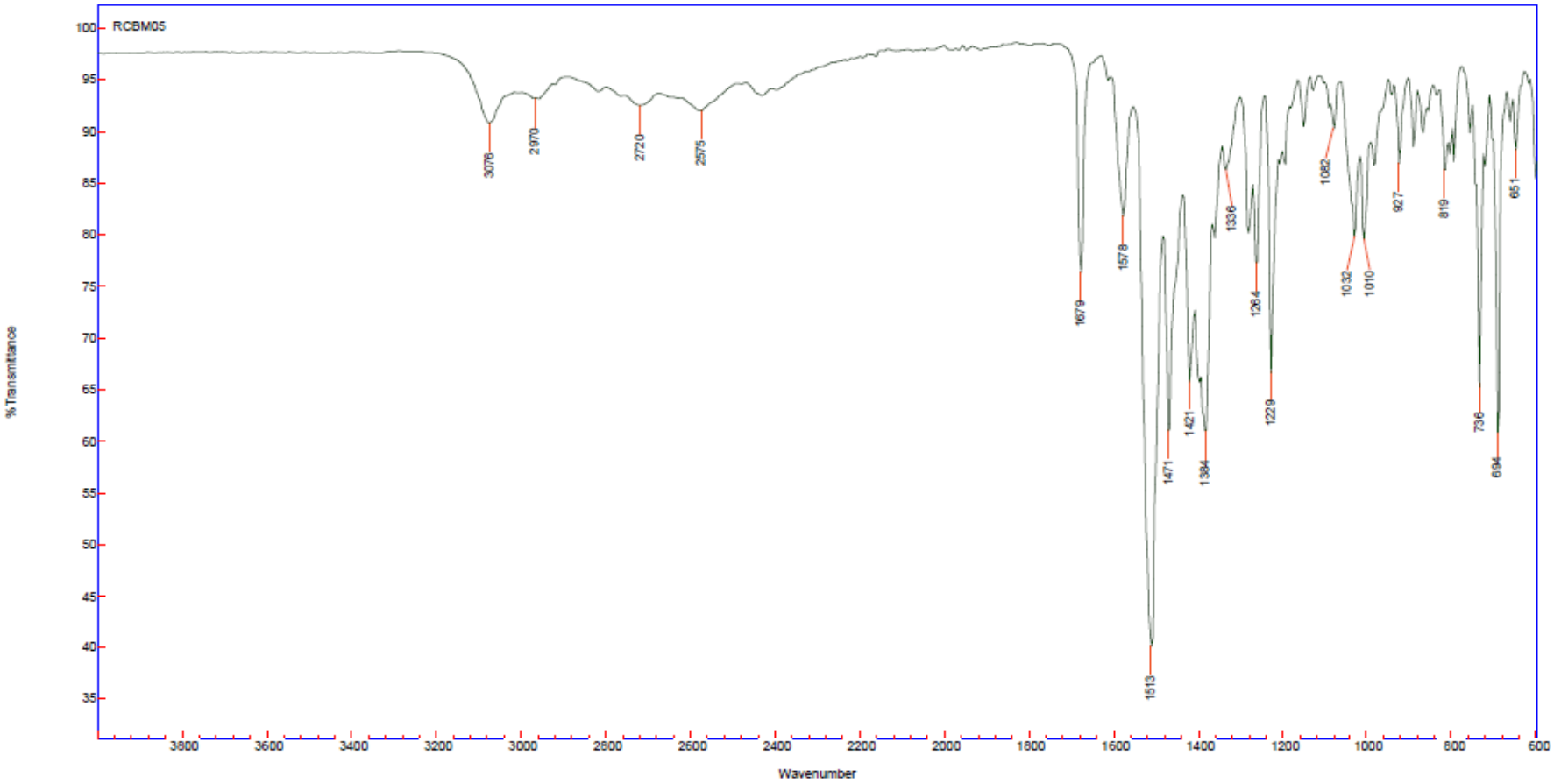

Figure S4. FTIR (KBr) spectrum of compound **13b**.

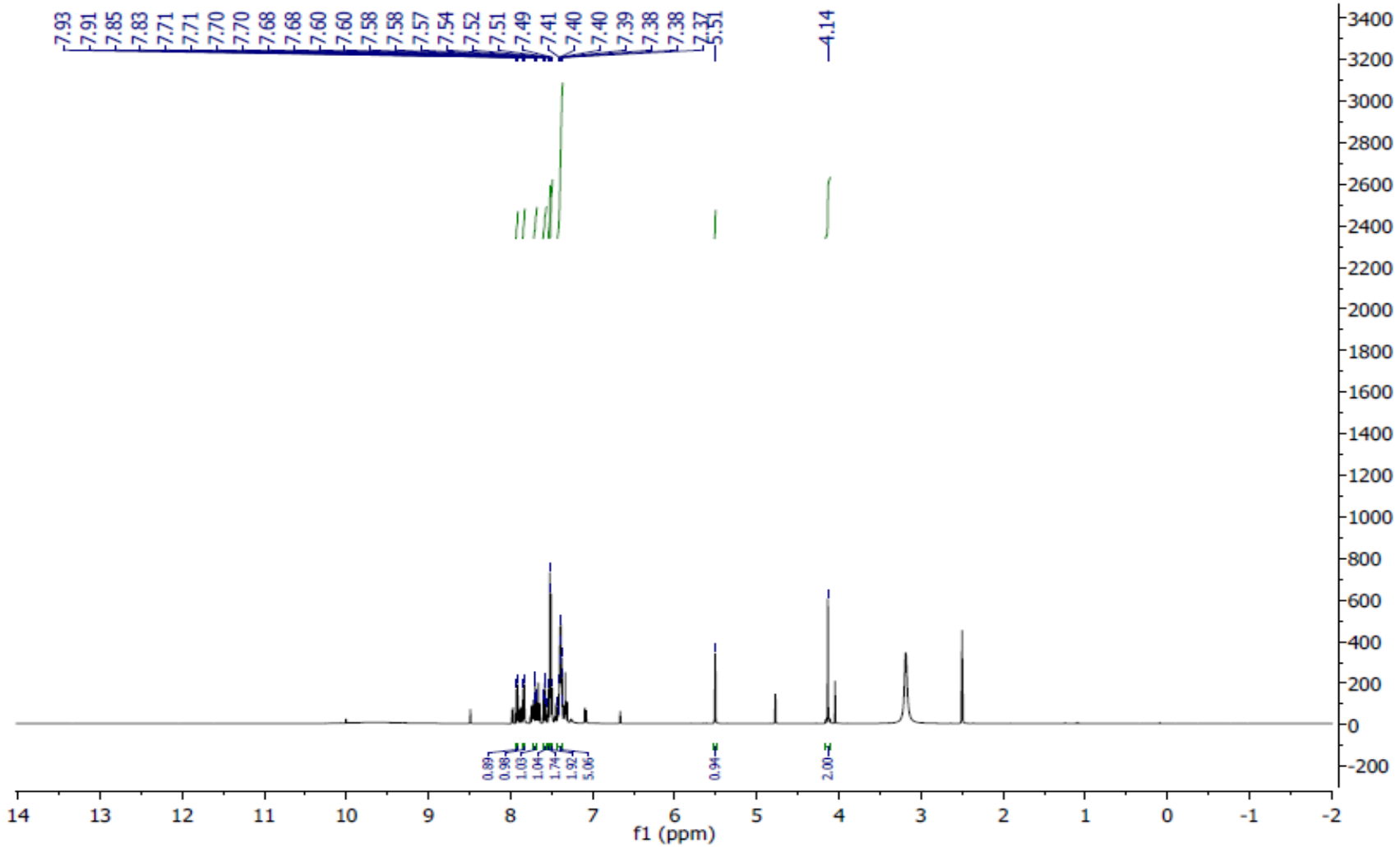

Figure S5. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **13c**.

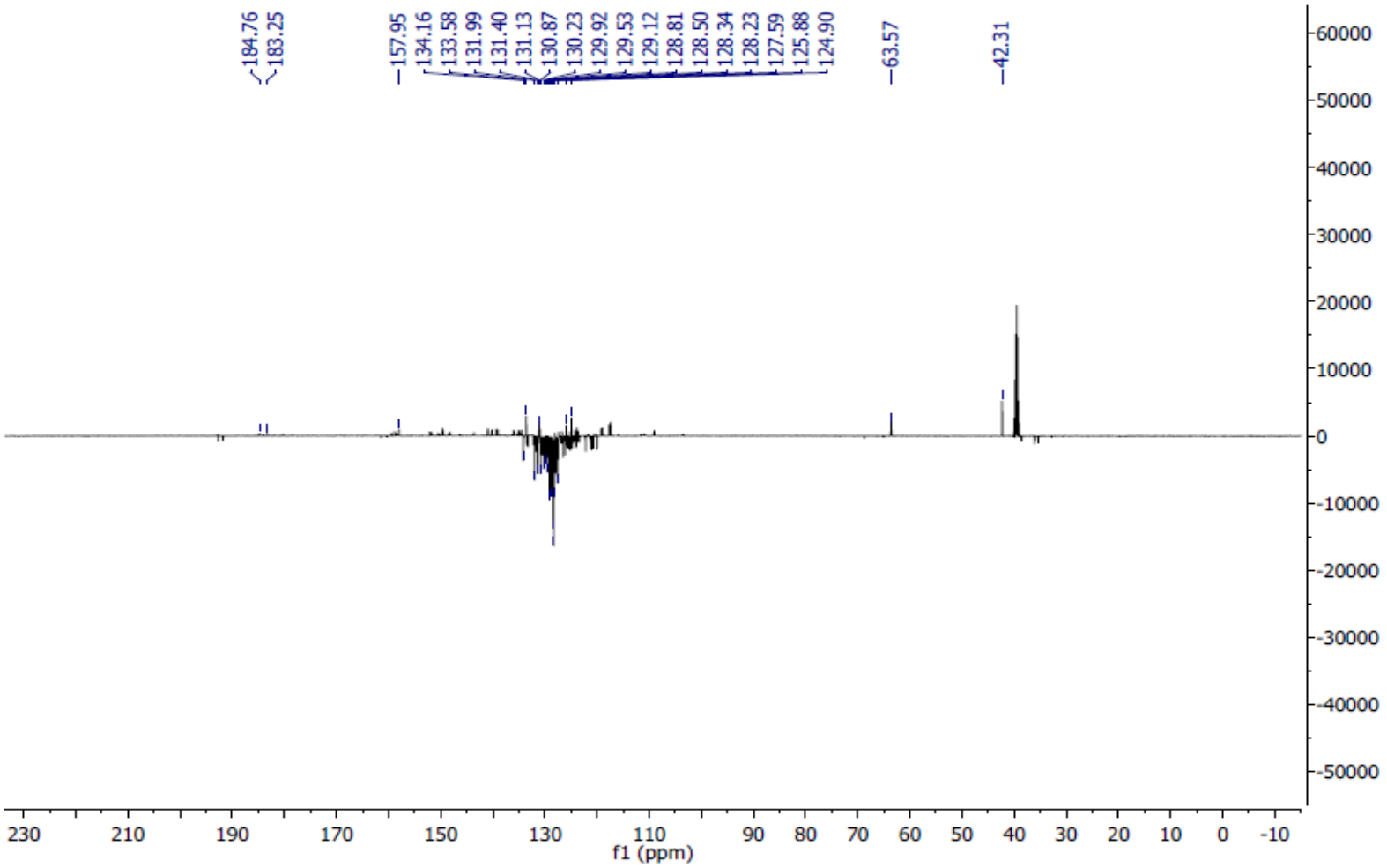

Figure S6. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **13c**.

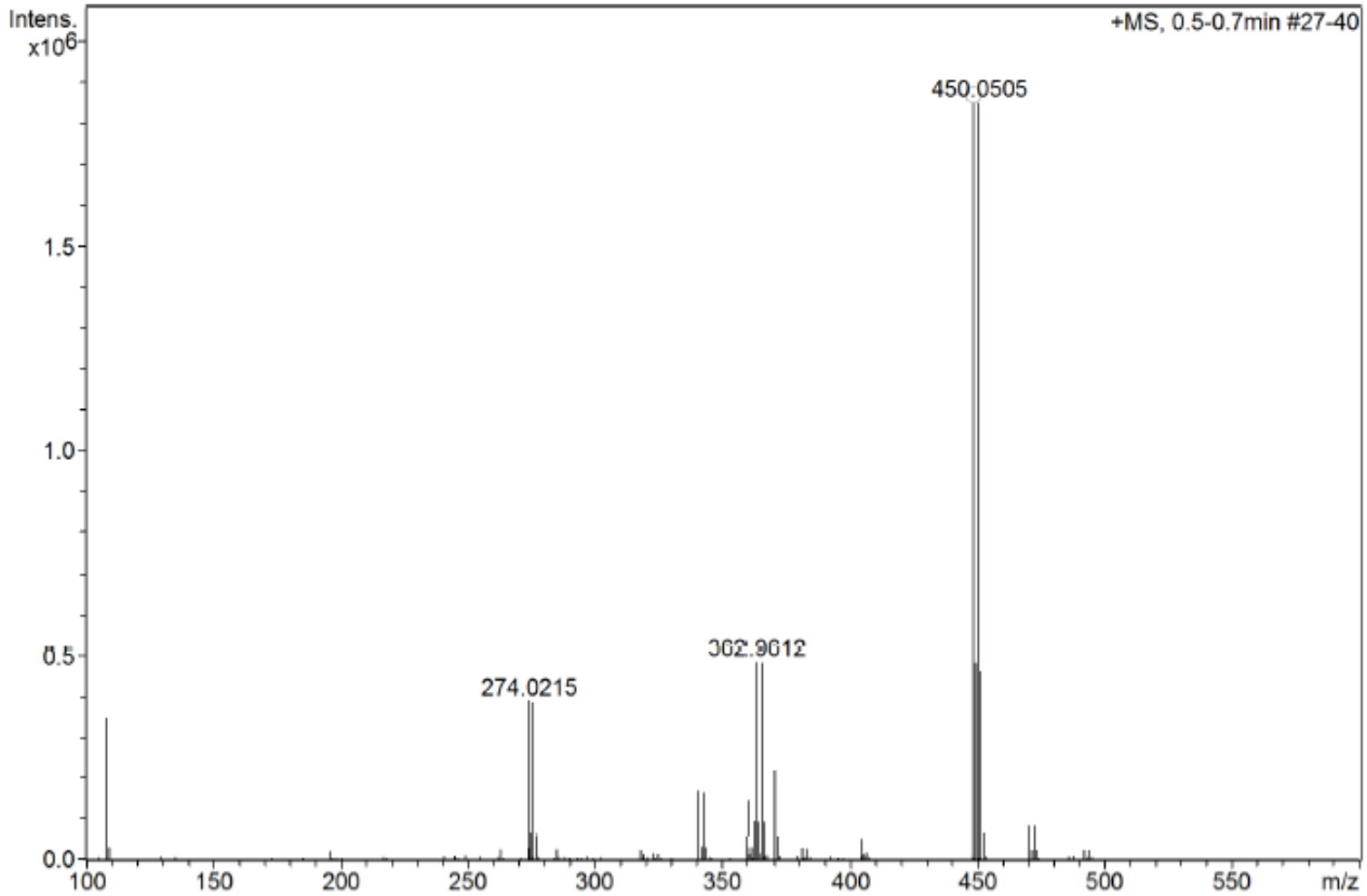

Figure S7. Mass spectrum of compound **13c**.

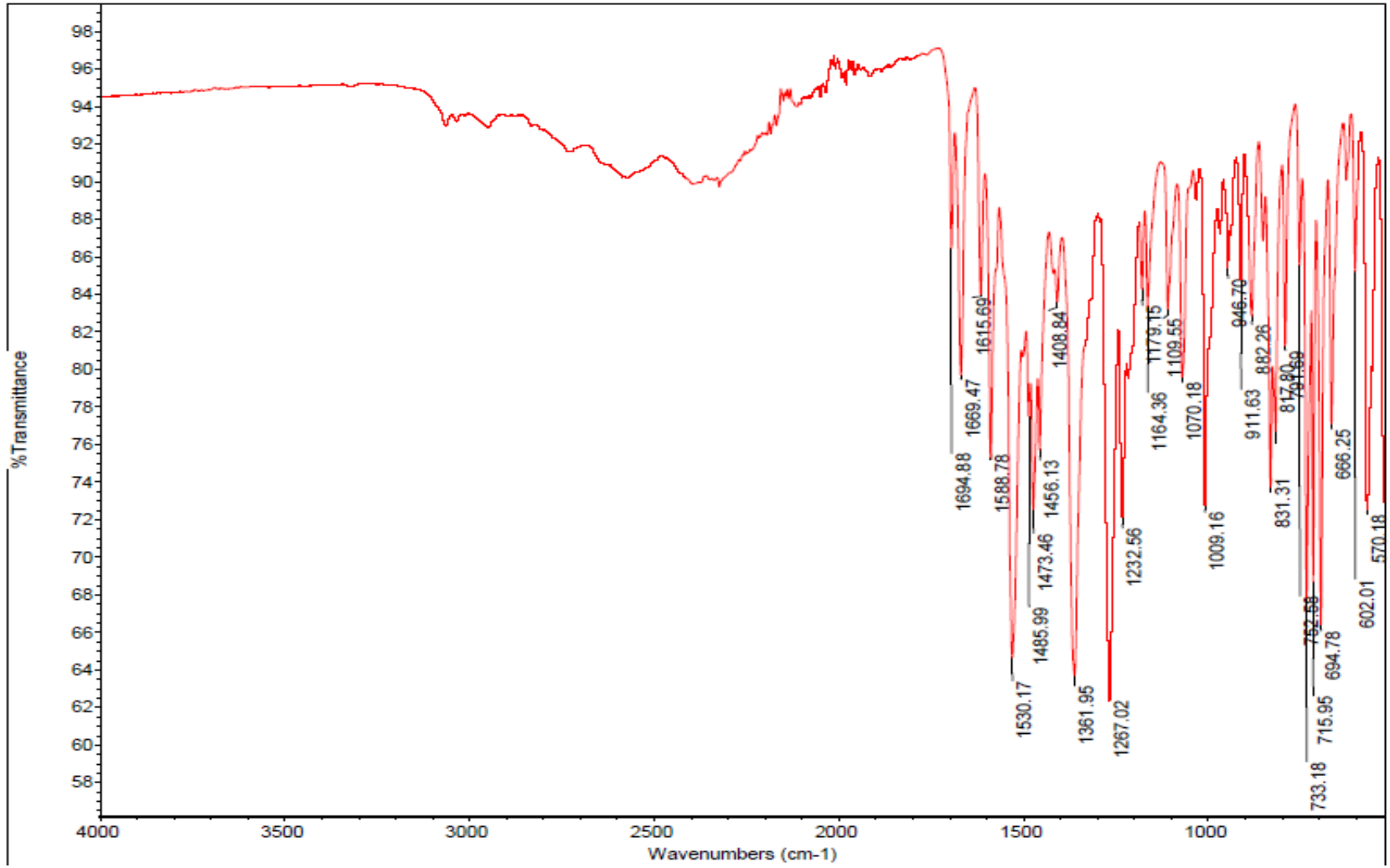

Figure S8. FTIR (KBr) spectrum of compound **13c**.

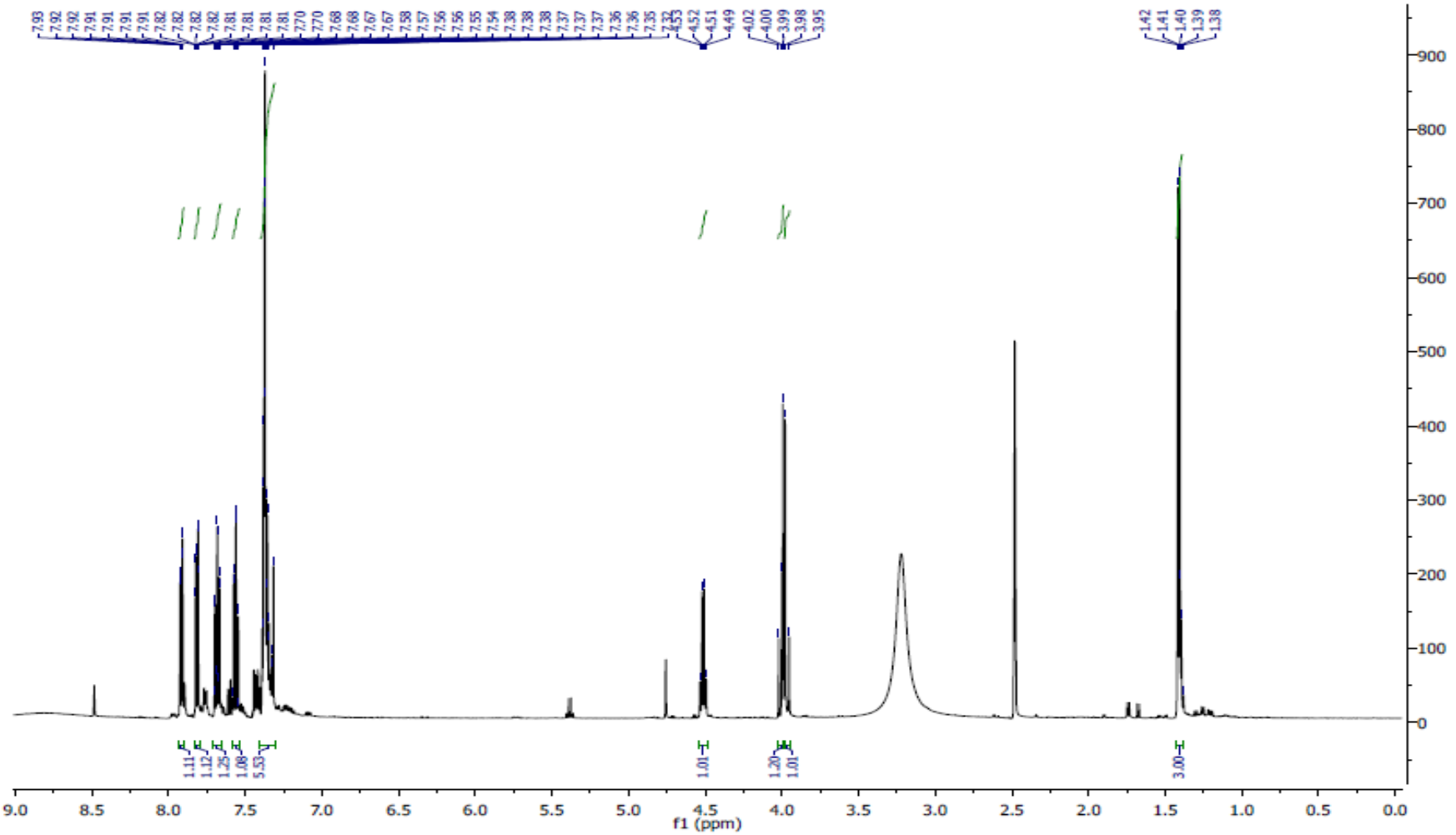

Figure S9. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **13e**.

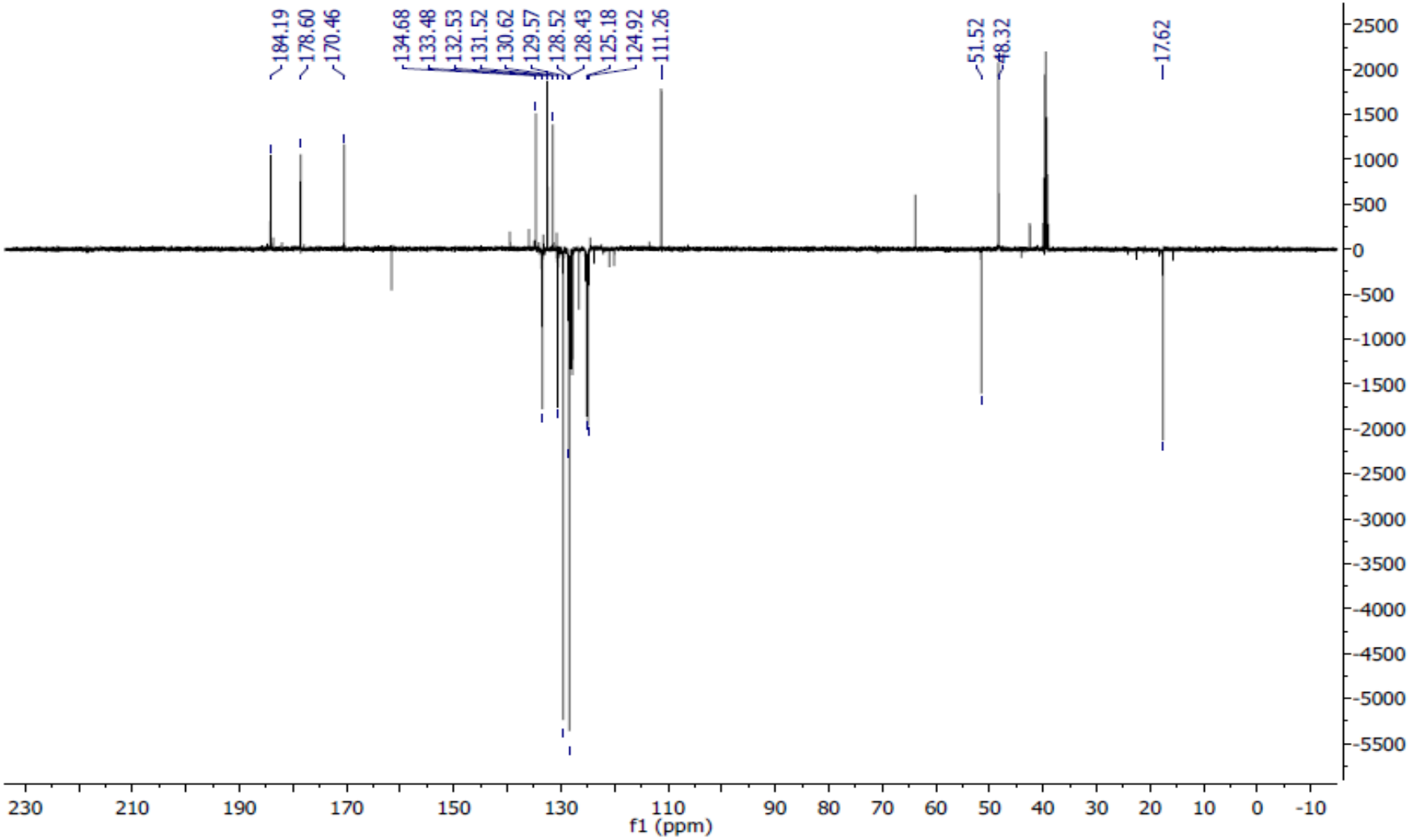

Figure S10. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **13e**.

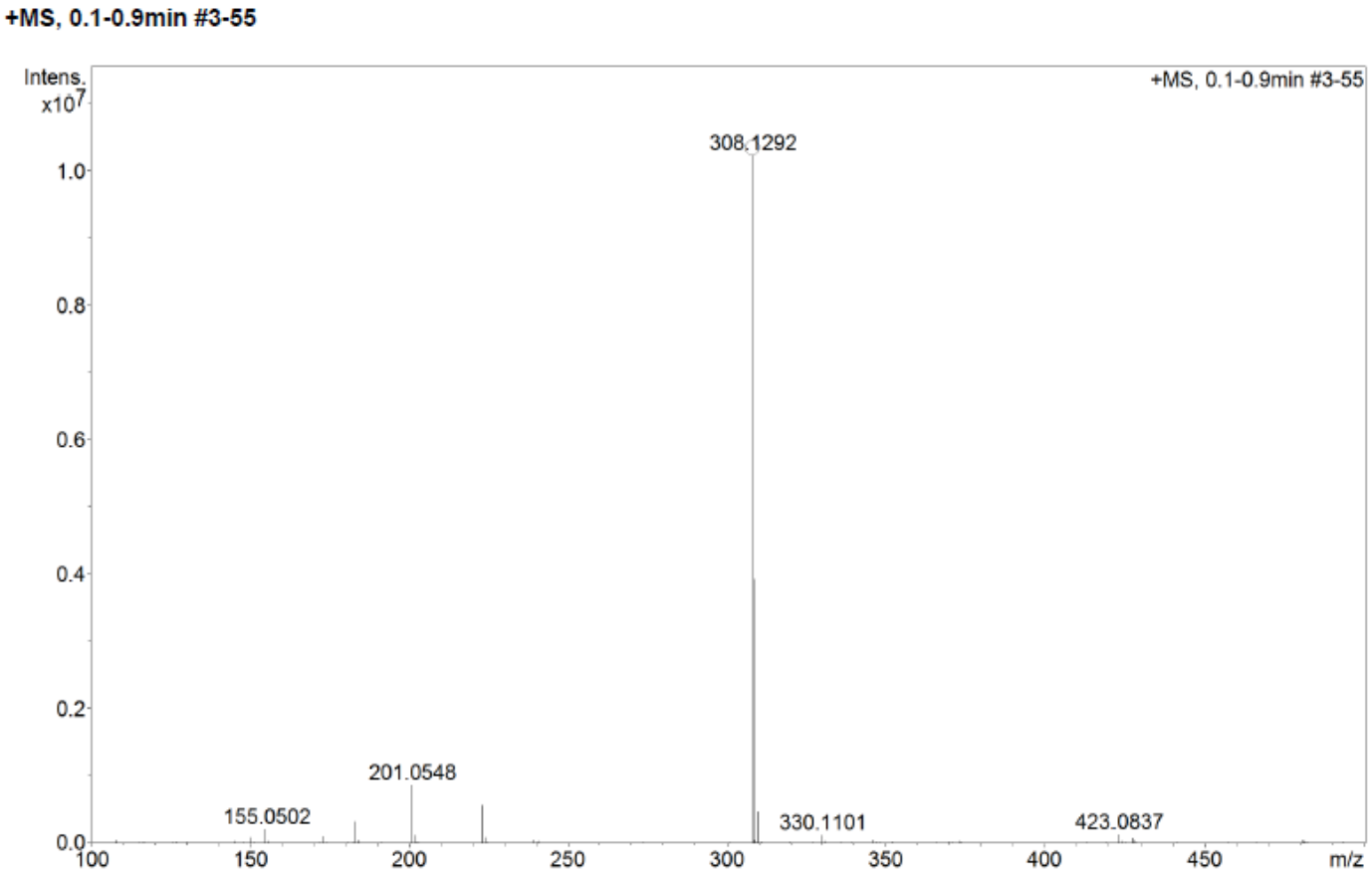

Figure S11. Mass spectrum of compound **13e**.

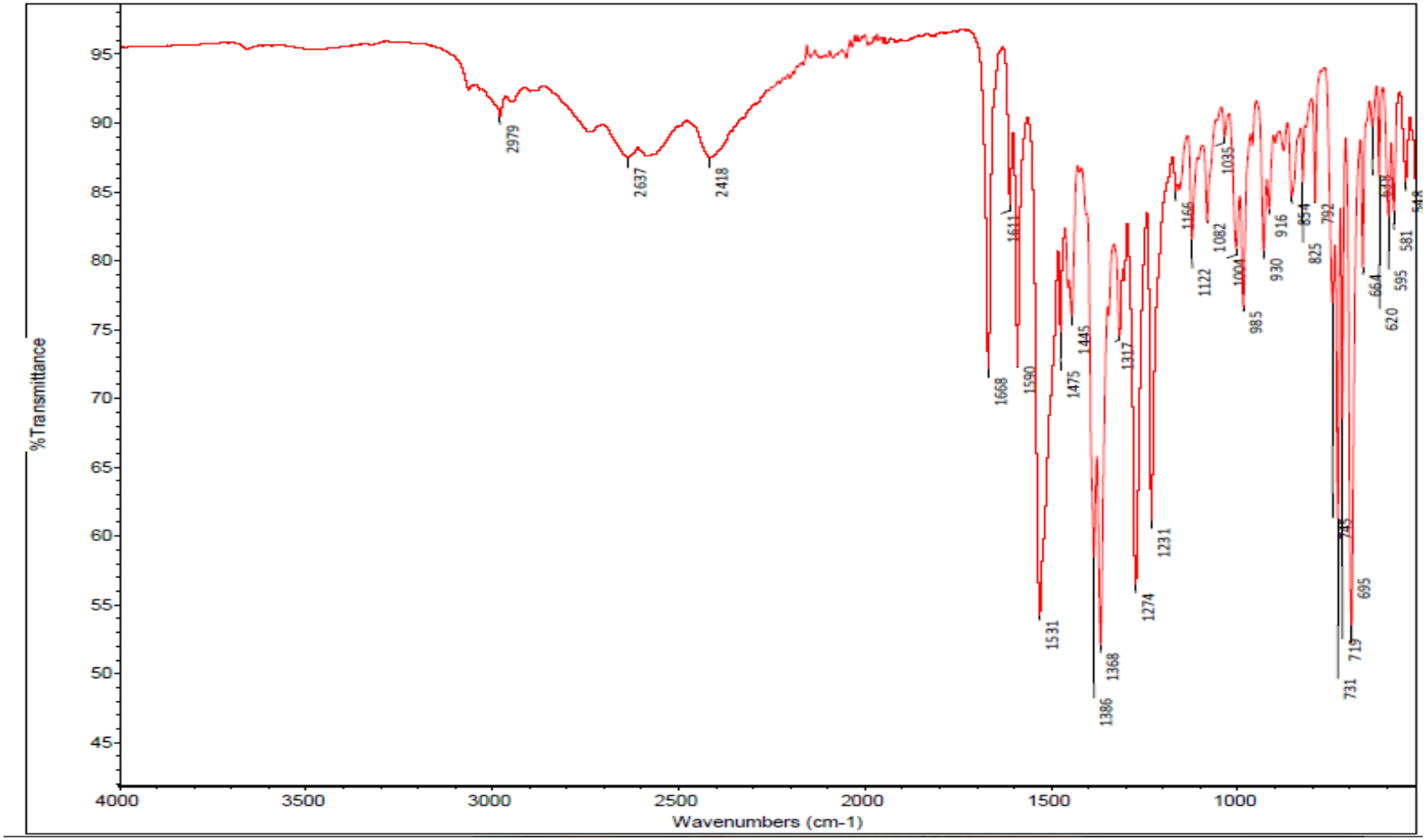

Figure S12. FTIR (KBr) spectrum of compound **13e**.

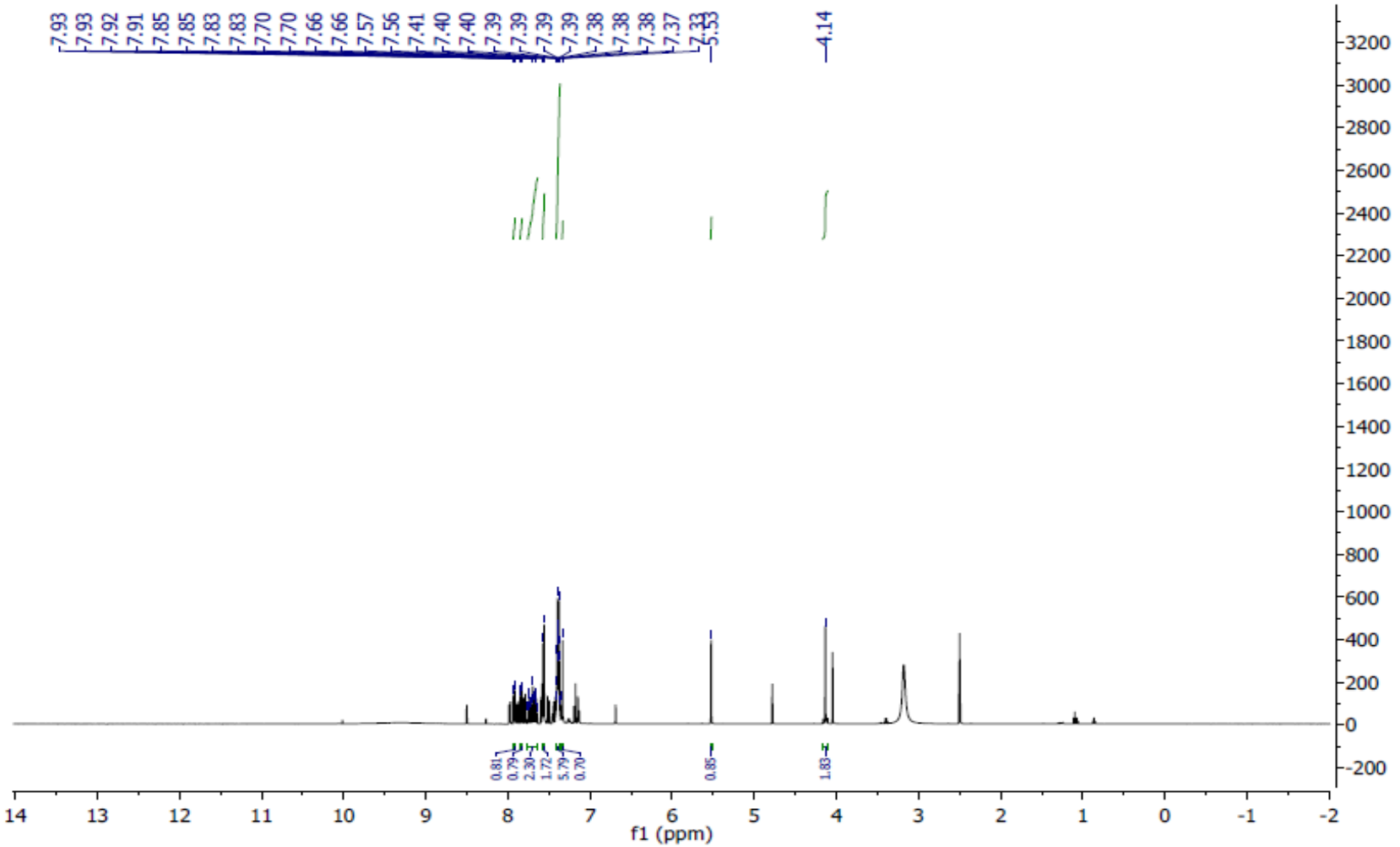

Figure S13. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **13f**.

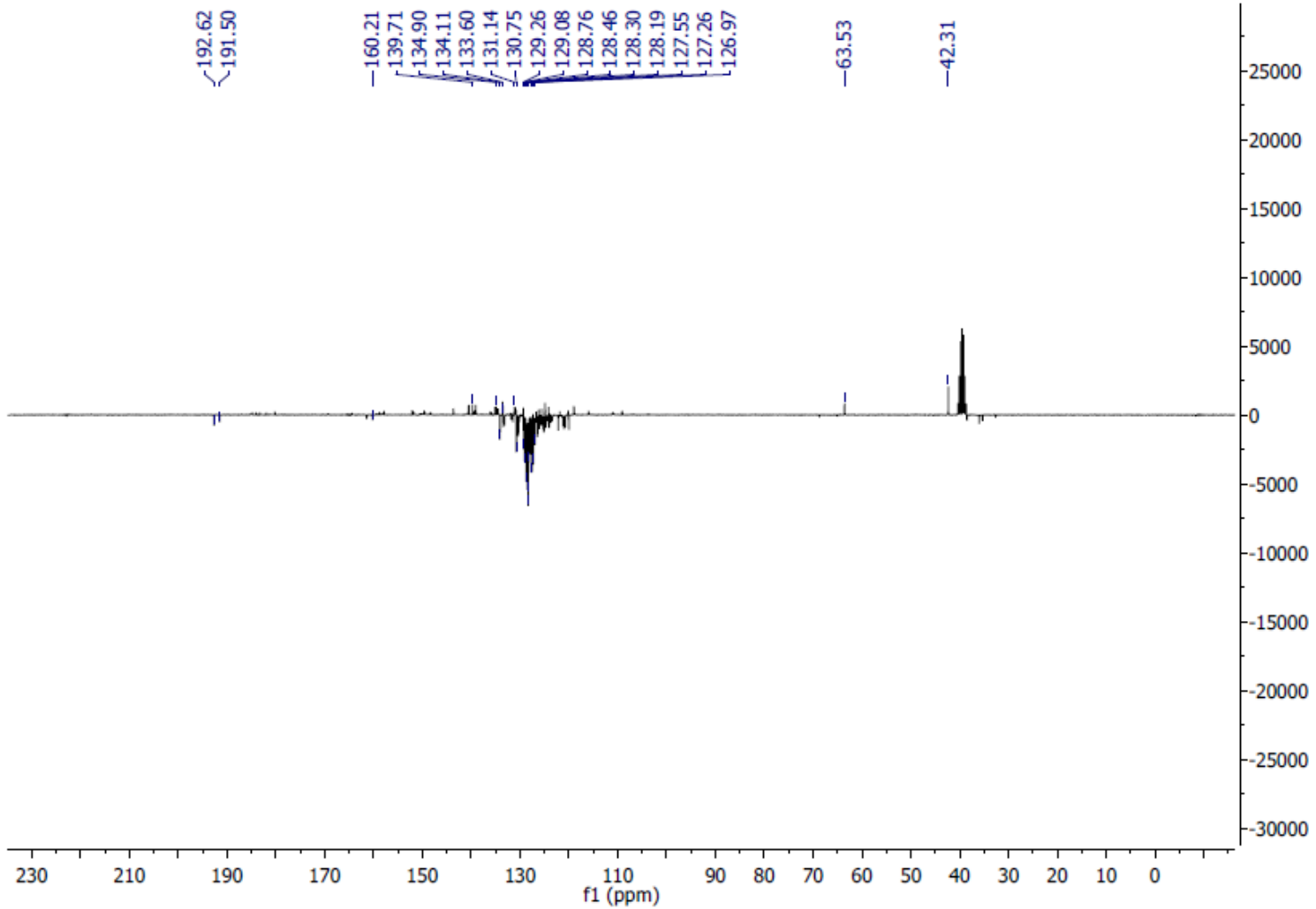

Figure S14. ^{13}C NMR spectrum (75 MHz, DMSO-d_6) of compound **13f**.

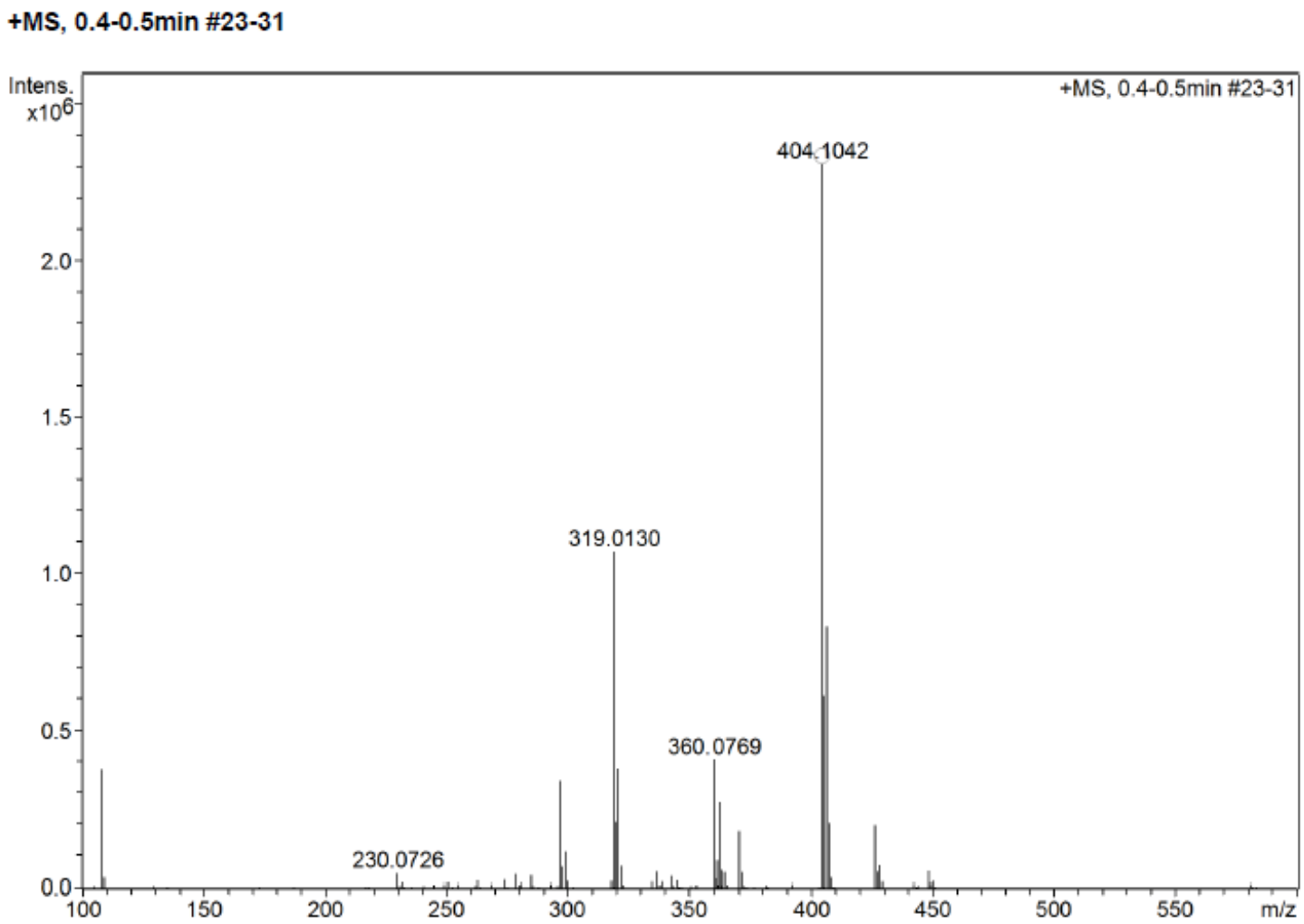

Figure S15. Mass spectrum of compound **13f**.

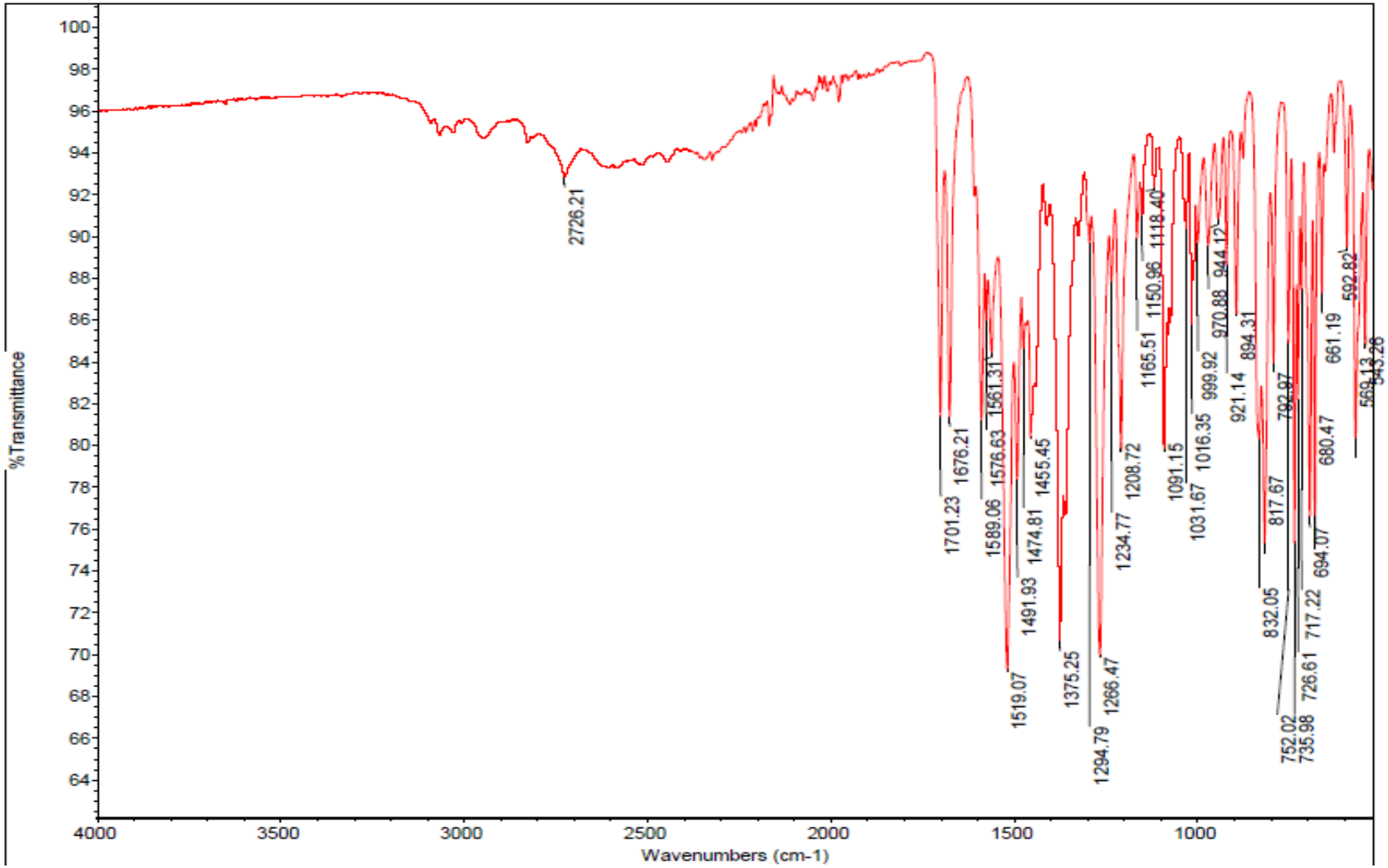

Figure S16. FTIR (KBr) spectrum of compound **13f**.

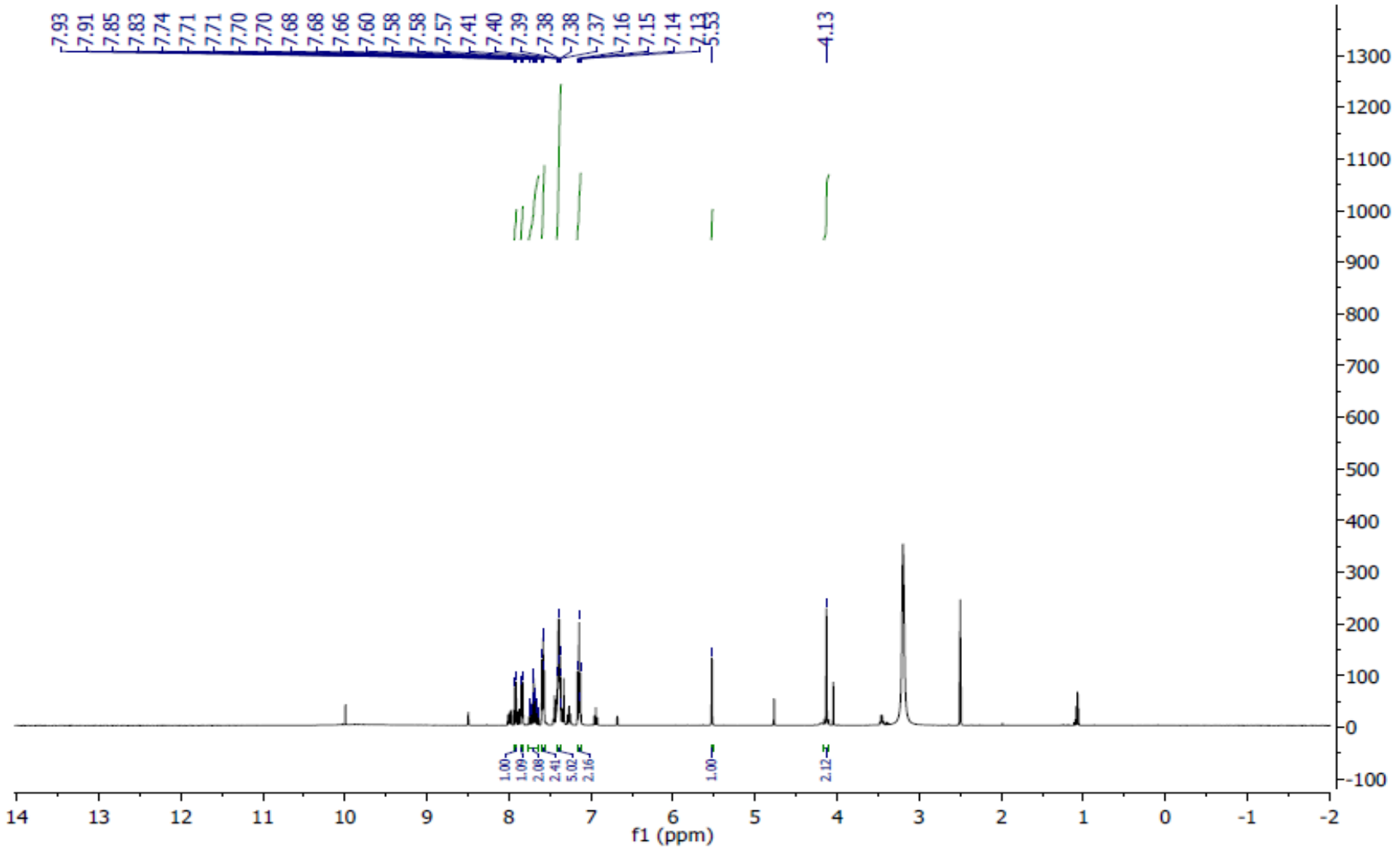

Figure S17. [1]H NMR spectrum (500 MHz, DMSO-d_6) of compound **13g**.

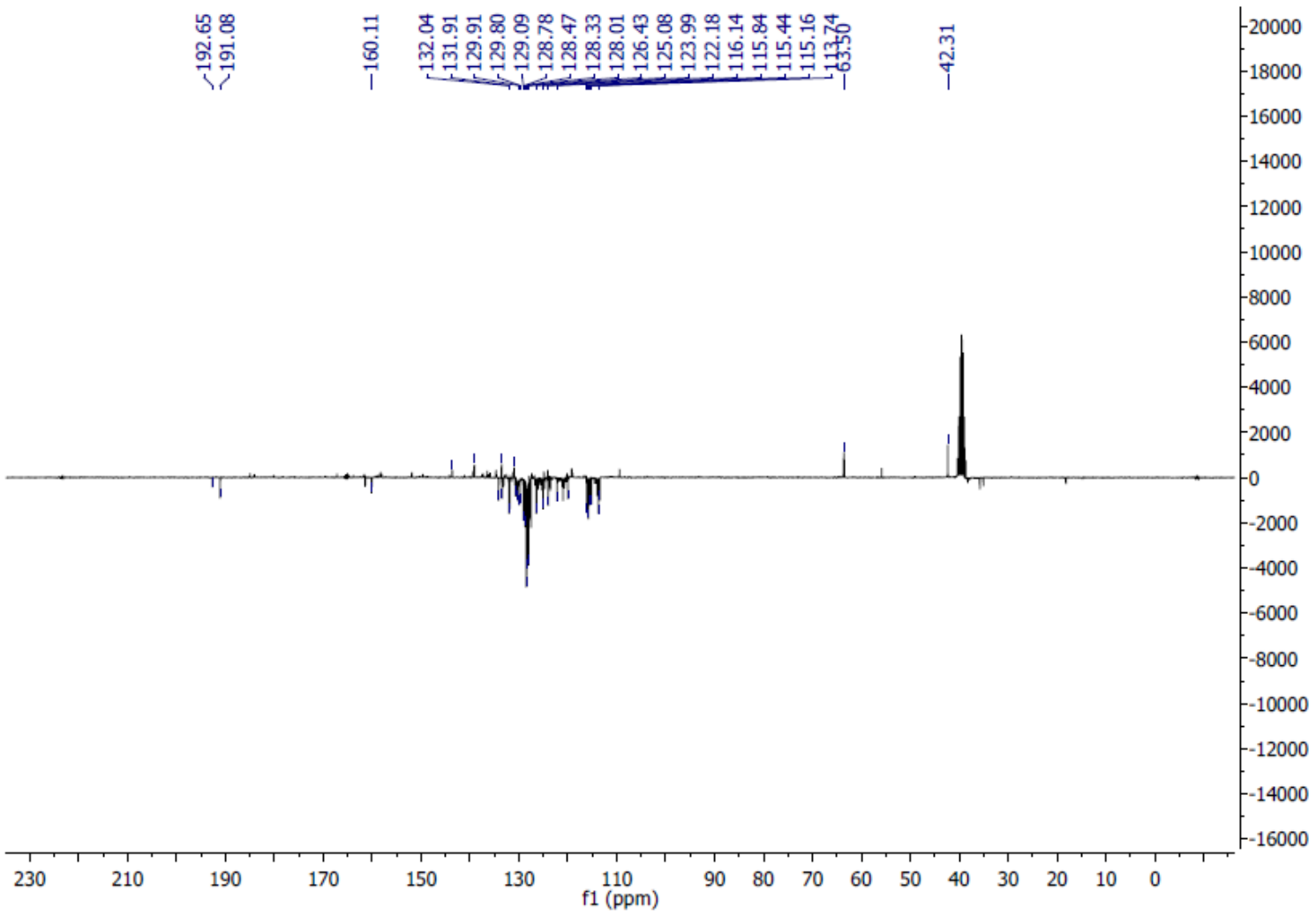

Figure S18. ^{13}C NMR spectrum (75 MHz, DMSO-d_6) of compound **13g**.

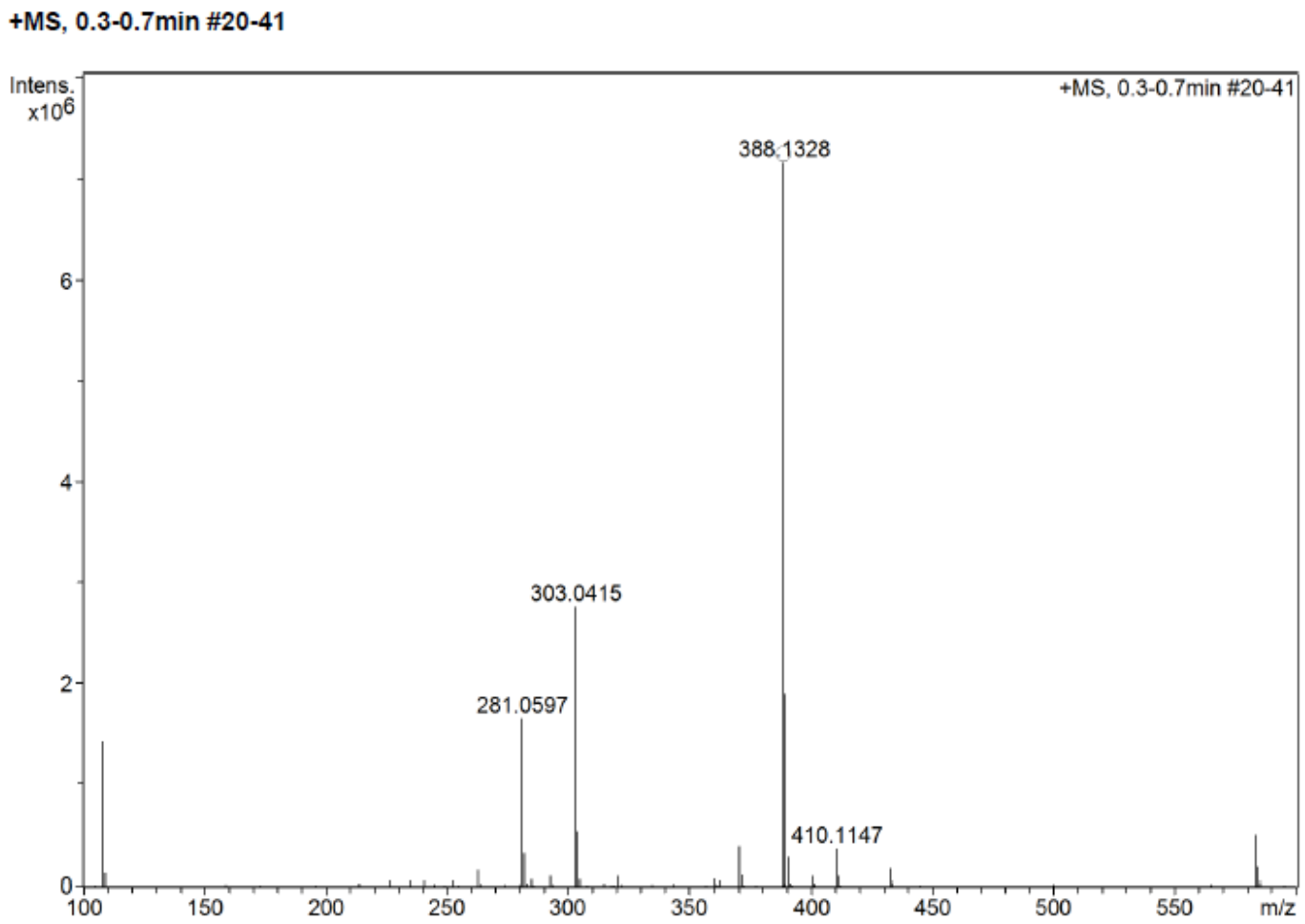

Figure S19. Mass spectrum of compound **13g**.

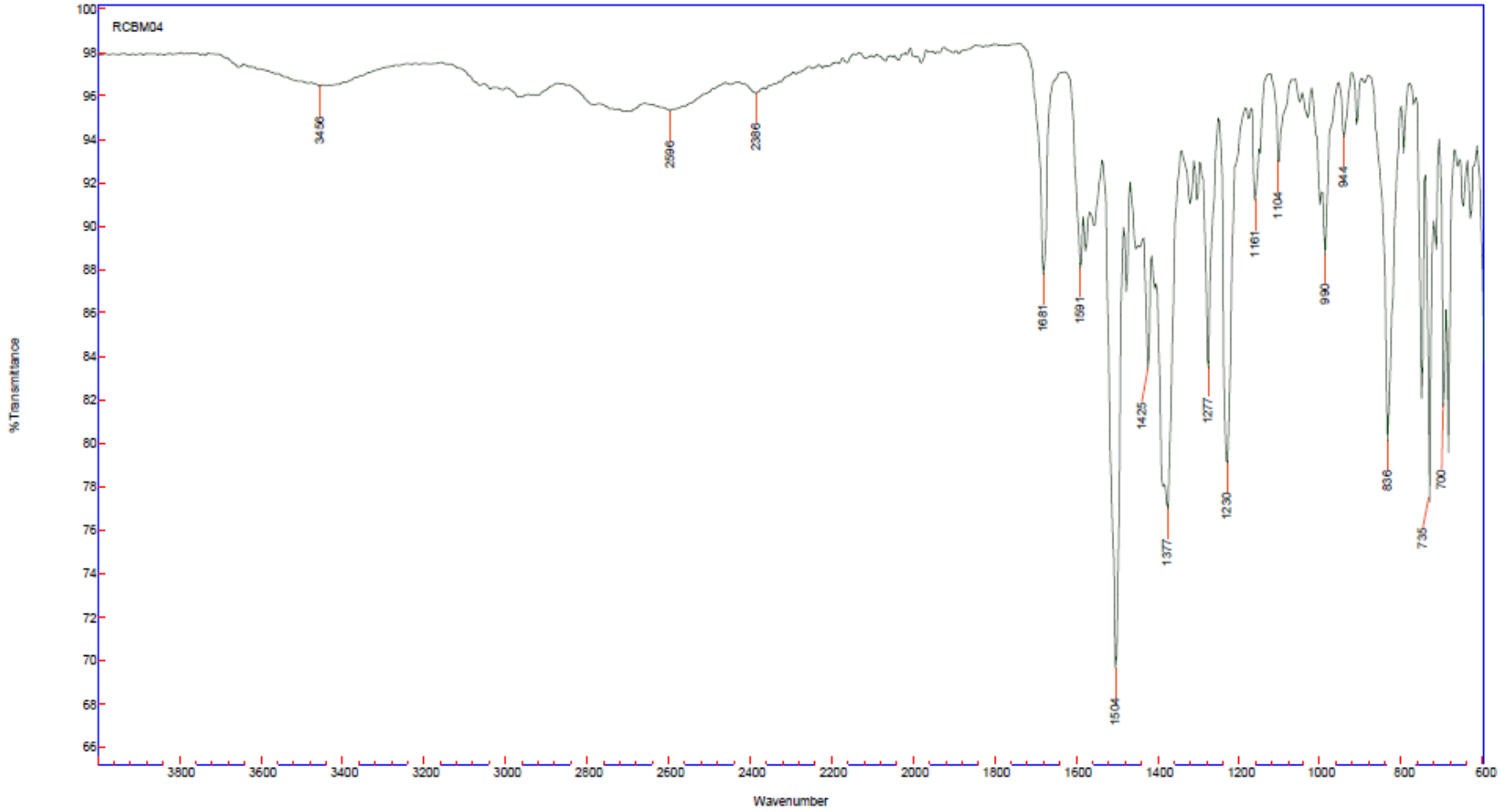

Figure S20. FTIR (KBr) spectrum of compound **13g**.

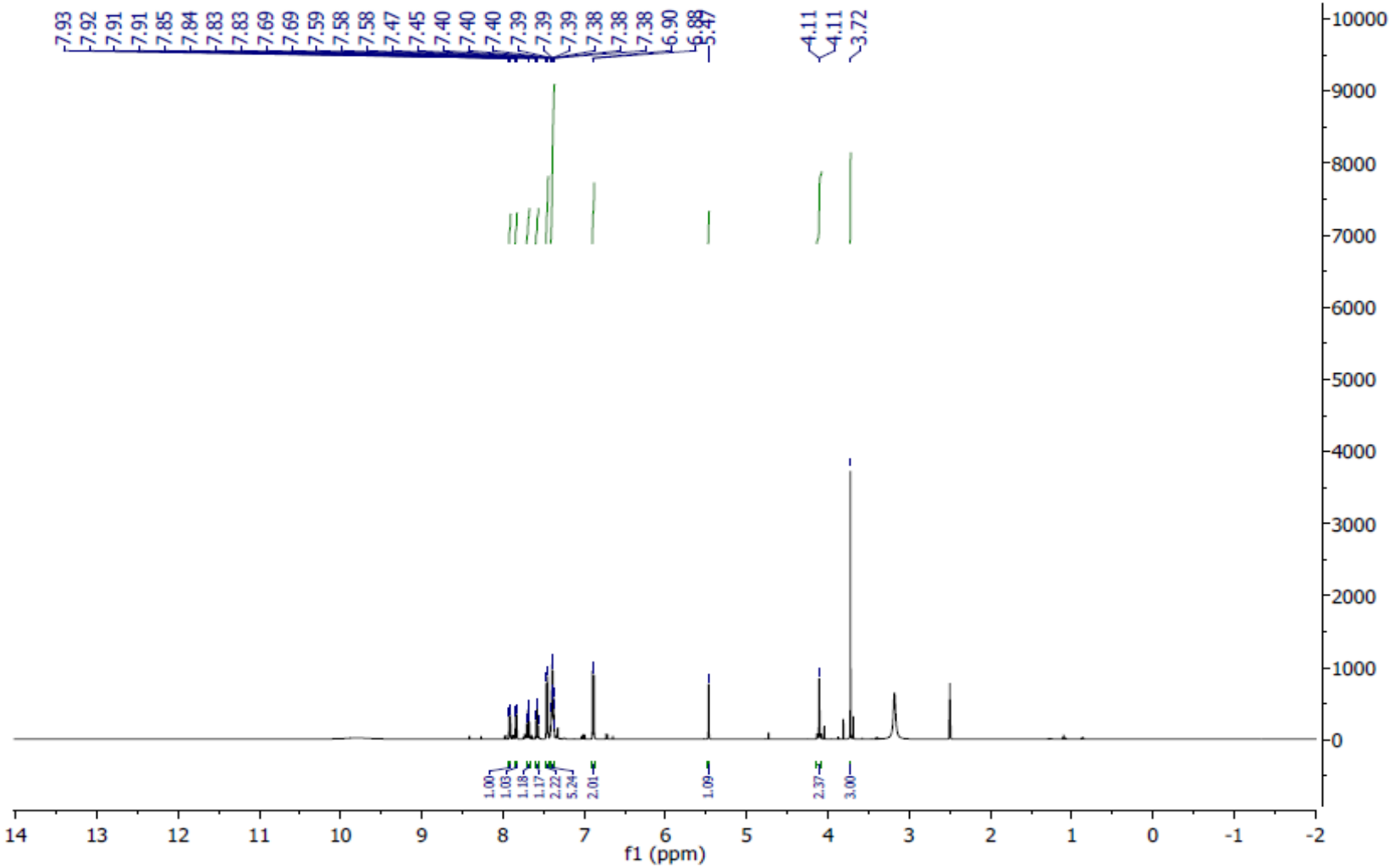

Figure S21. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **13h**.

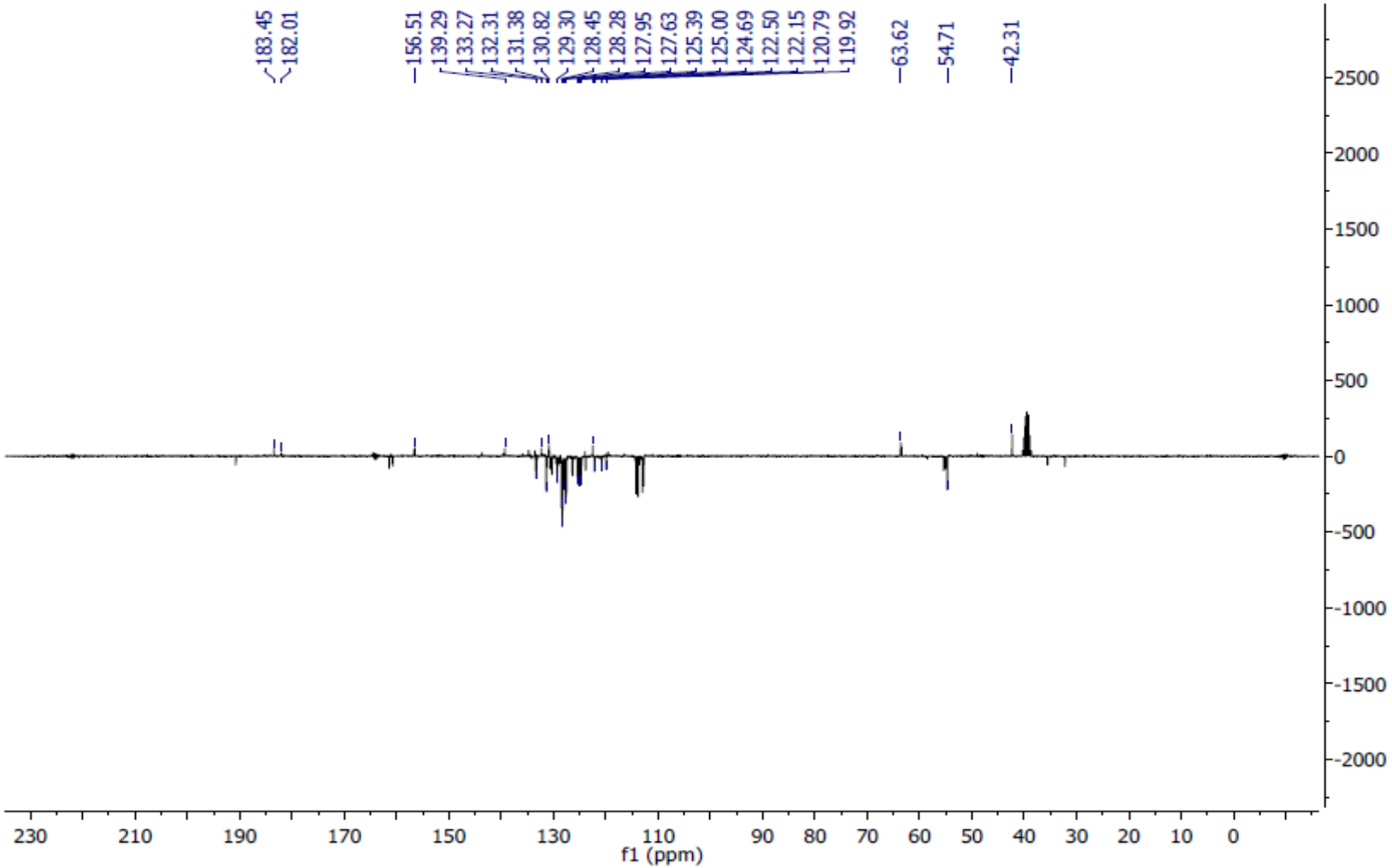

Figure S22. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **13h**.

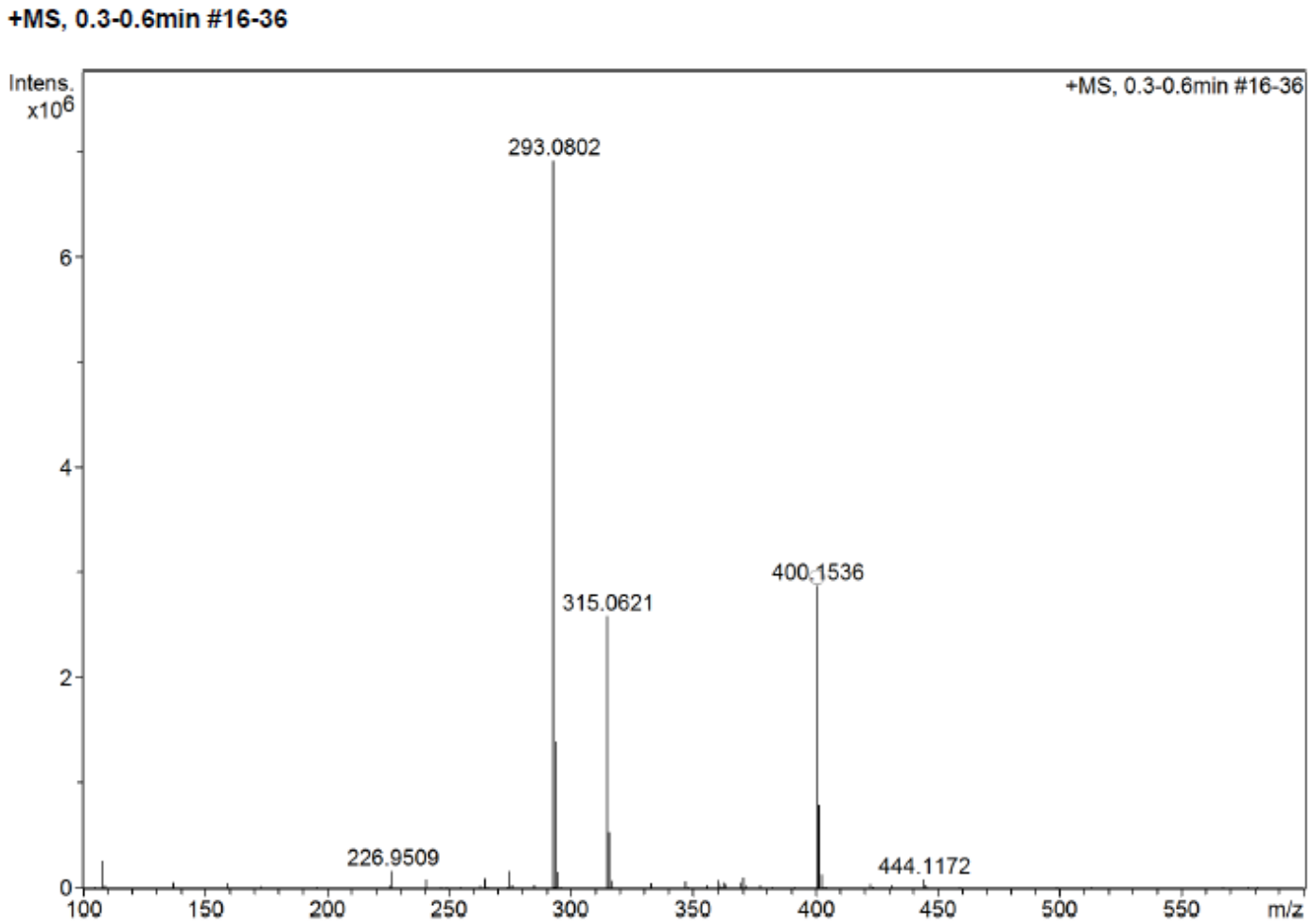

Figure S23. Mass spectrum of compound **13h**.

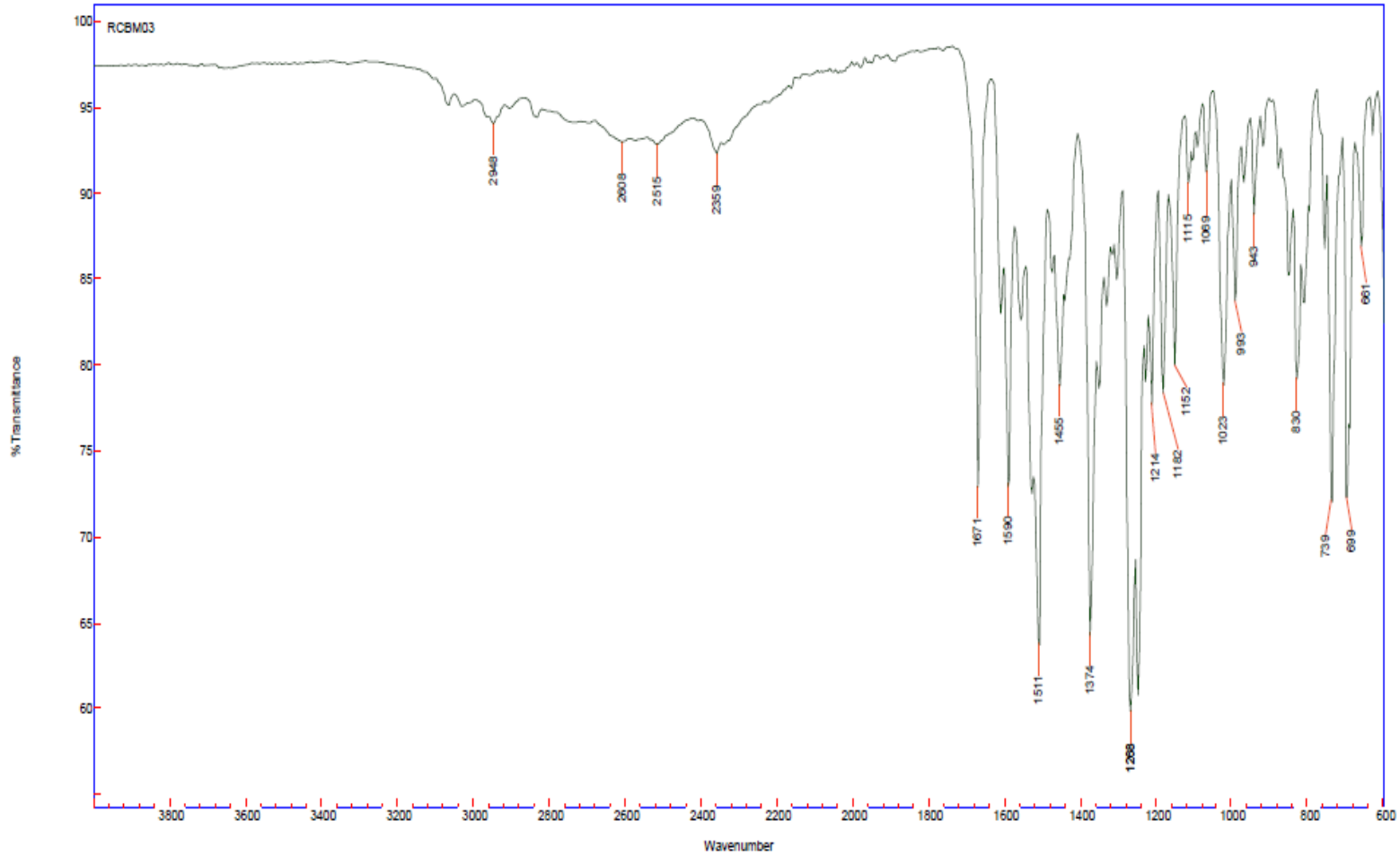

Figure S24. FTIR (KBr) spectrum of compound **13h**.

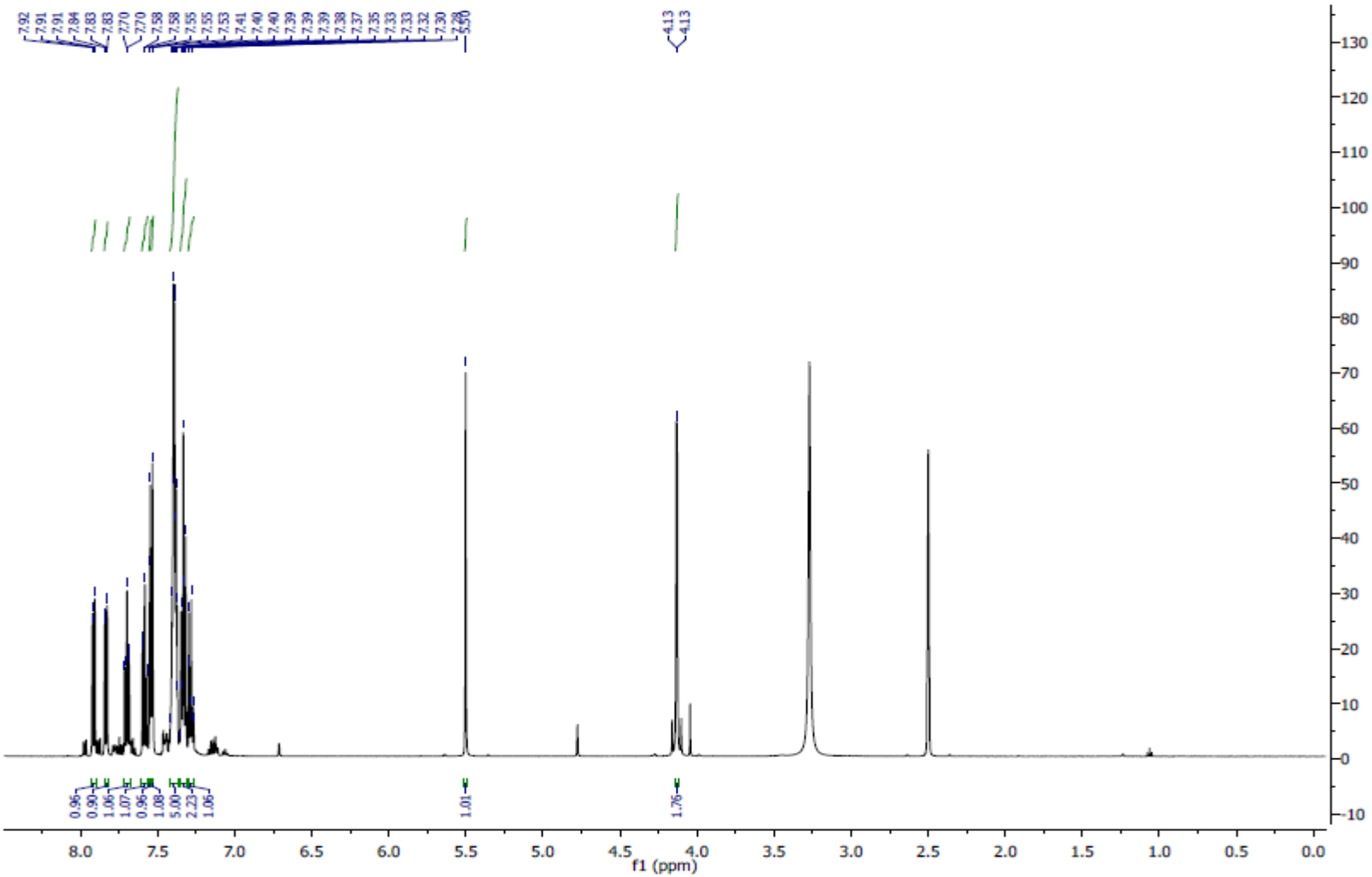

Figure S25. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **13i**.

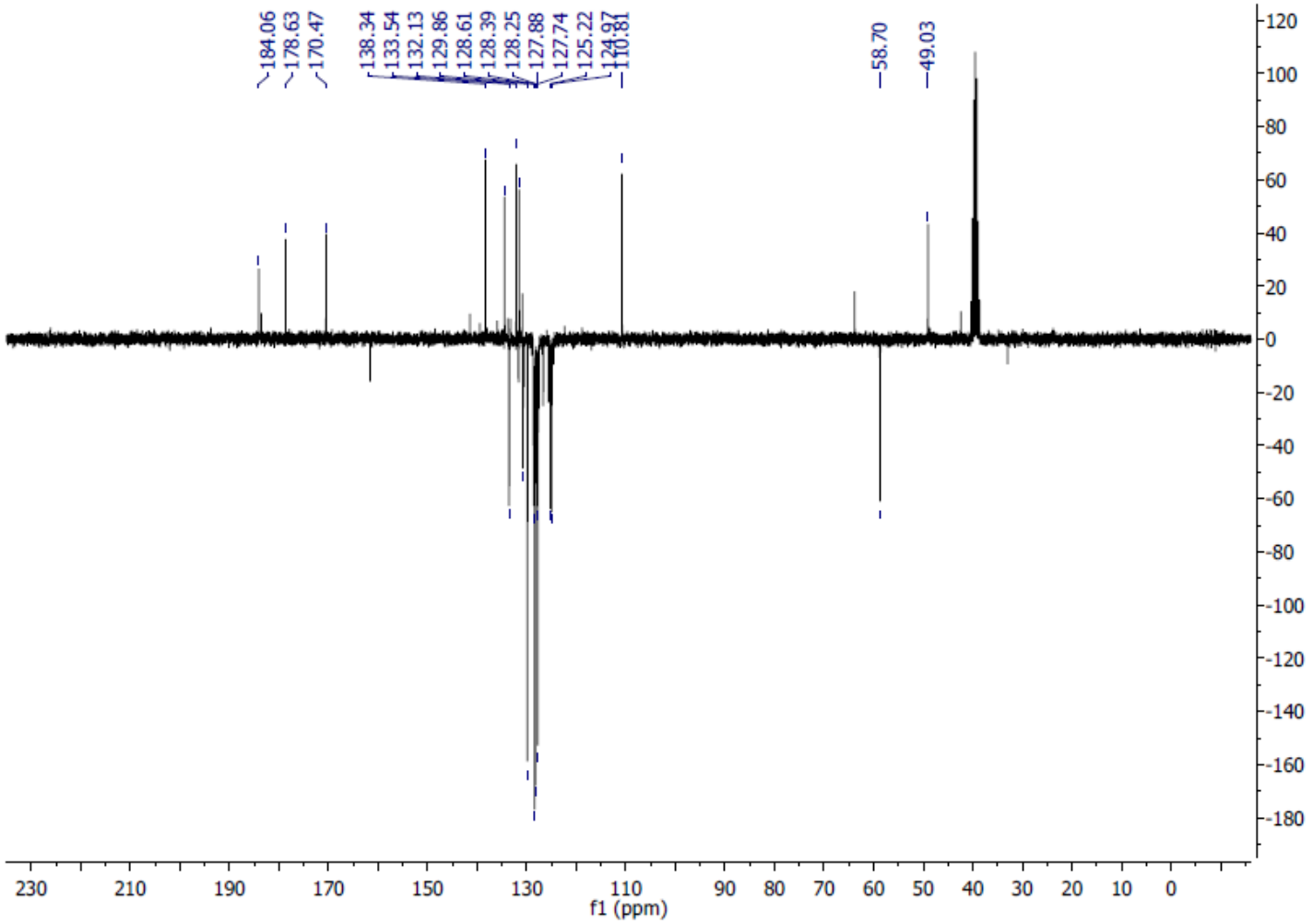

Figure S26. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **13i**.

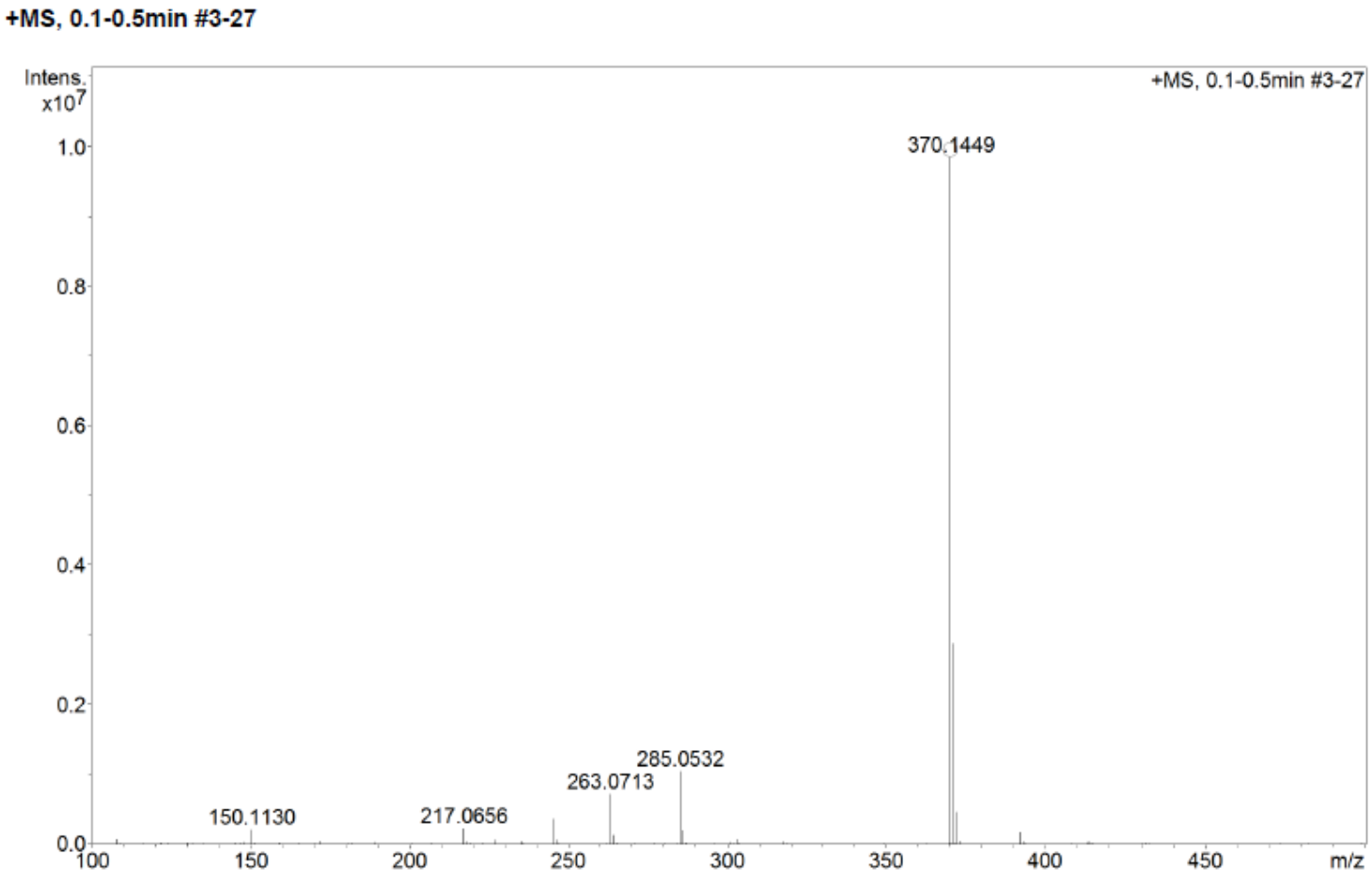

Figure S27. Mass spectrum of compound **13i**.

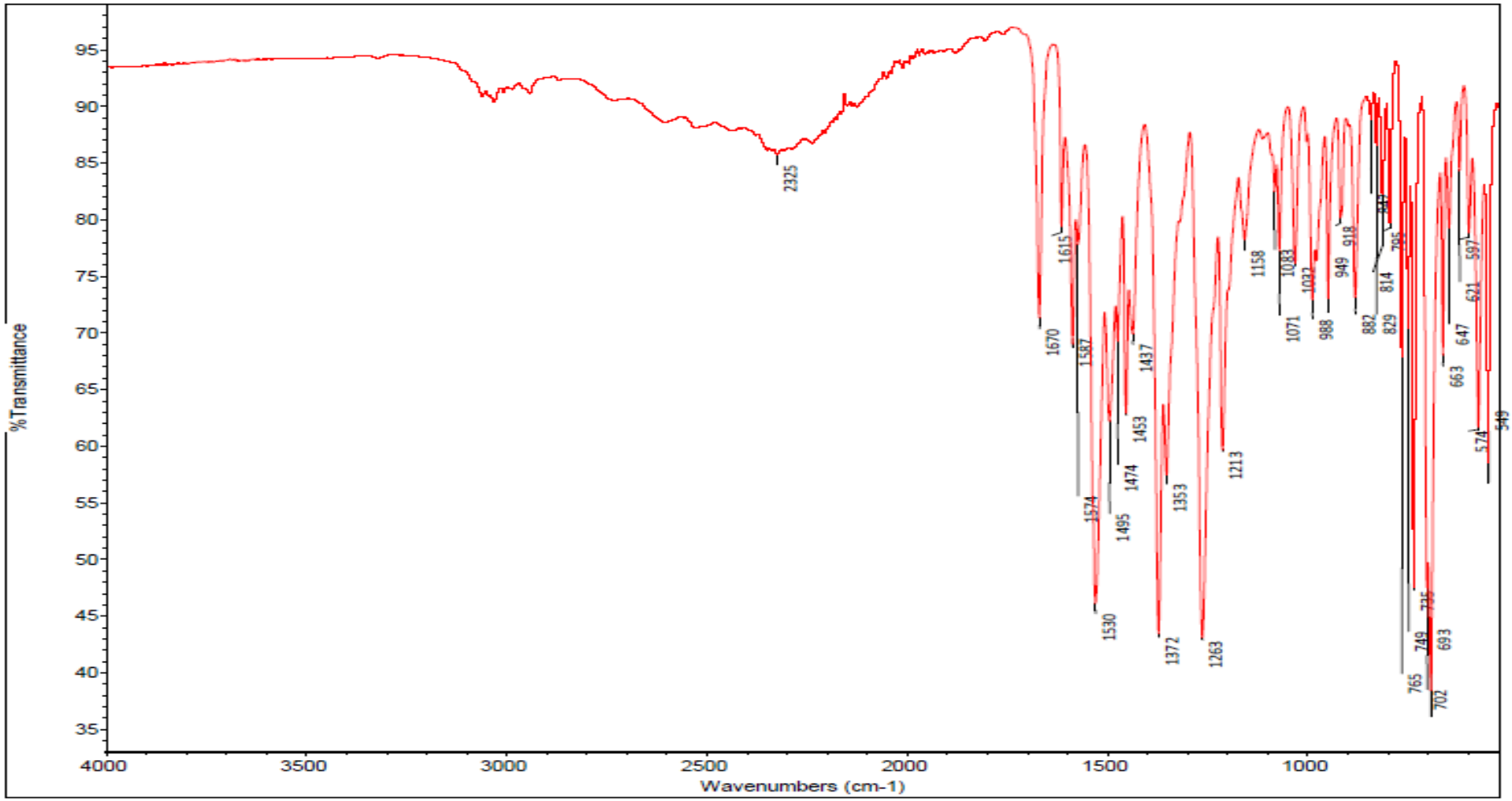

Figure S28. FTIR (KBr) spectrum of compound **13i**.

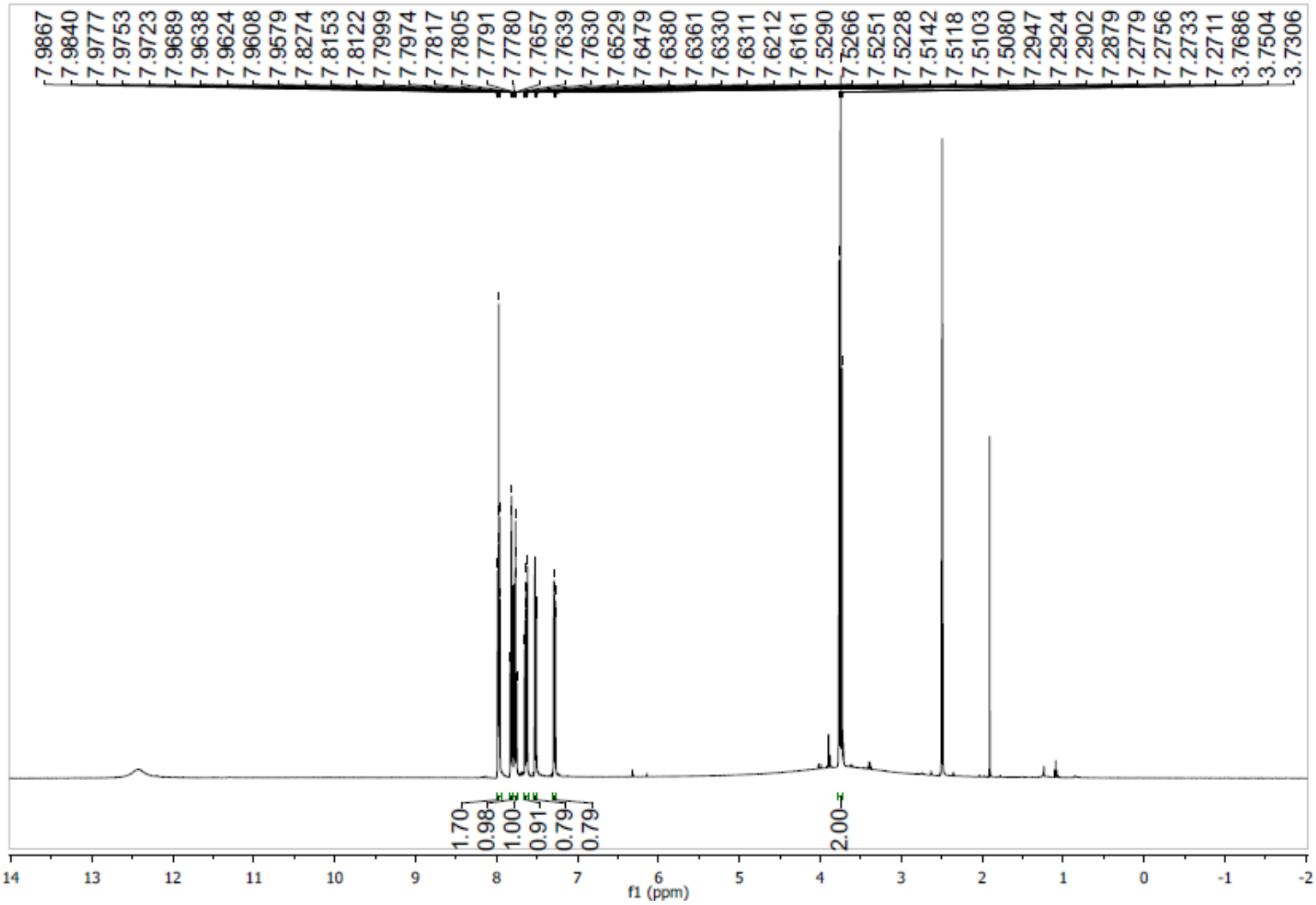

Figure S29. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15a**.

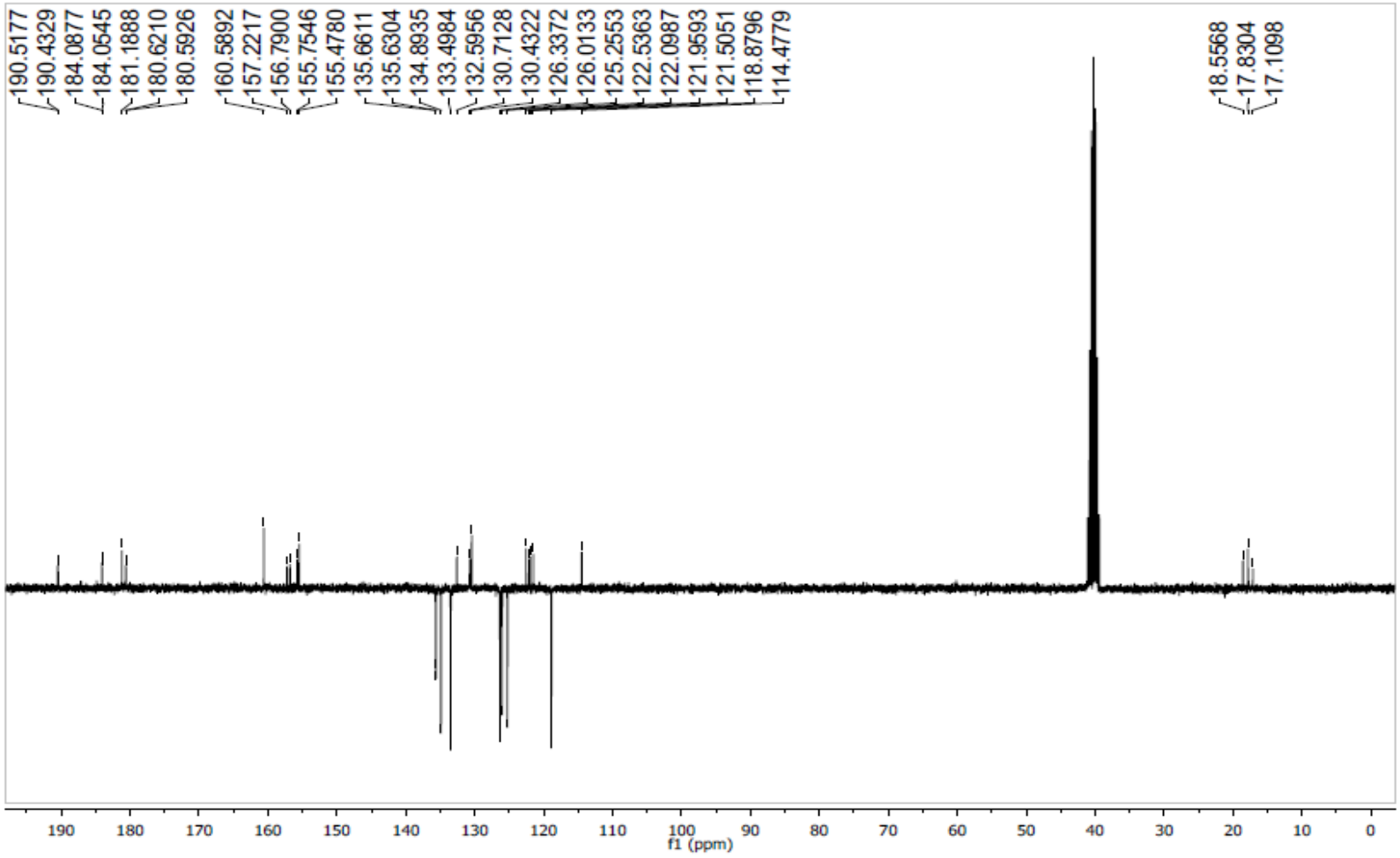

Figure S30. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15a**.

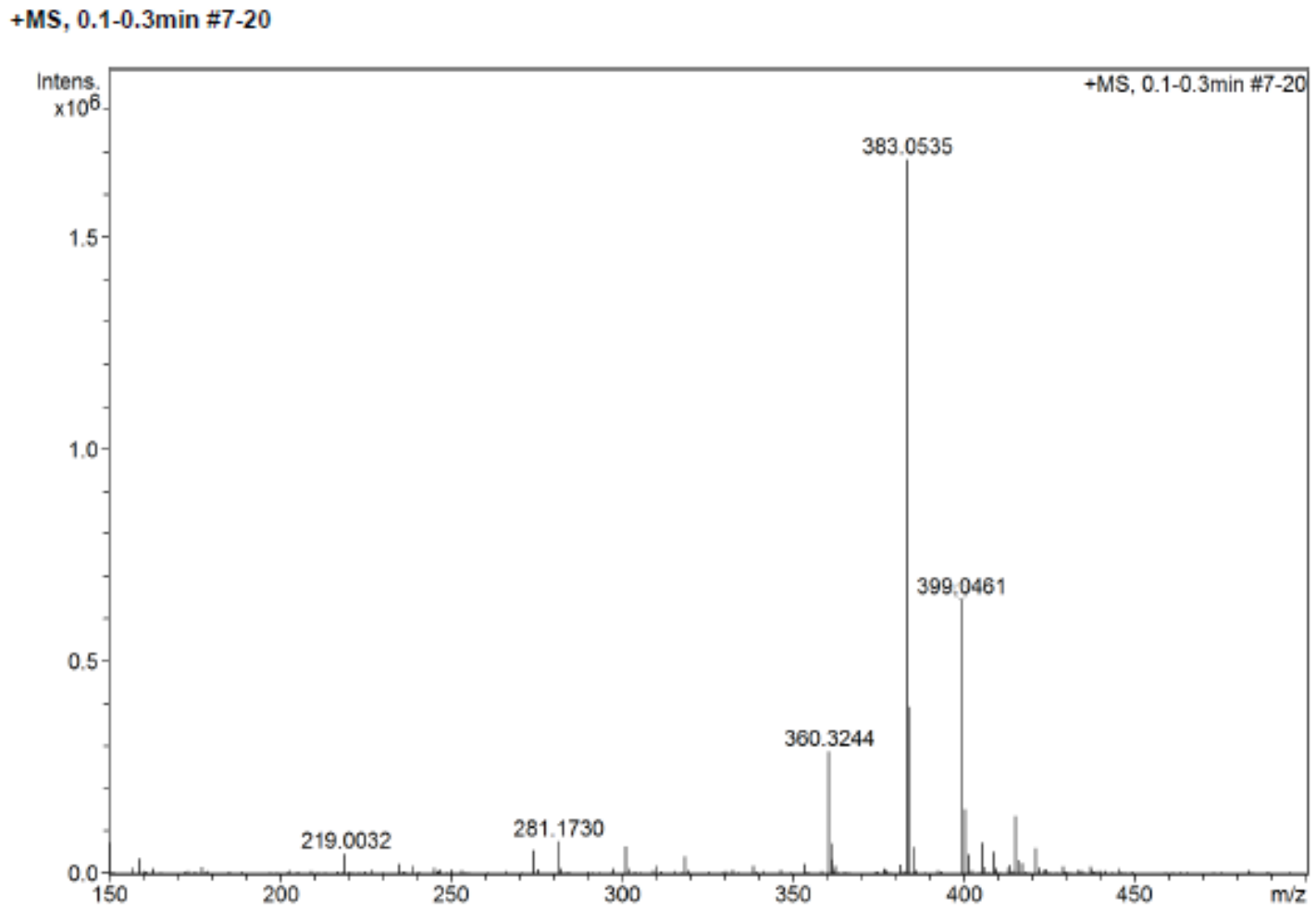

Figure S31. Mass spectrum of compound **15a**.

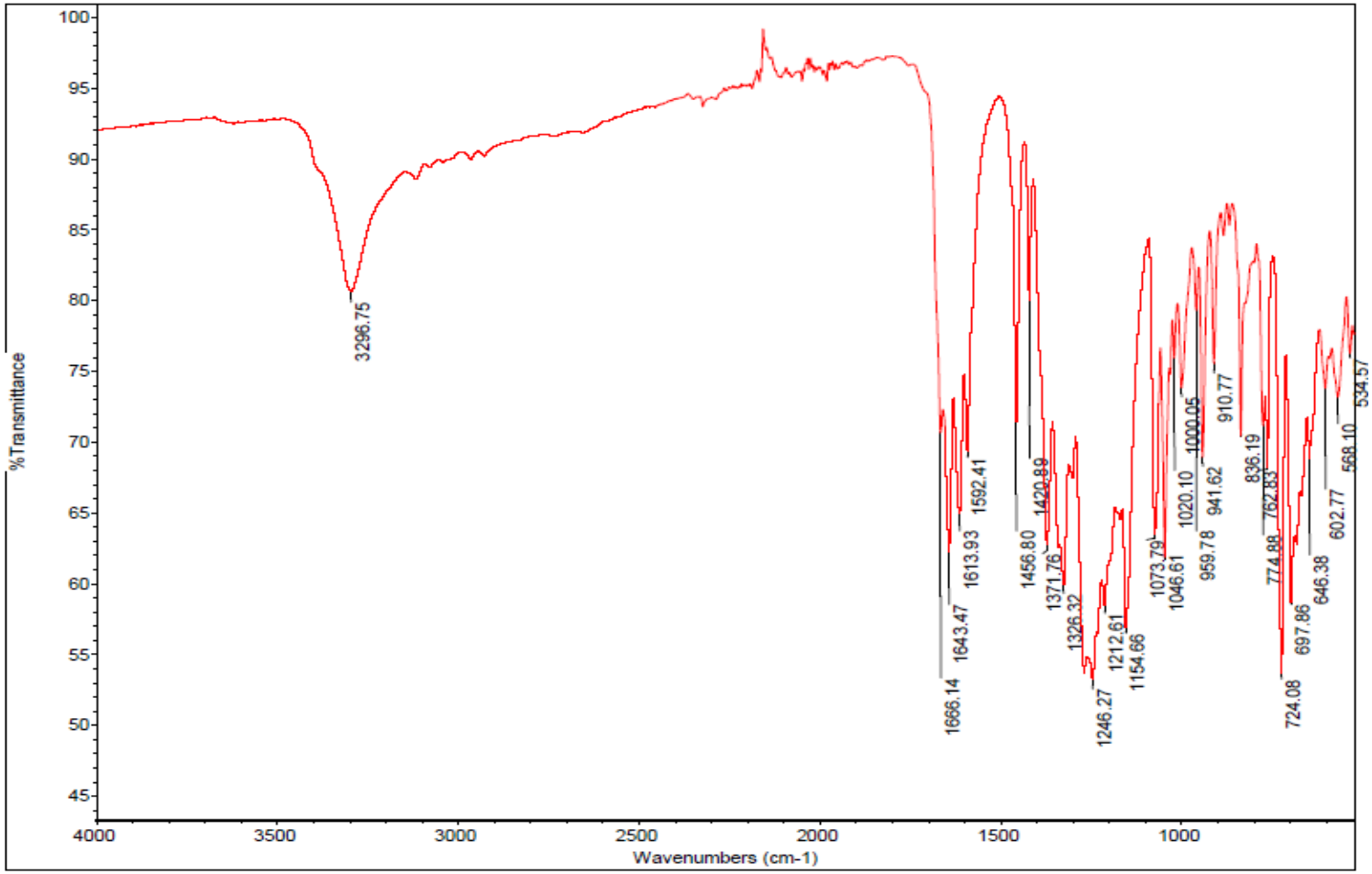

Figure S32. FTIR (KBr) spectrum of compound **15a**.

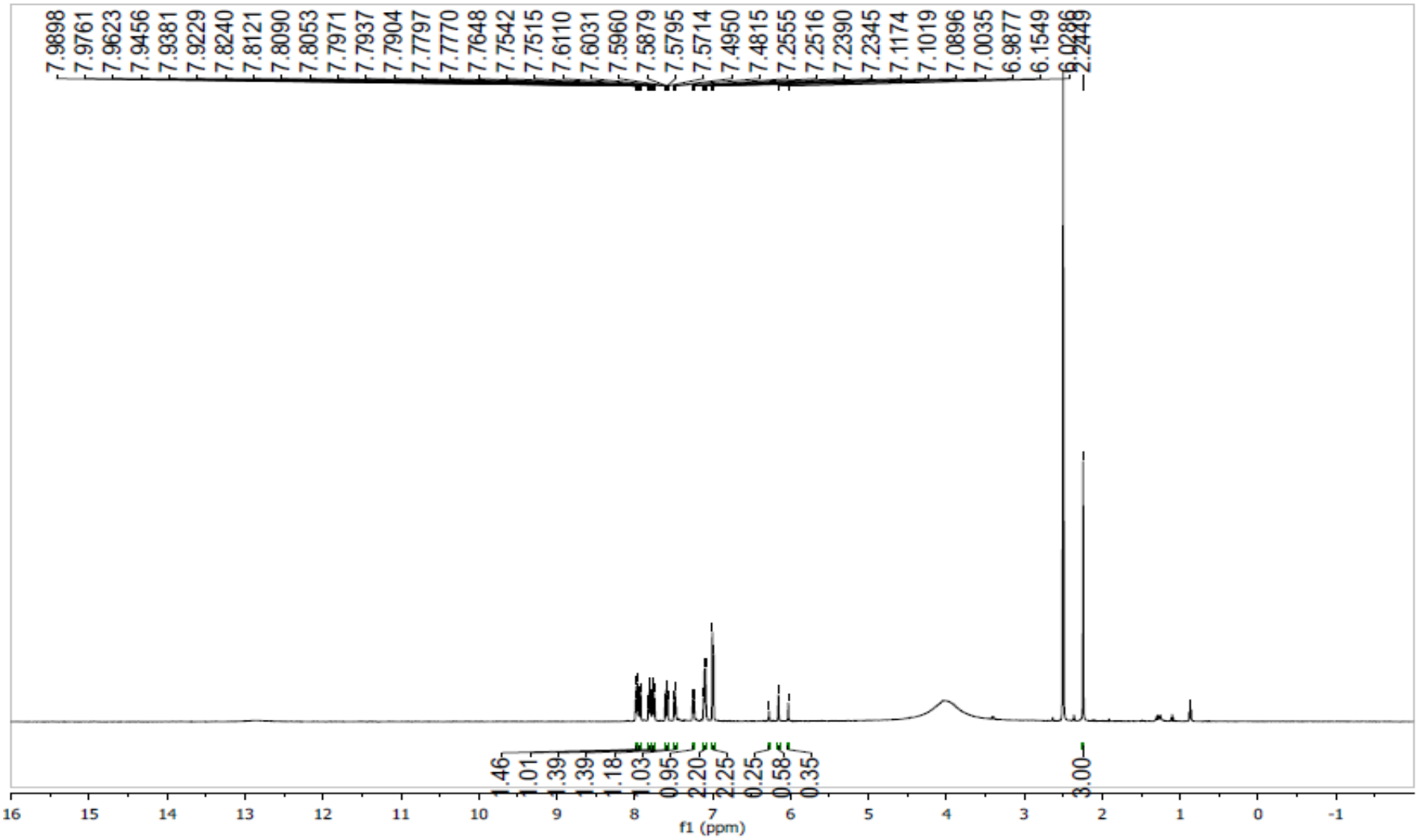

Figure S33. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15b**.

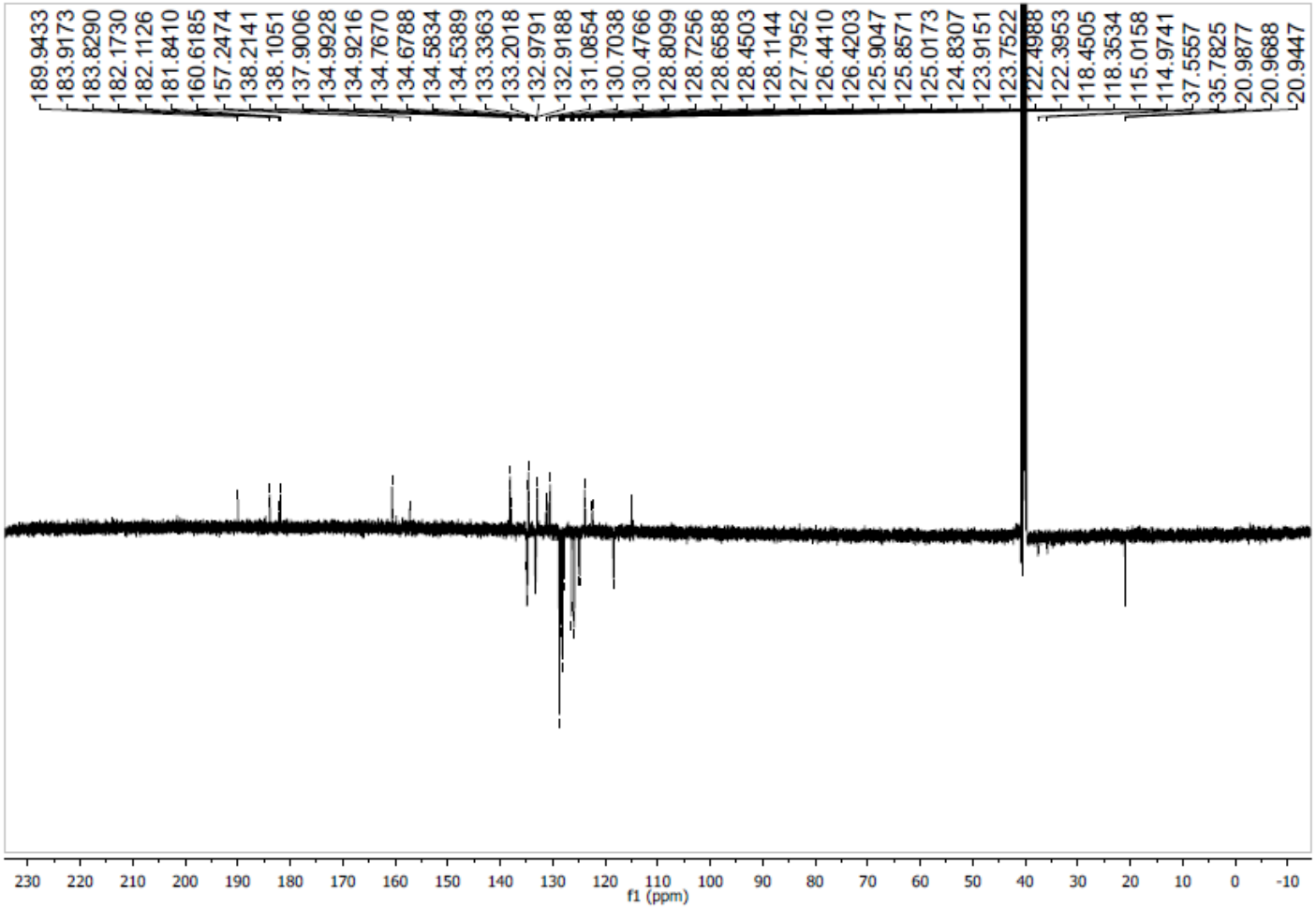

Figure S34. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15b**.

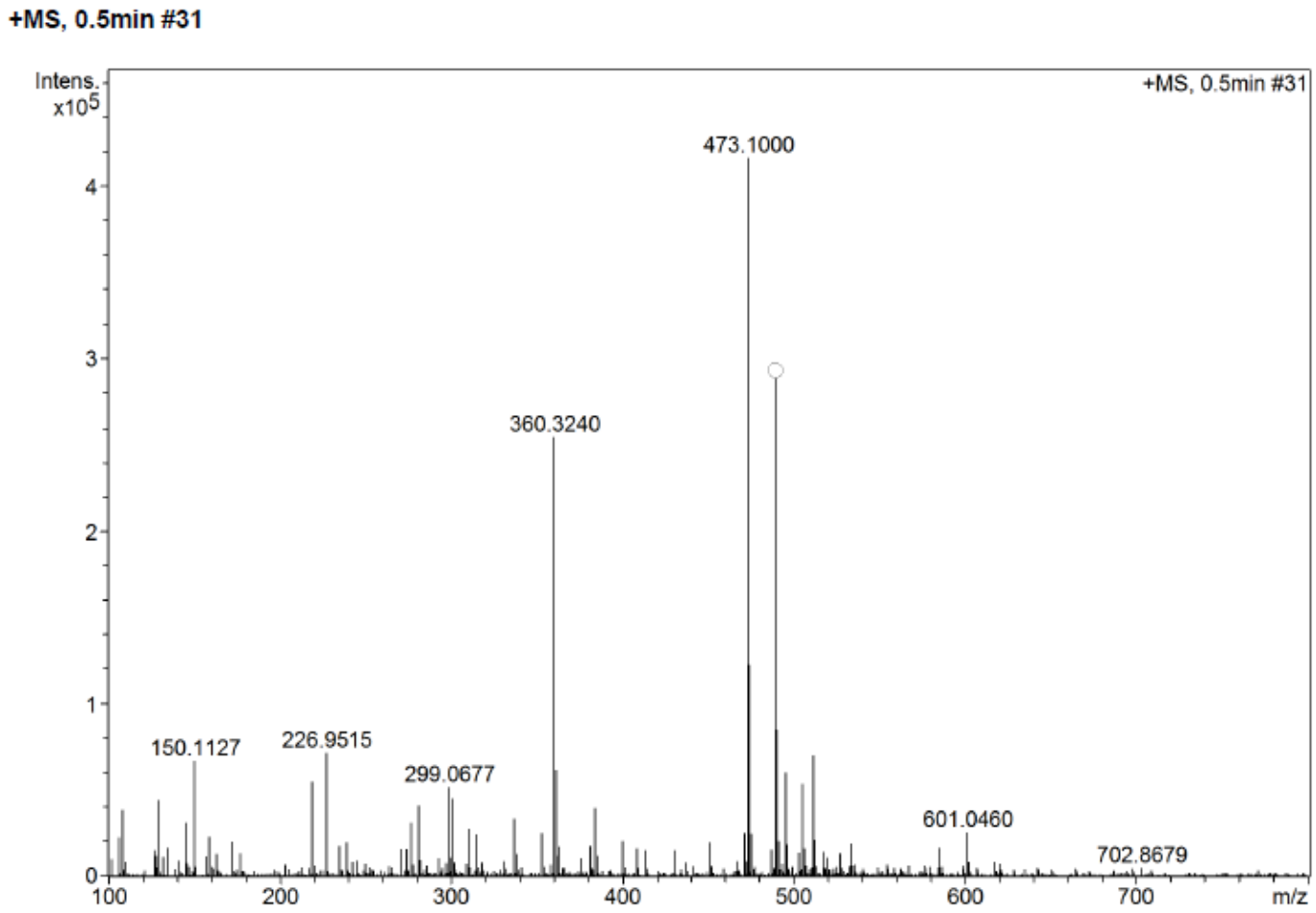

Figure S35. Mass spectrum of compound **15b**.

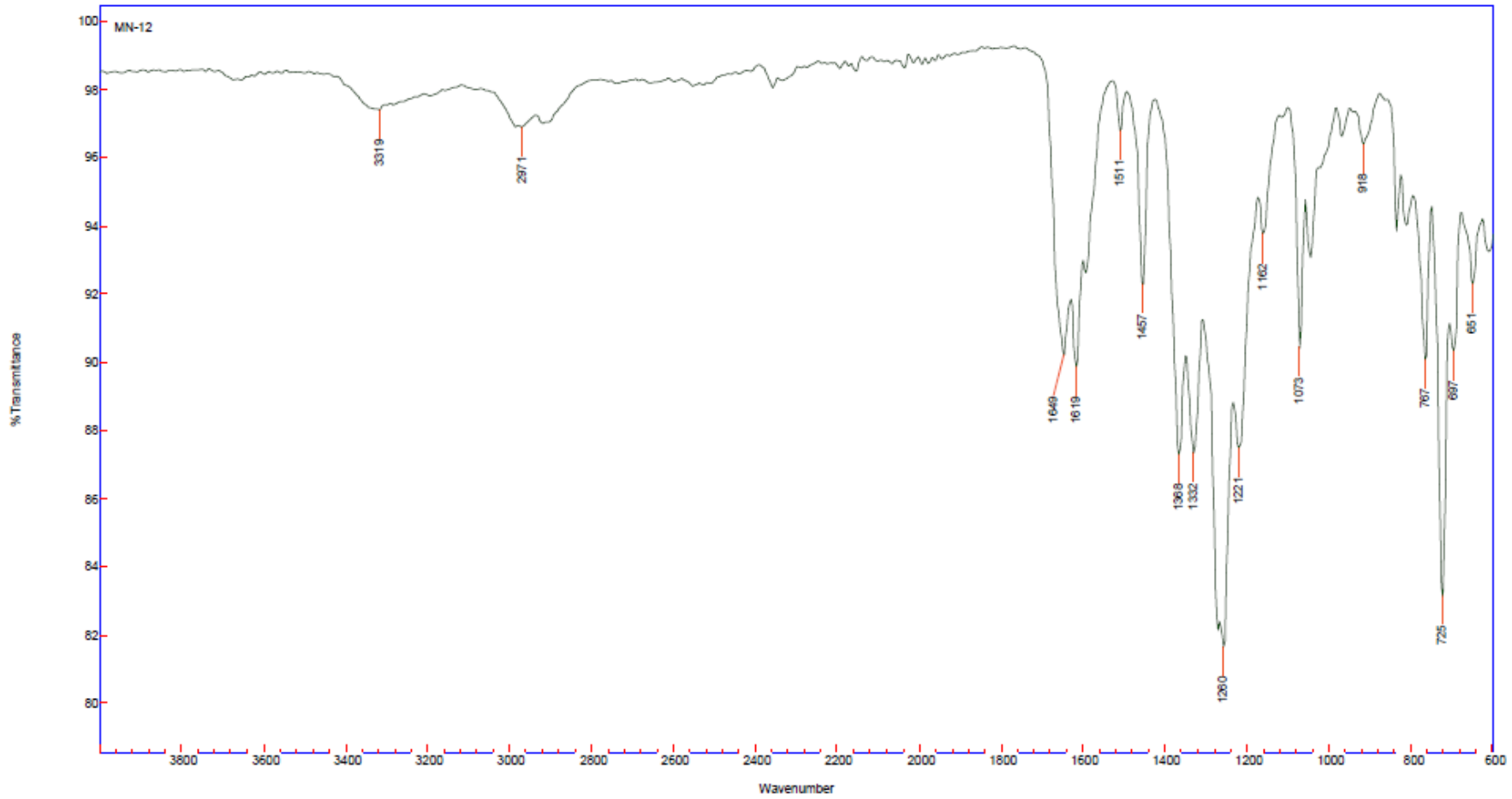

Figure S36. FTIR (KBr) spectrum of compound **15b**.

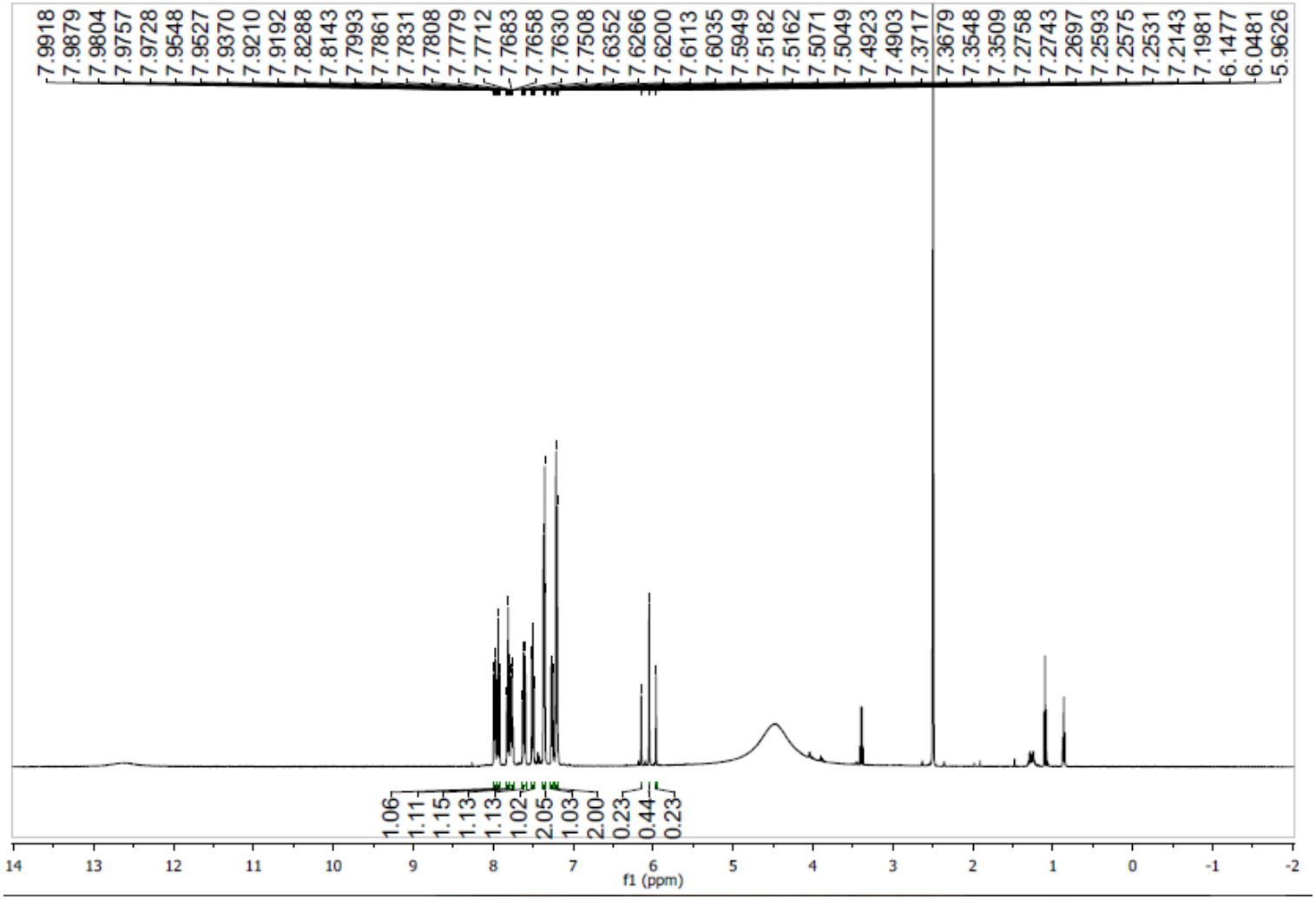

Figure S37. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15c**.

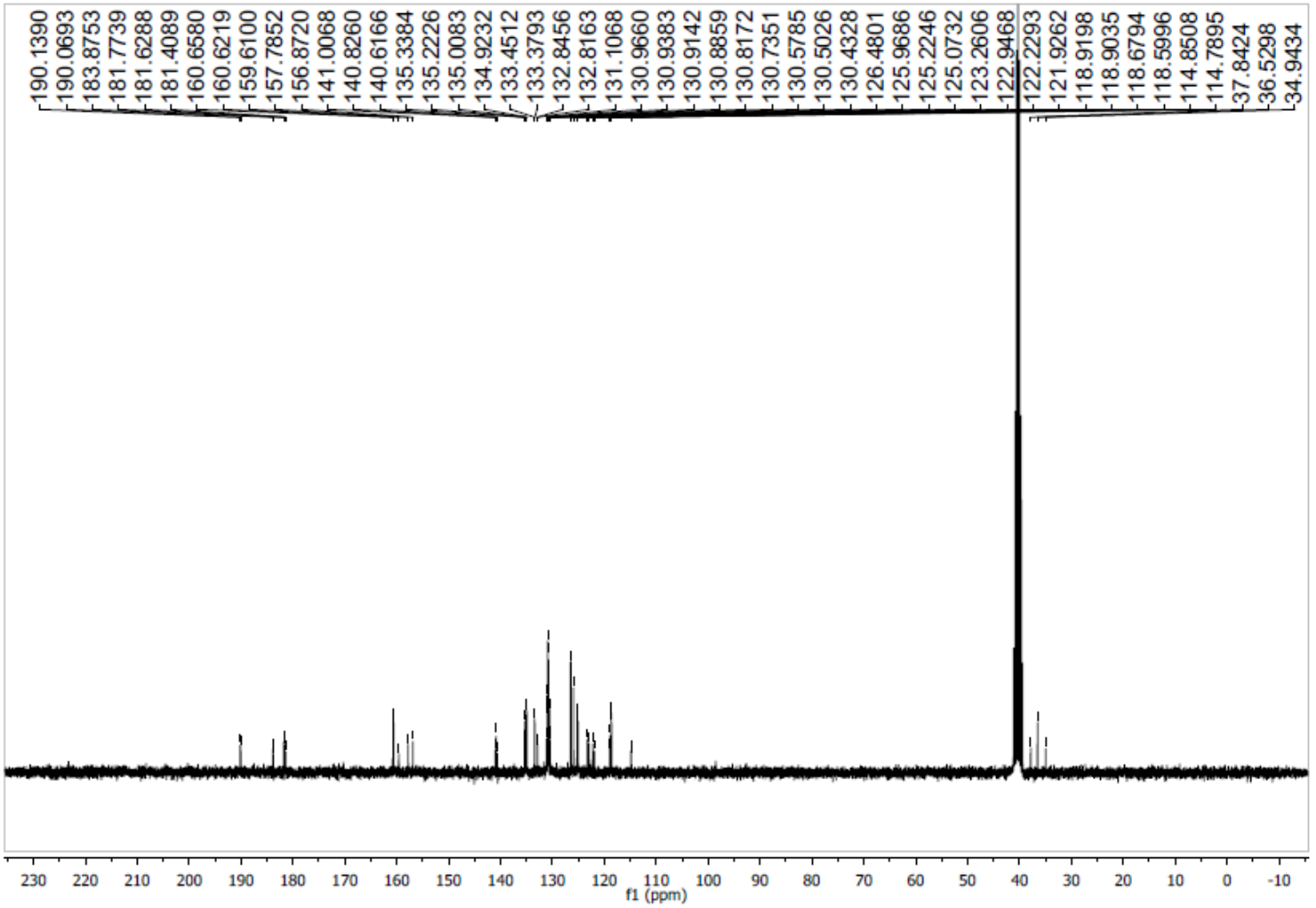

Figure S38. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15c**.

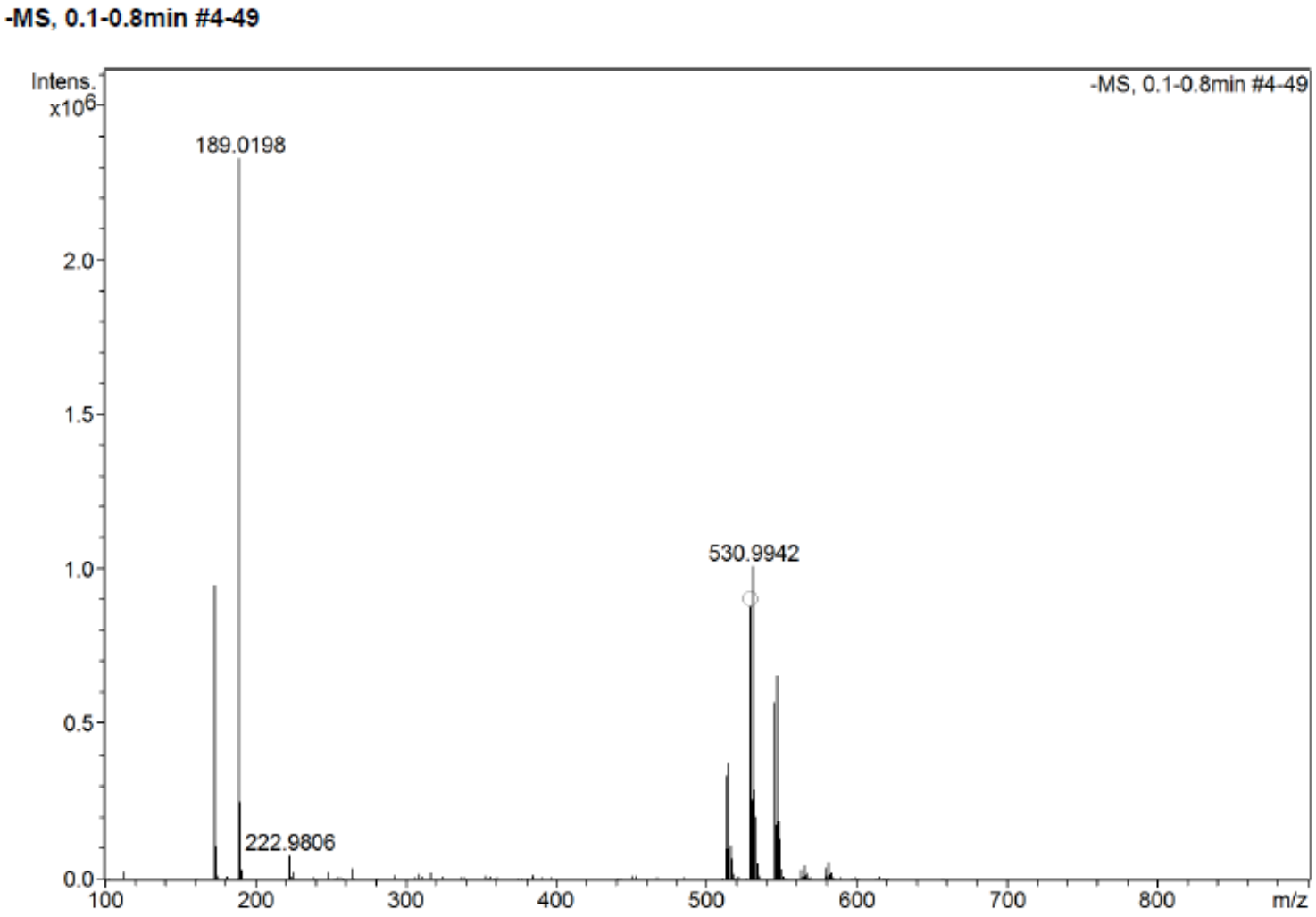

Figure S39. Mass spectrum of compound **15c**.

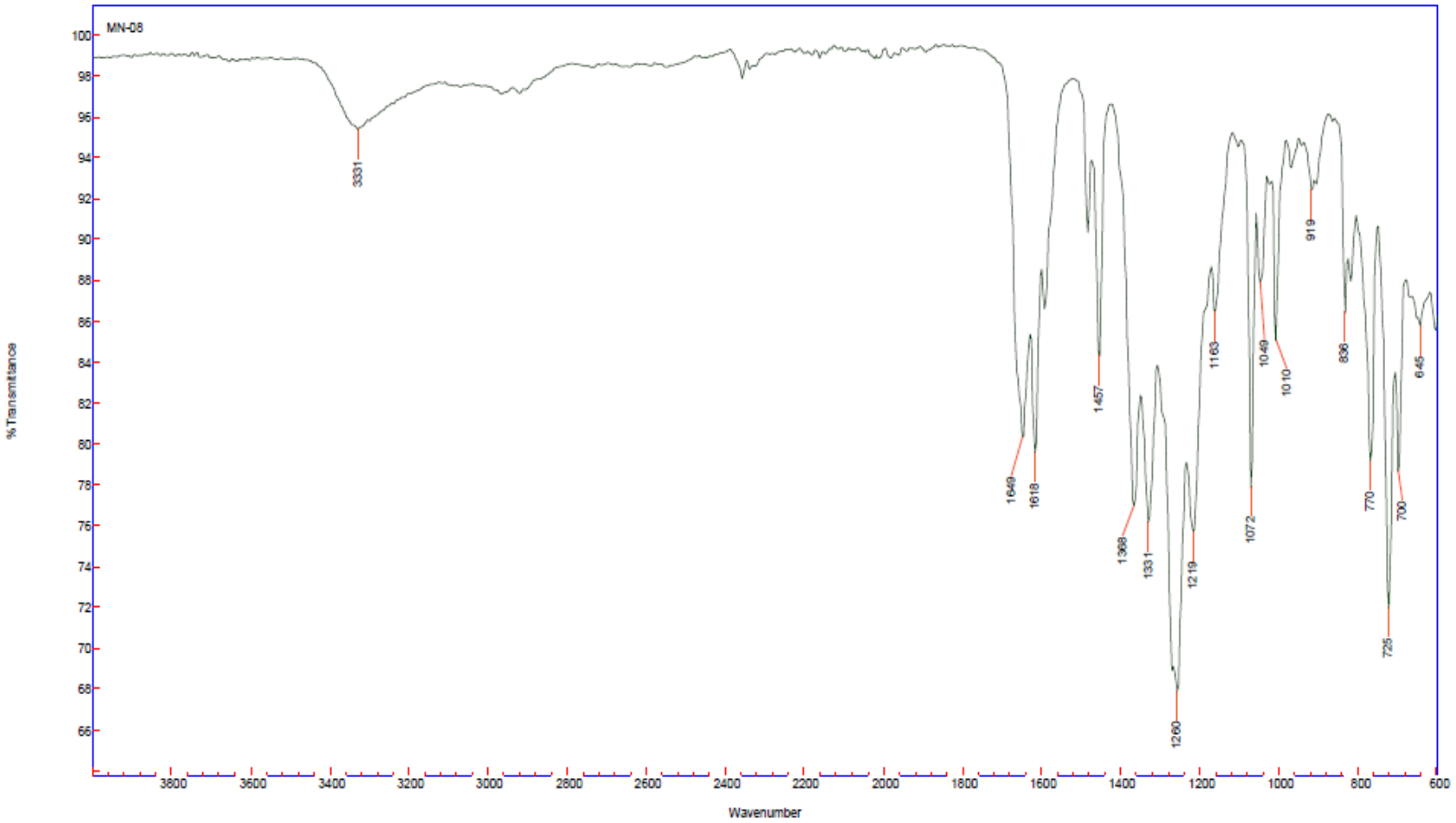

Figure S40. FTIR (KBr) spectrum of compound **15c**.

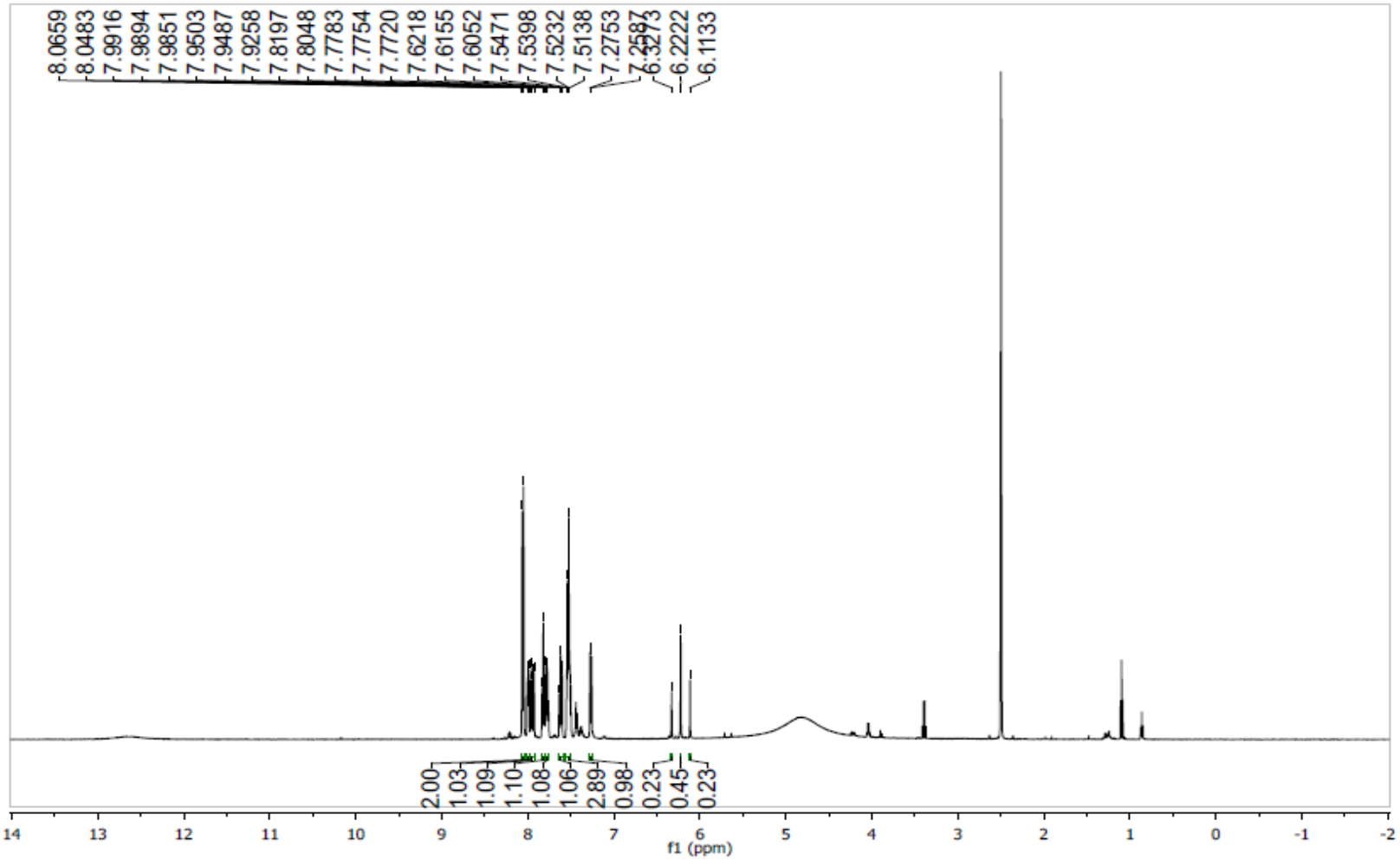

Figure S41. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15d**.

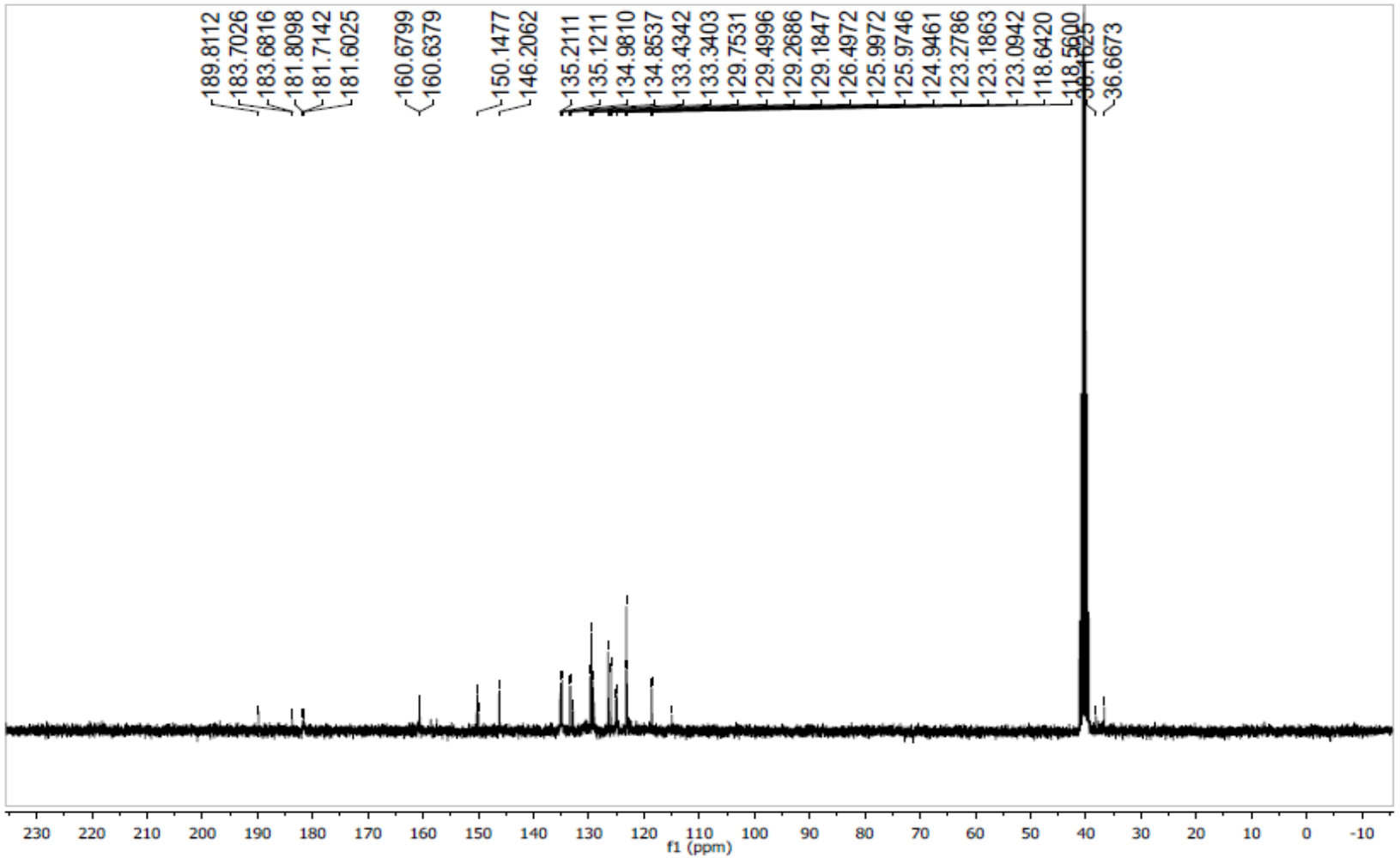

Figure S42. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15d**.

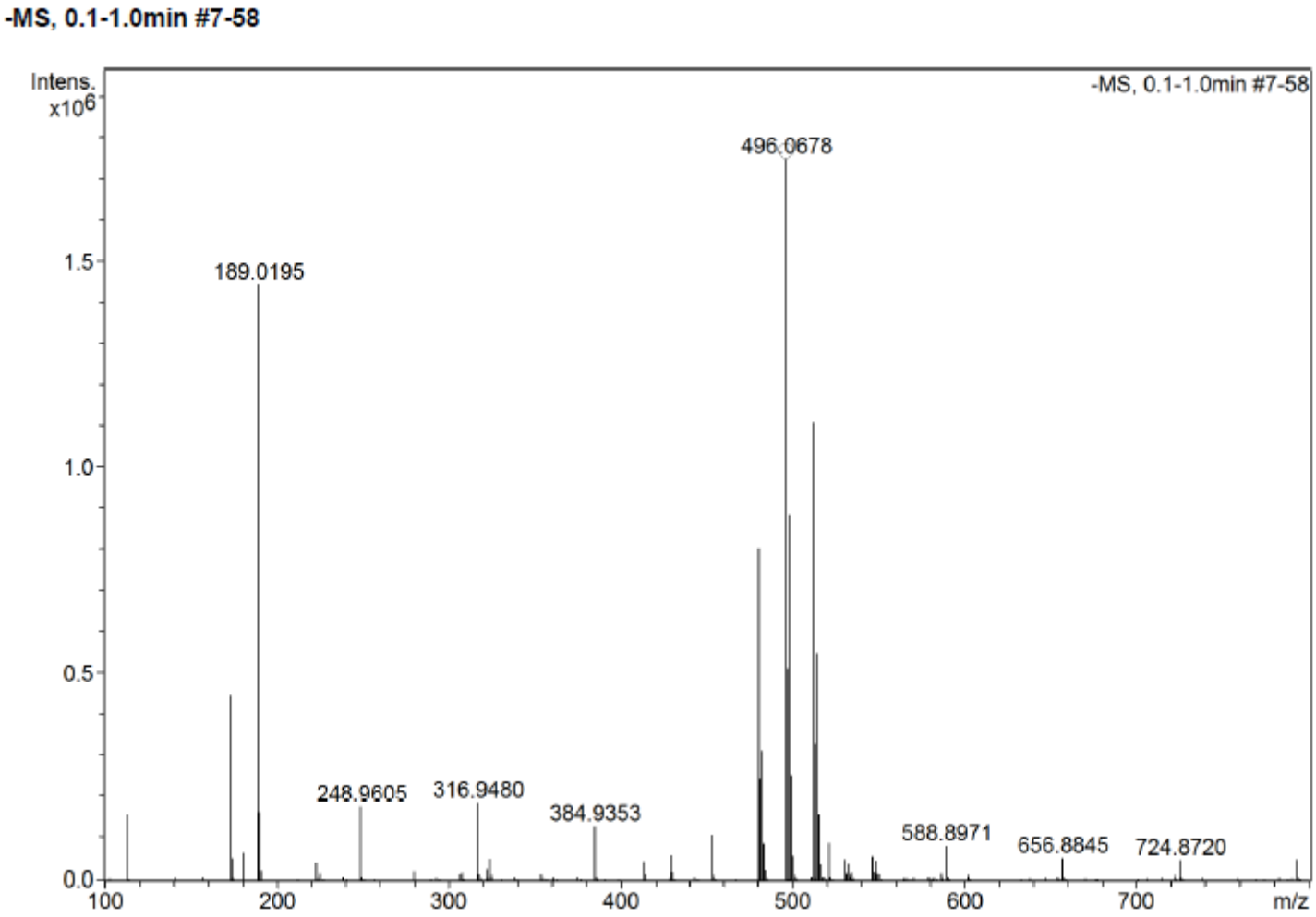

Figure S43. Mass spectrum of compound **15d**.

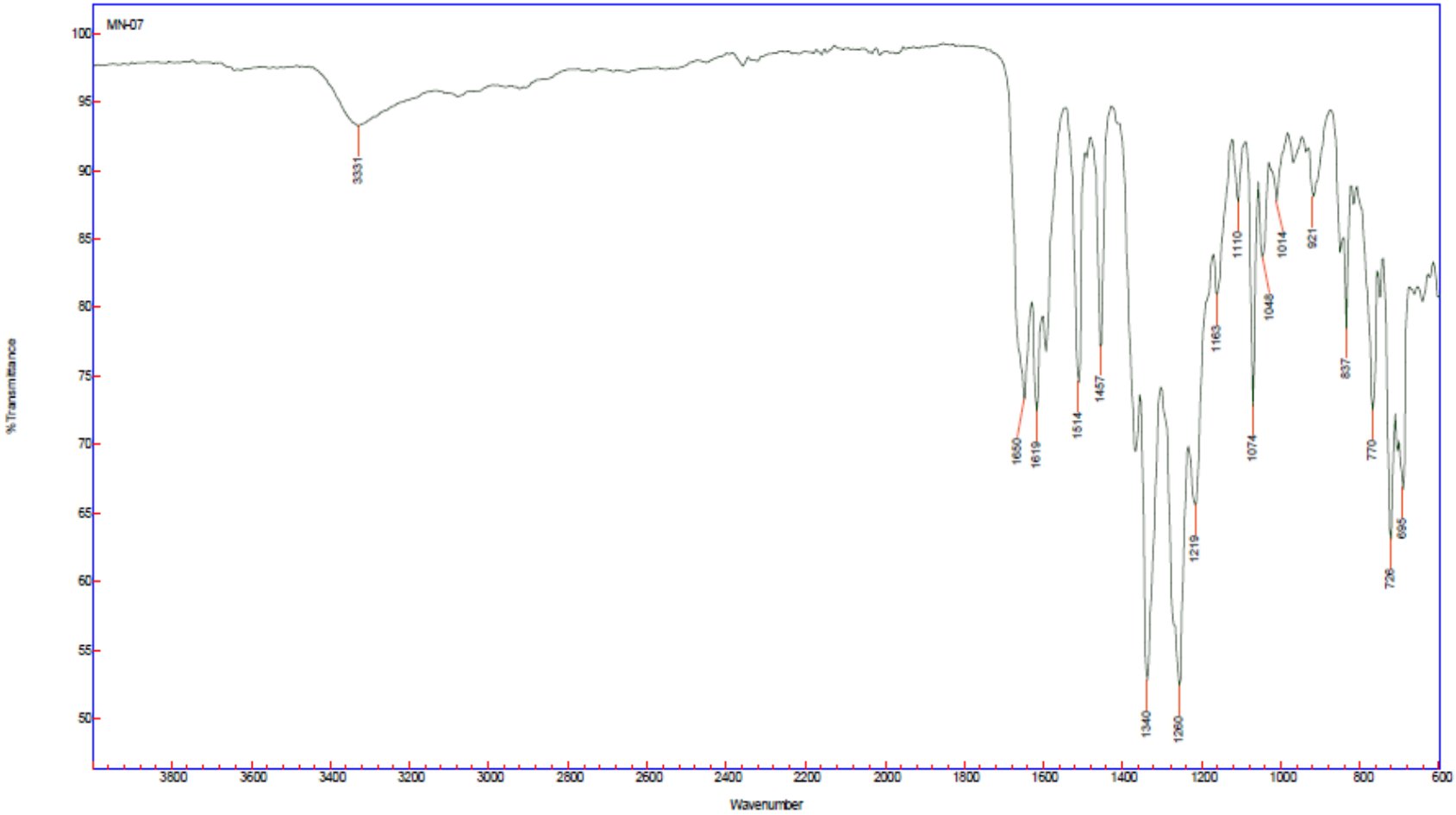

Figure S44. FTIR (KBr) spectrum of compound **15a**.

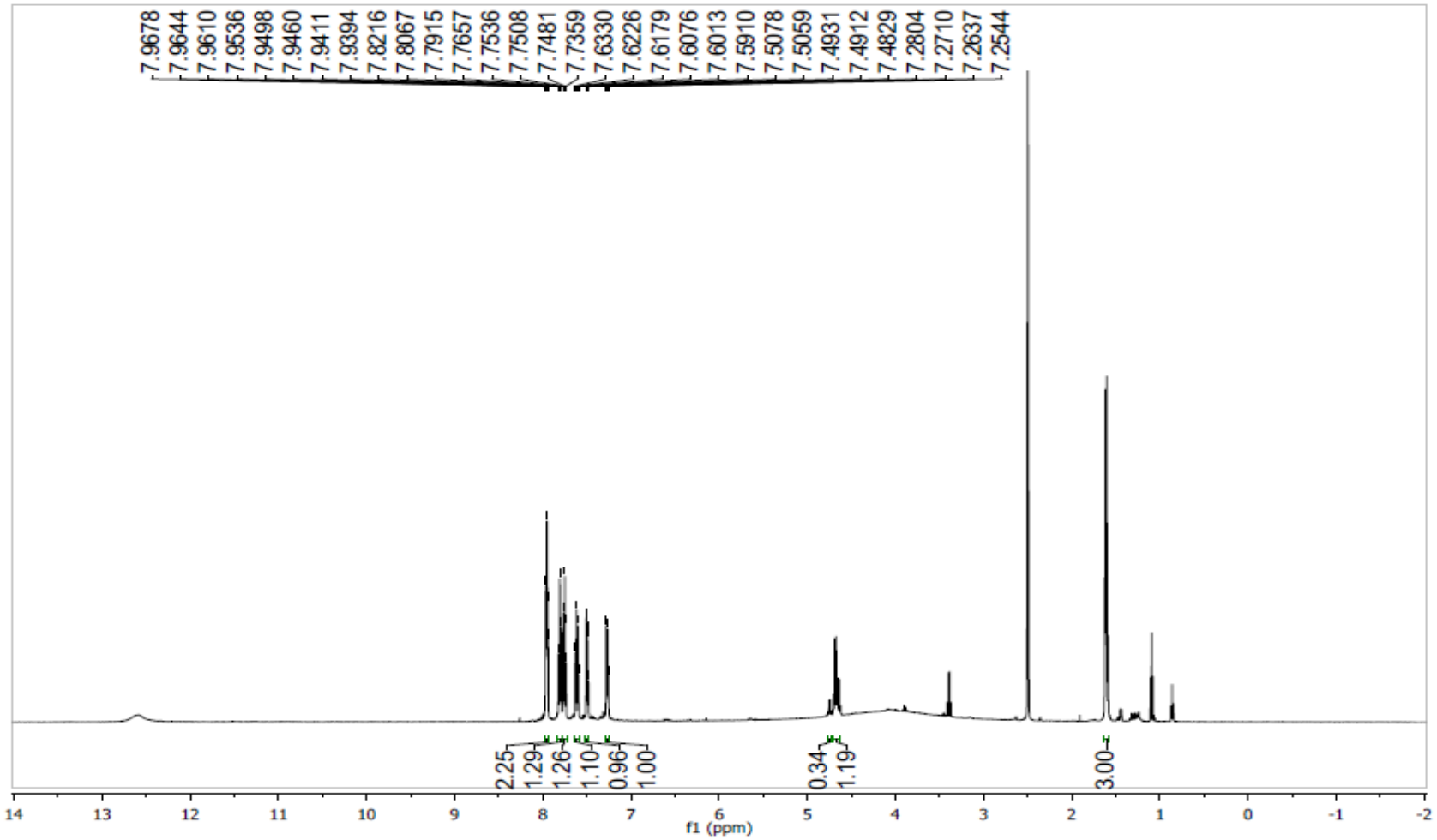

Figure S45. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15e**.

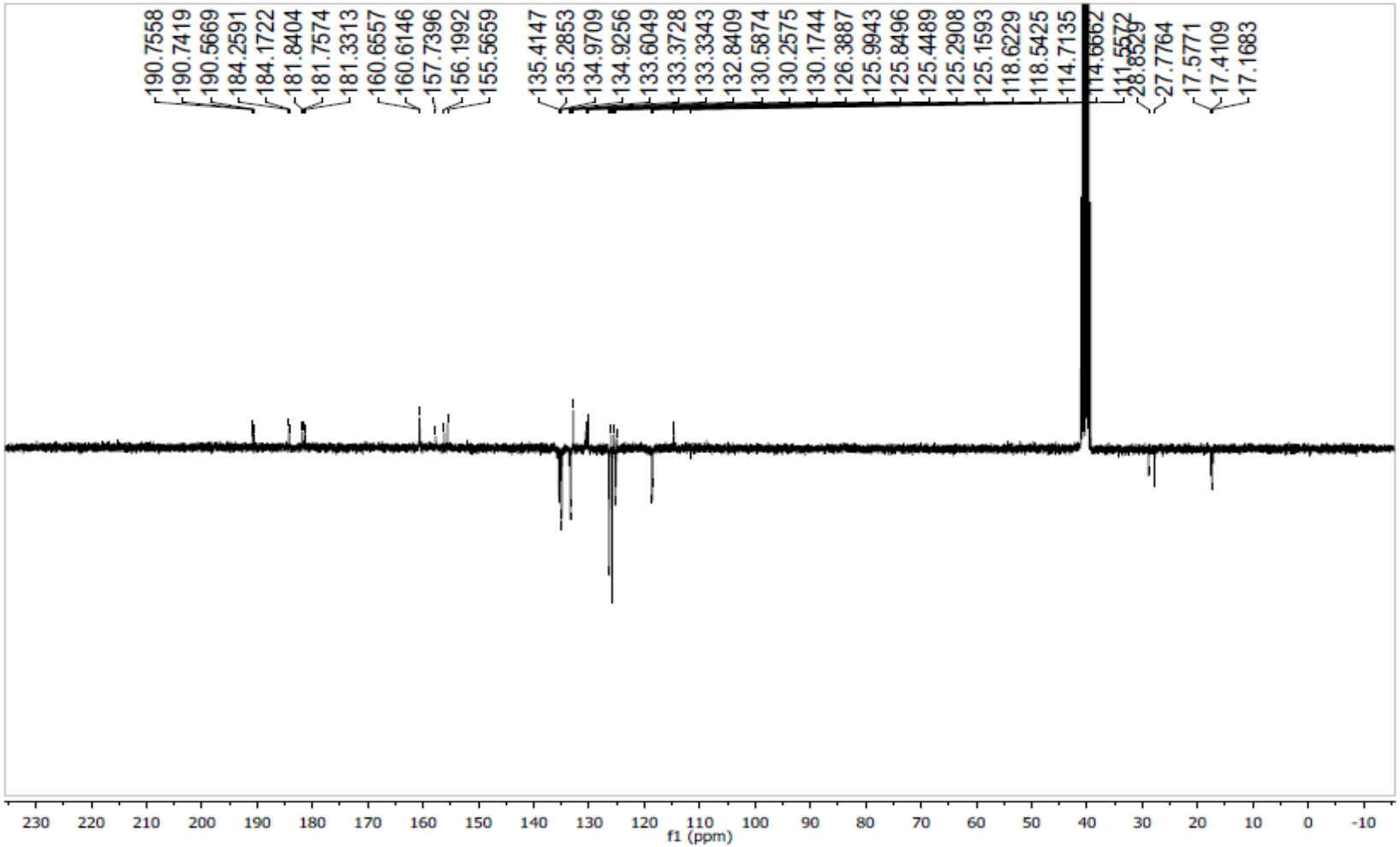

Figure S46. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15e**.

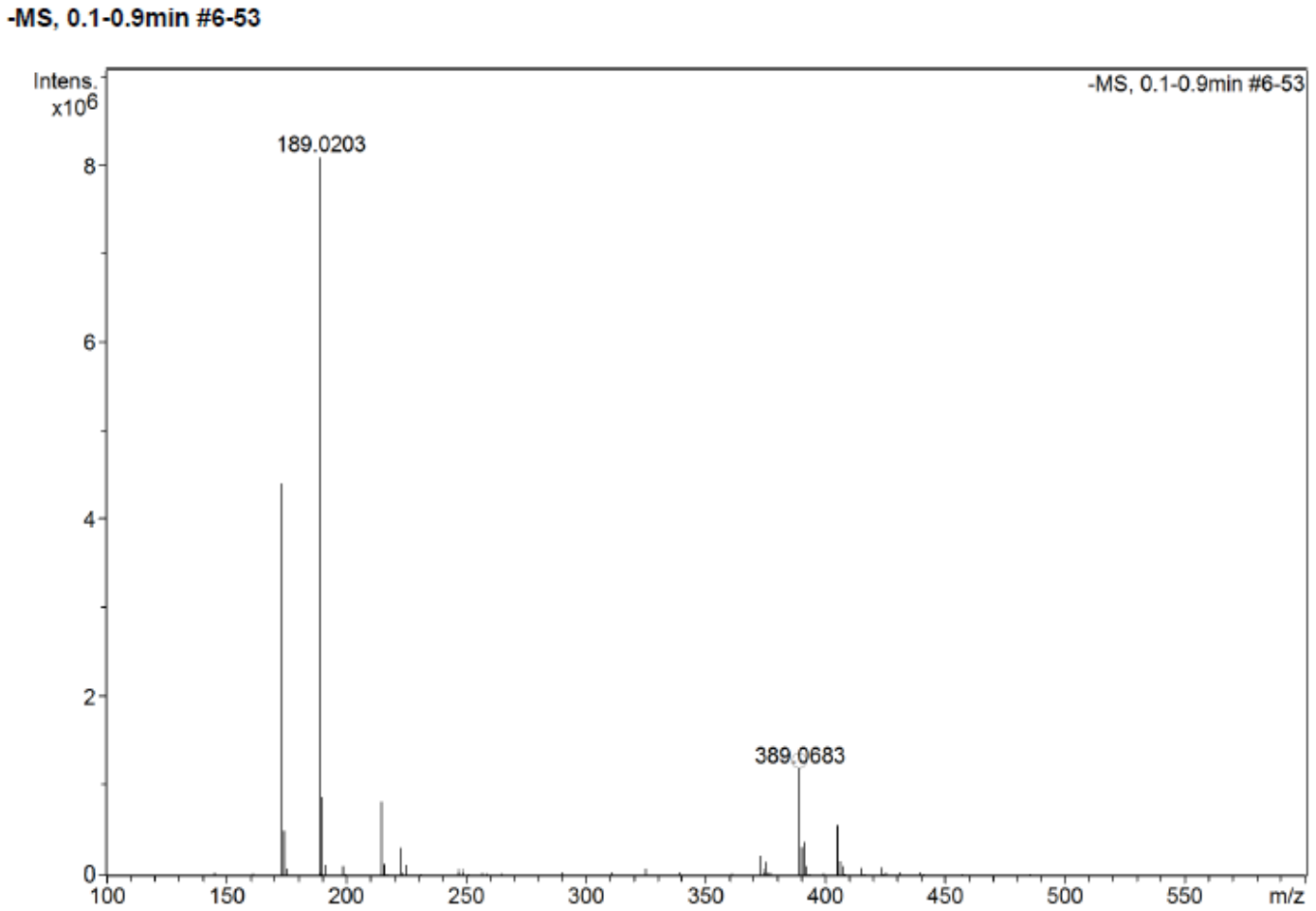

Figure S47. Mass spectrum of compound **15e**.

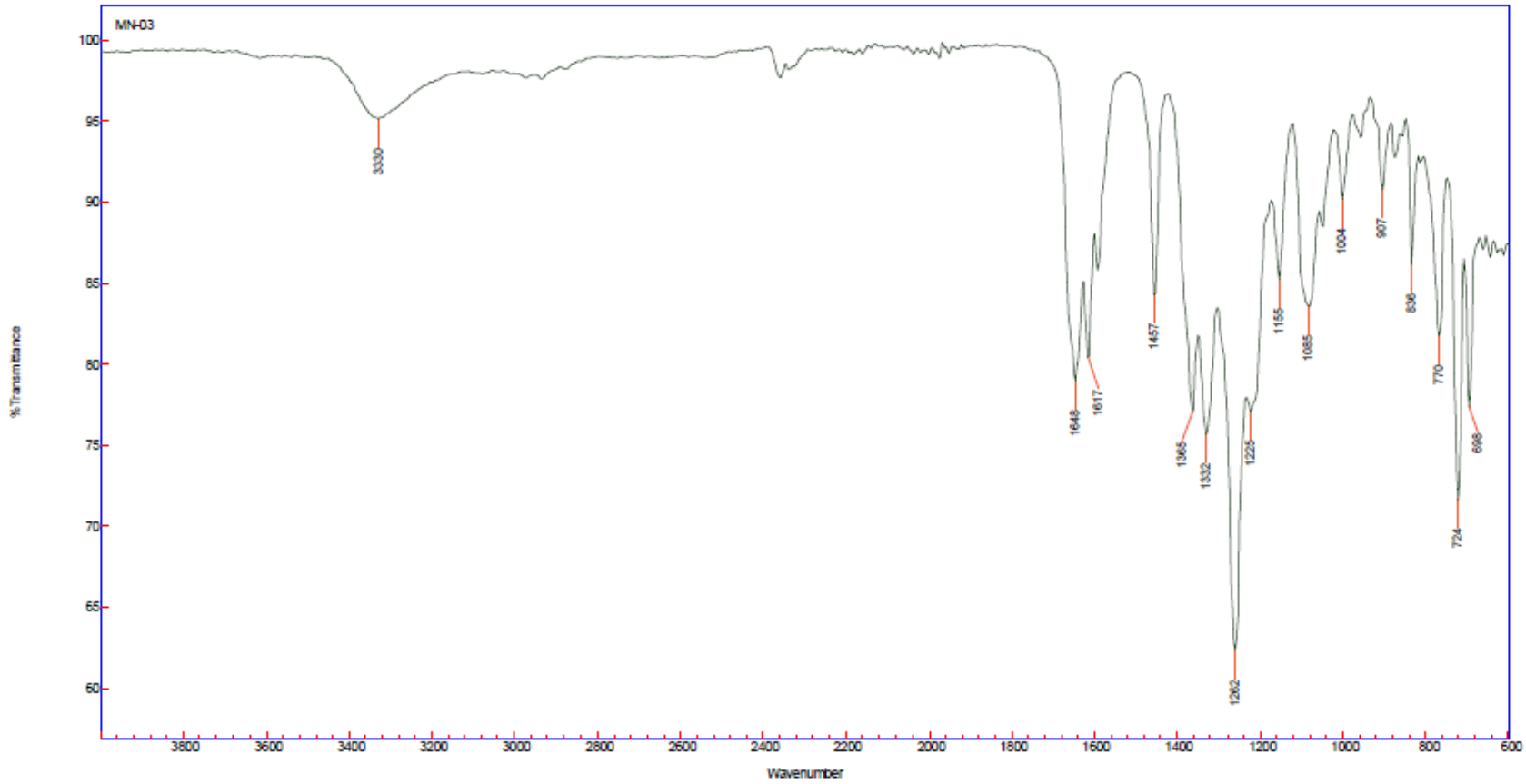

Figure S48. FTIR (KBr) spectrum of compound **15e**.

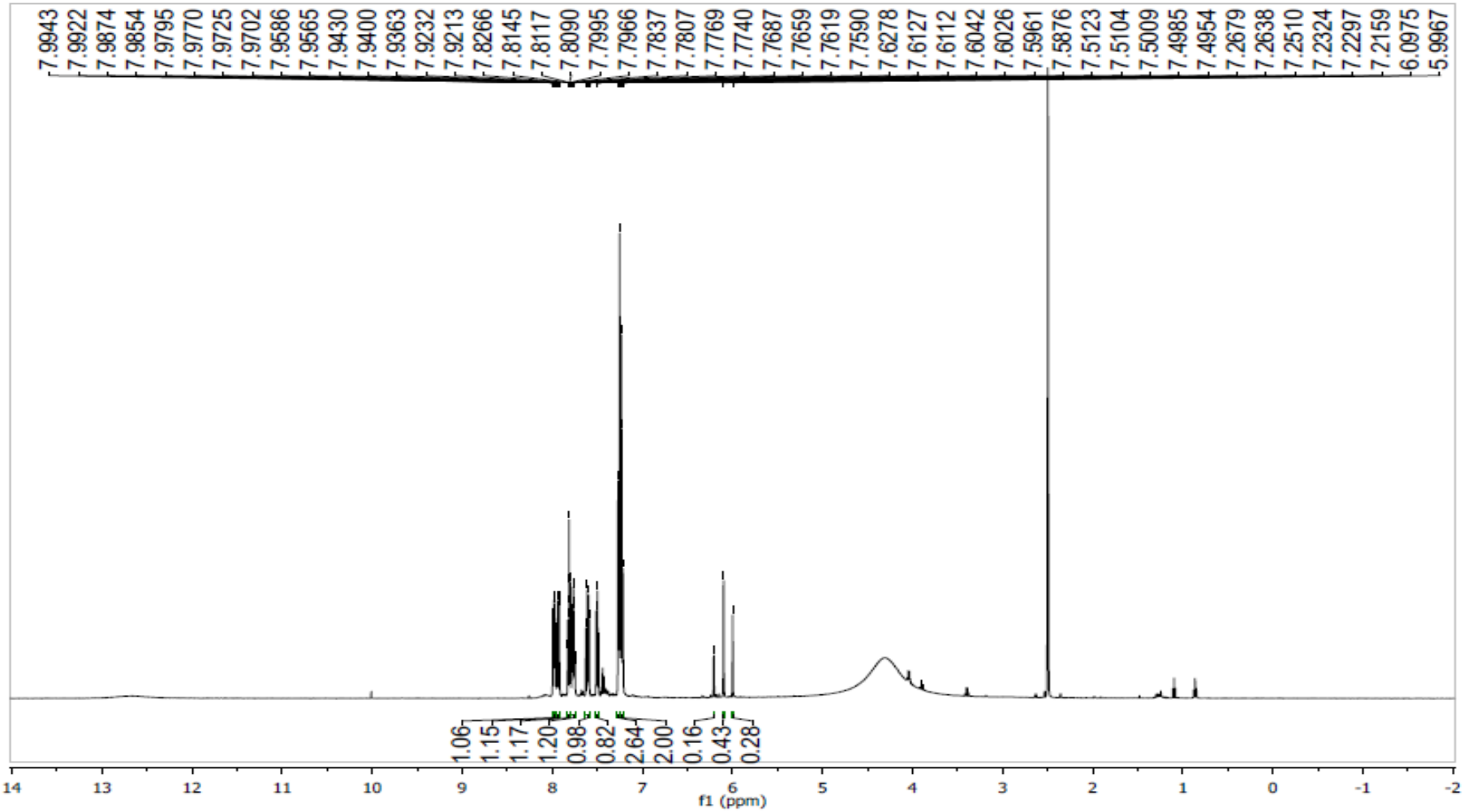

Figure S49. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15f**.

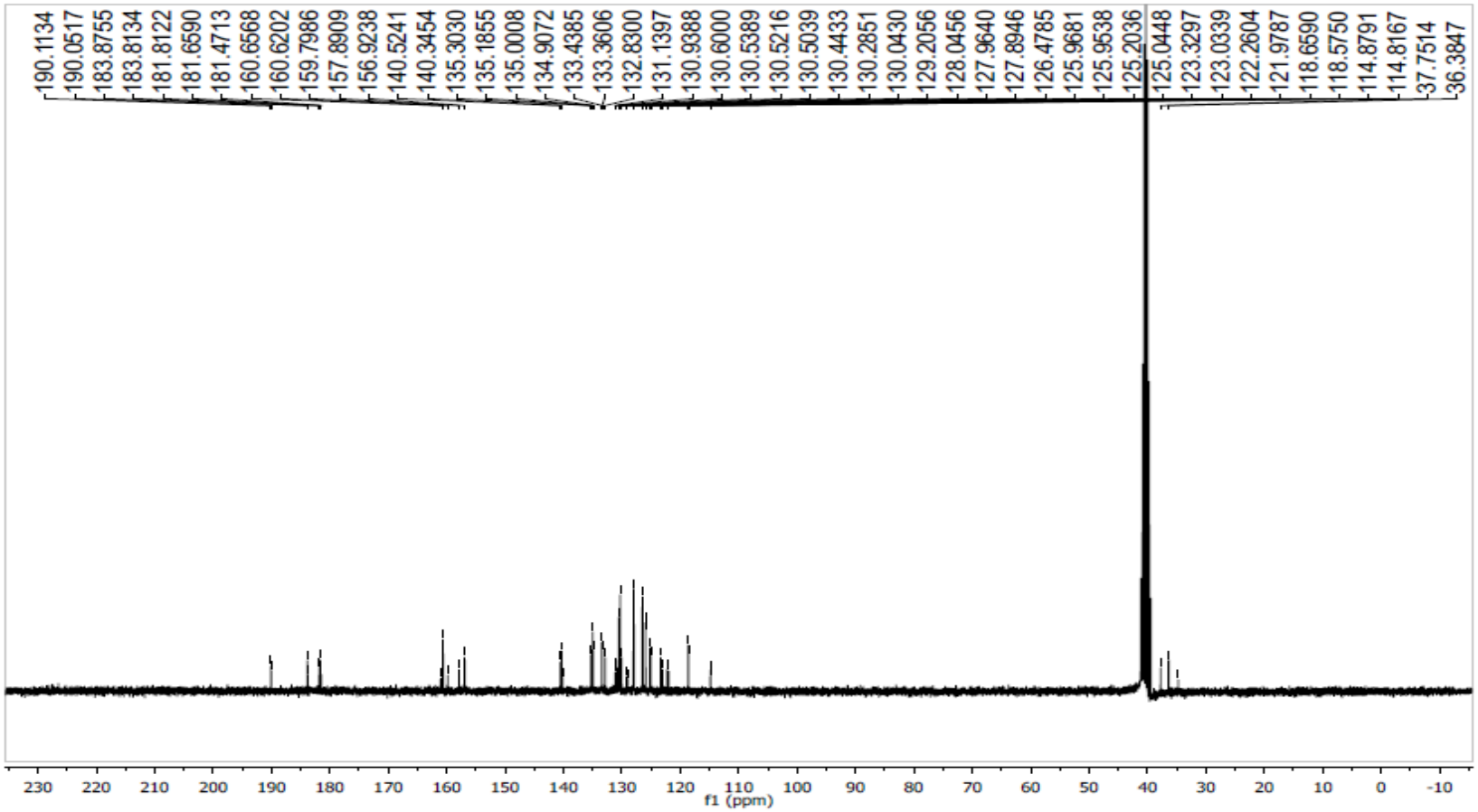

Figure S50. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15f**.

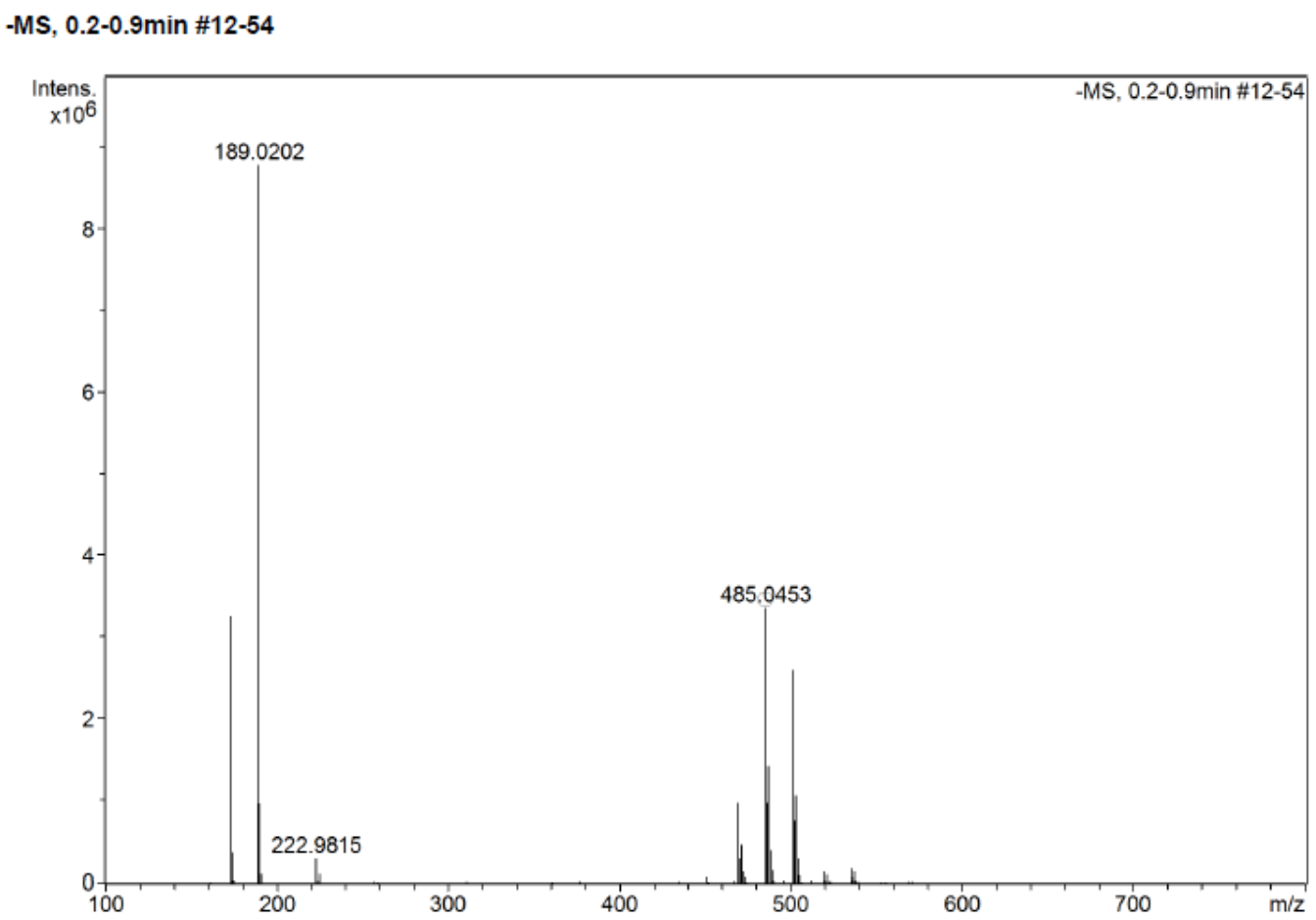

Figure S51. Mass spectrum of compound **15f**.

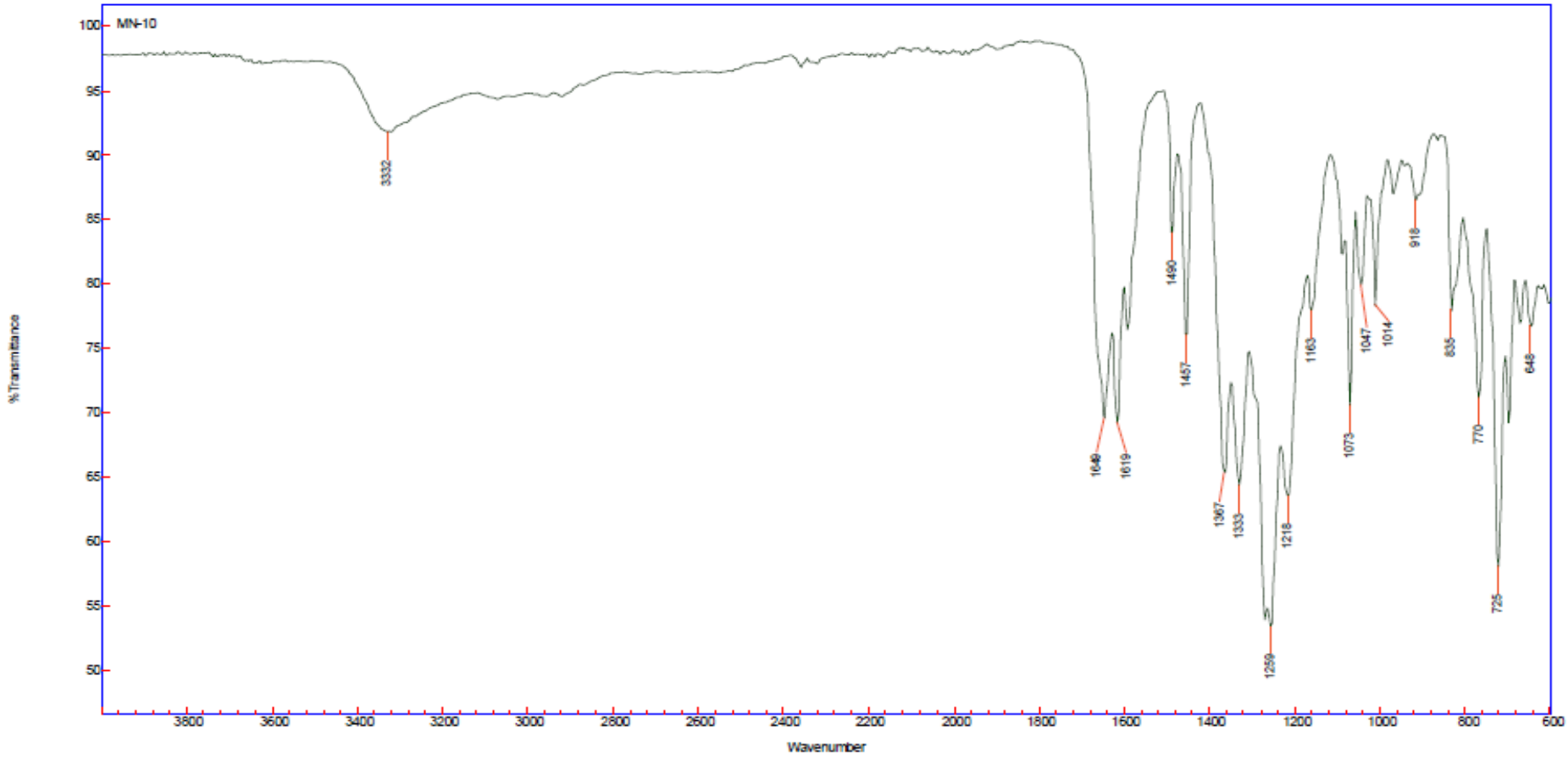

Figure S52. FTIR (KBr) spectrum of compound **15f**.

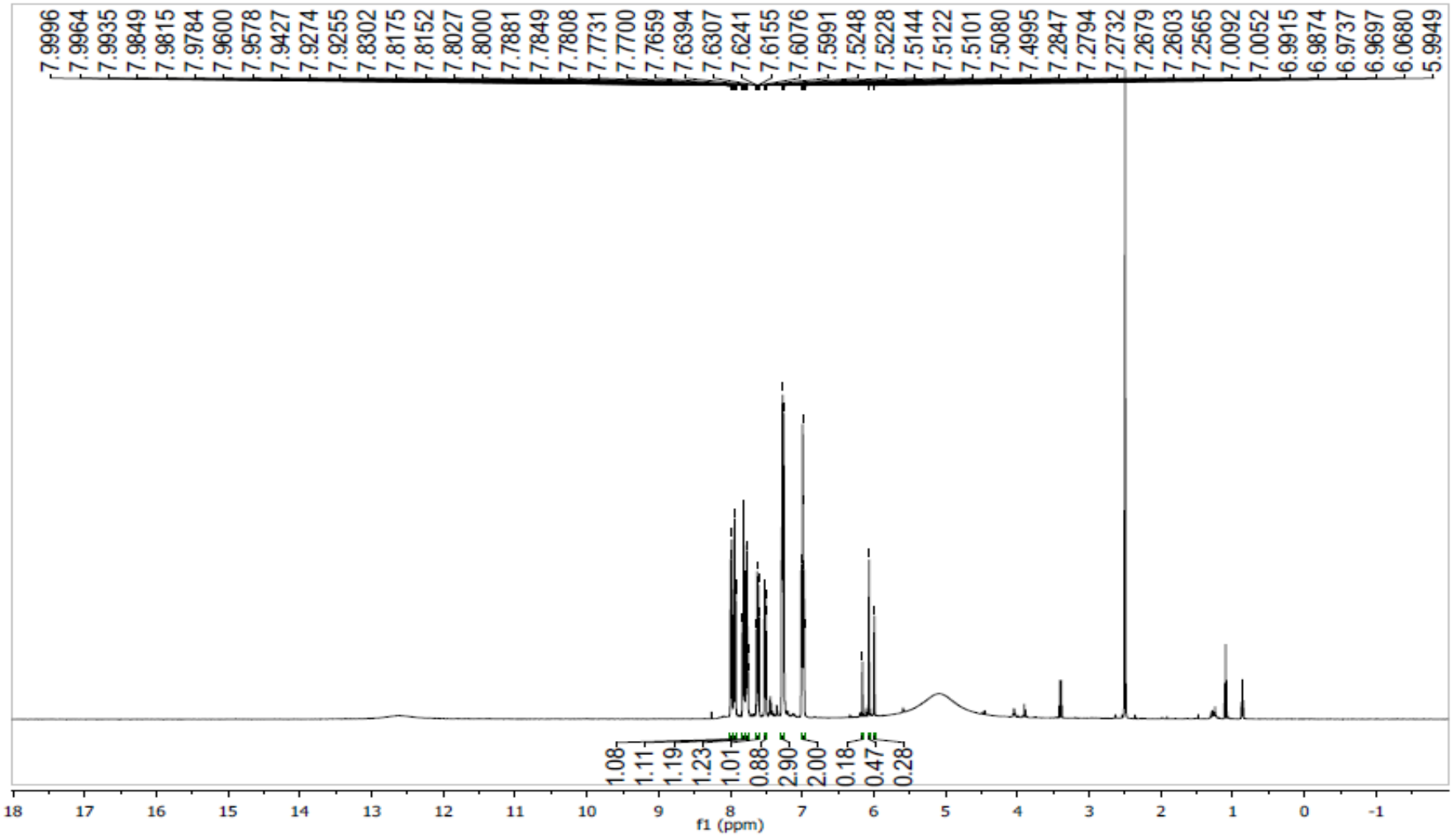

Figure S53. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15g**.

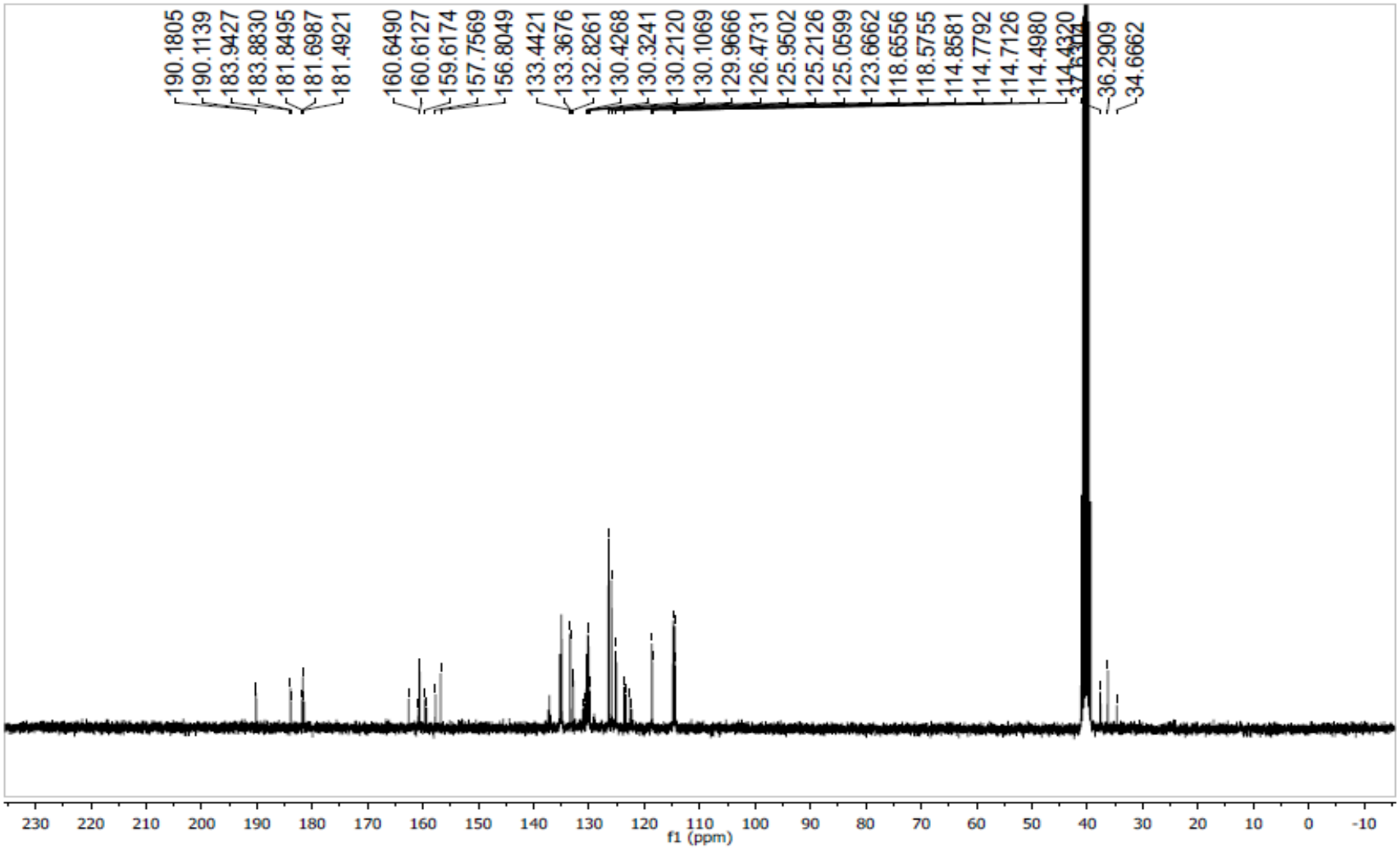

Figure S54. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15g**.

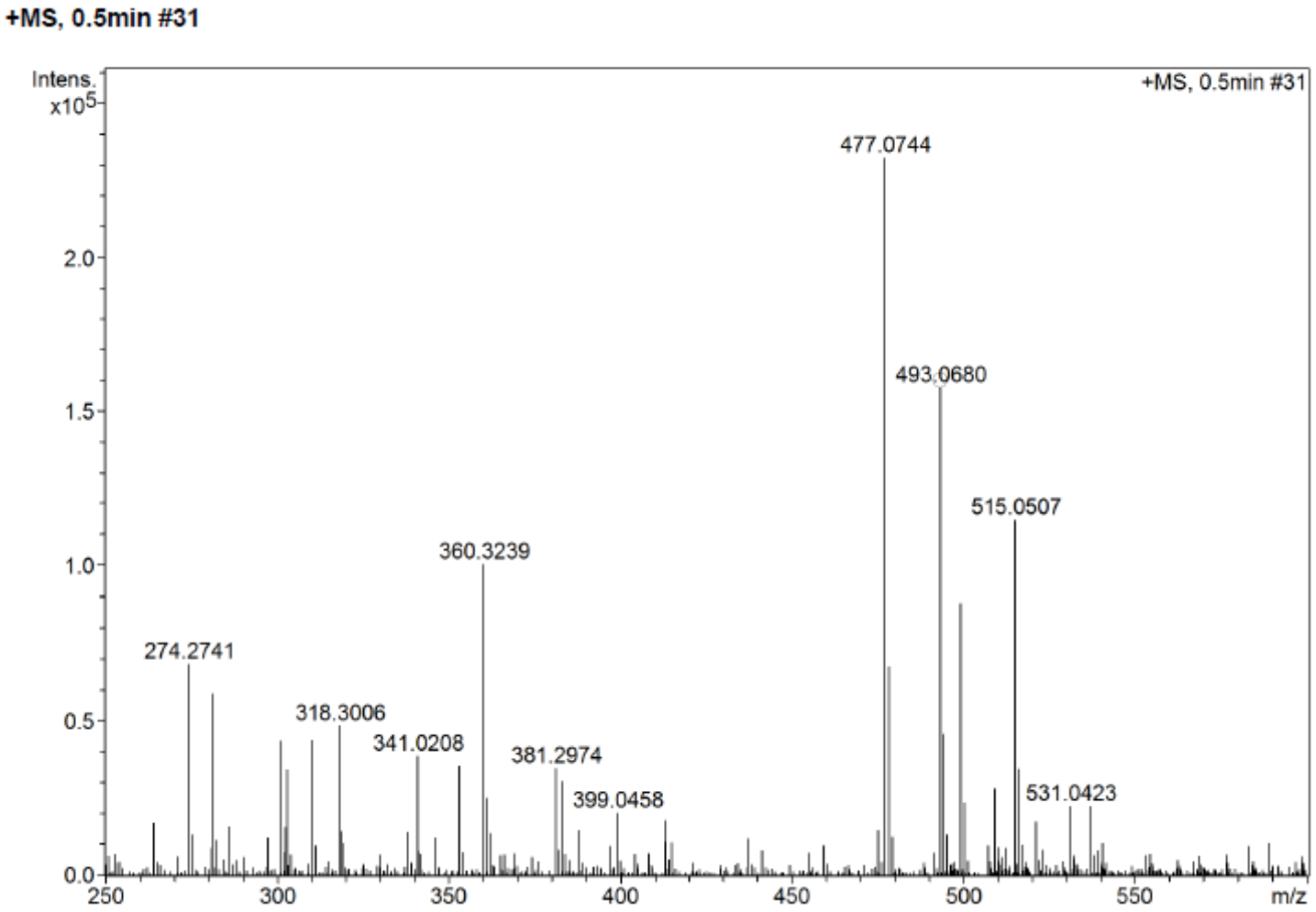

Figure S55. Mass spectrum of compound **15g**.

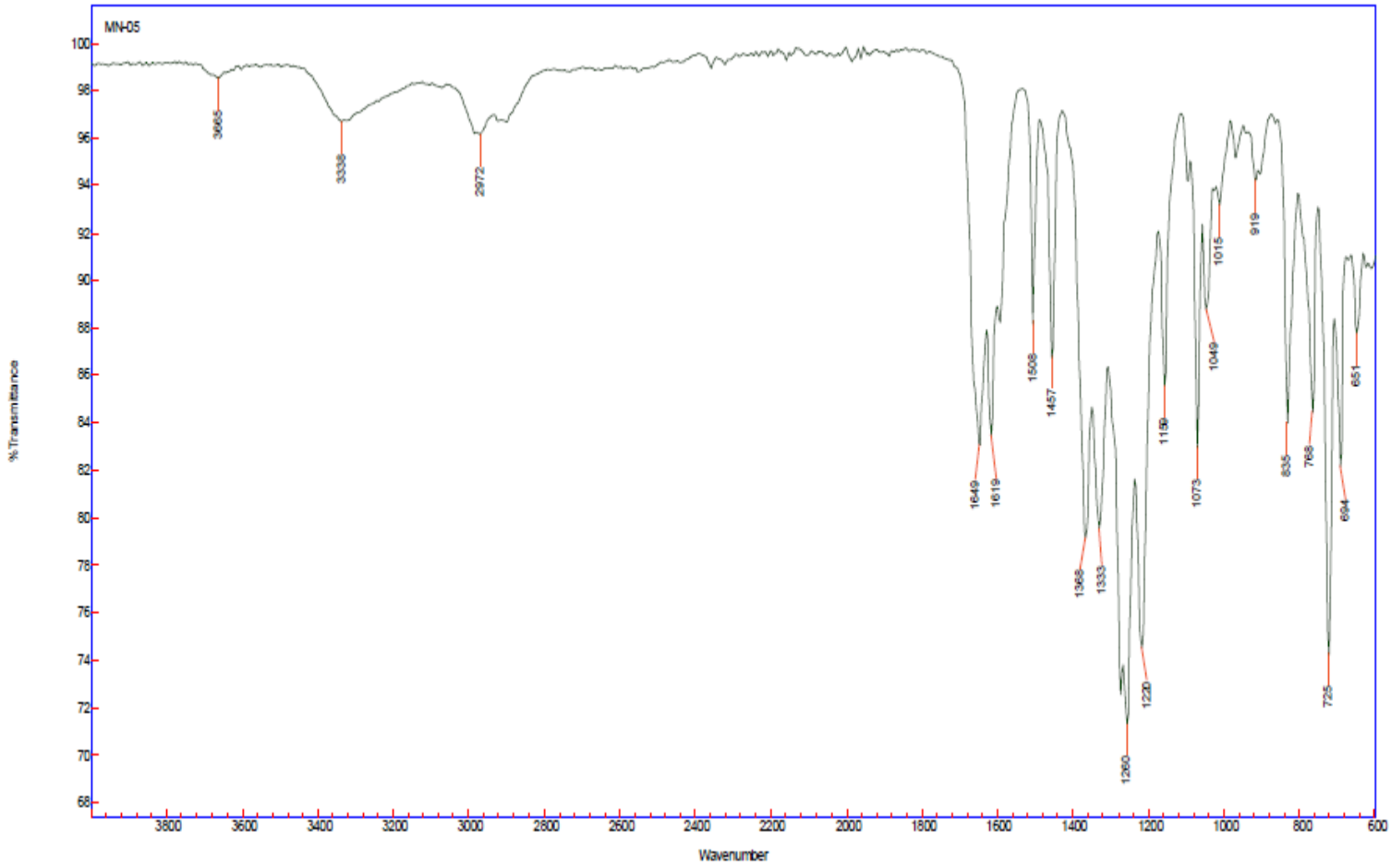

Figure S56. FTIR (KBr) spectrum of compound **15g**.

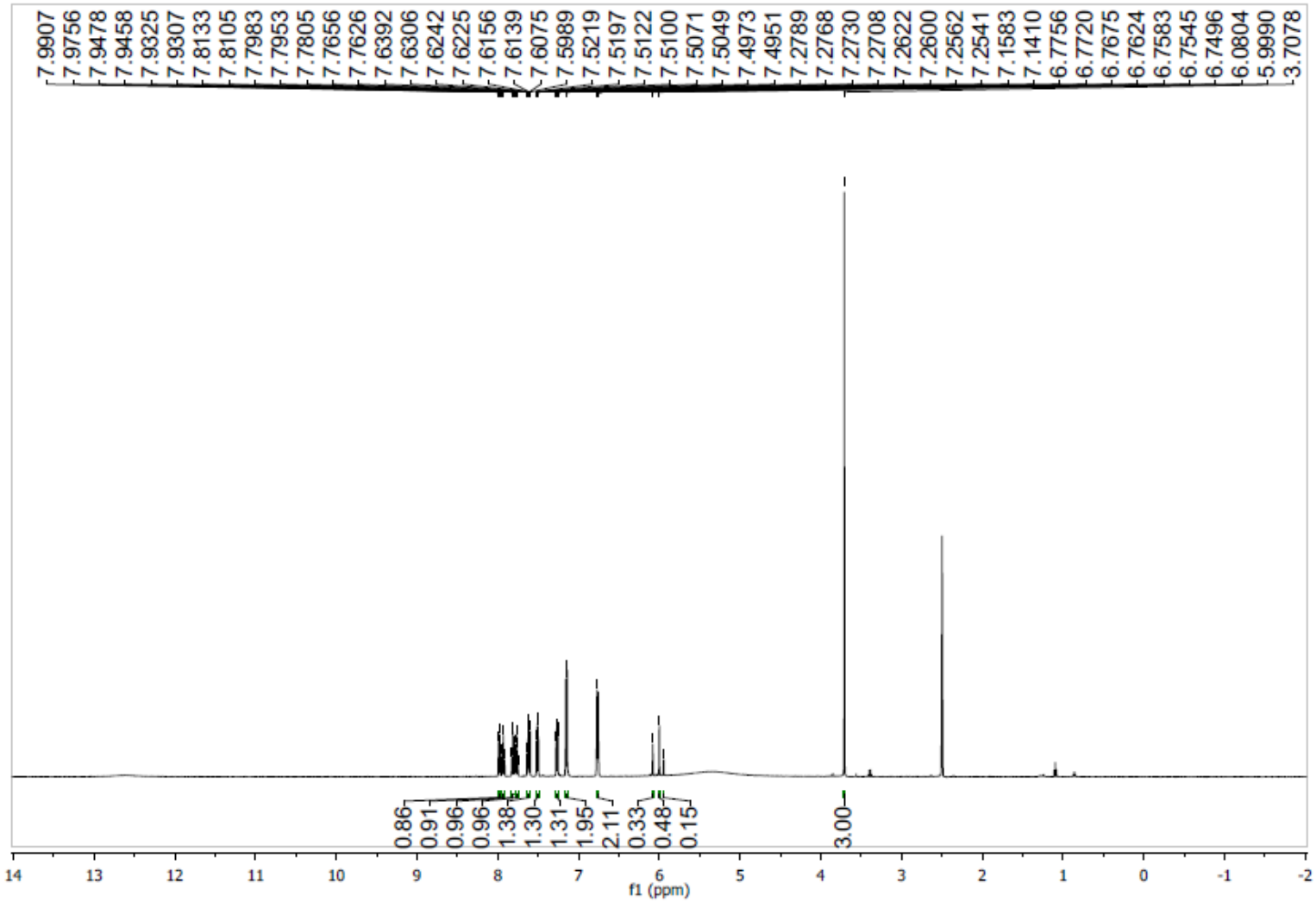

Figure S57. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15h**.

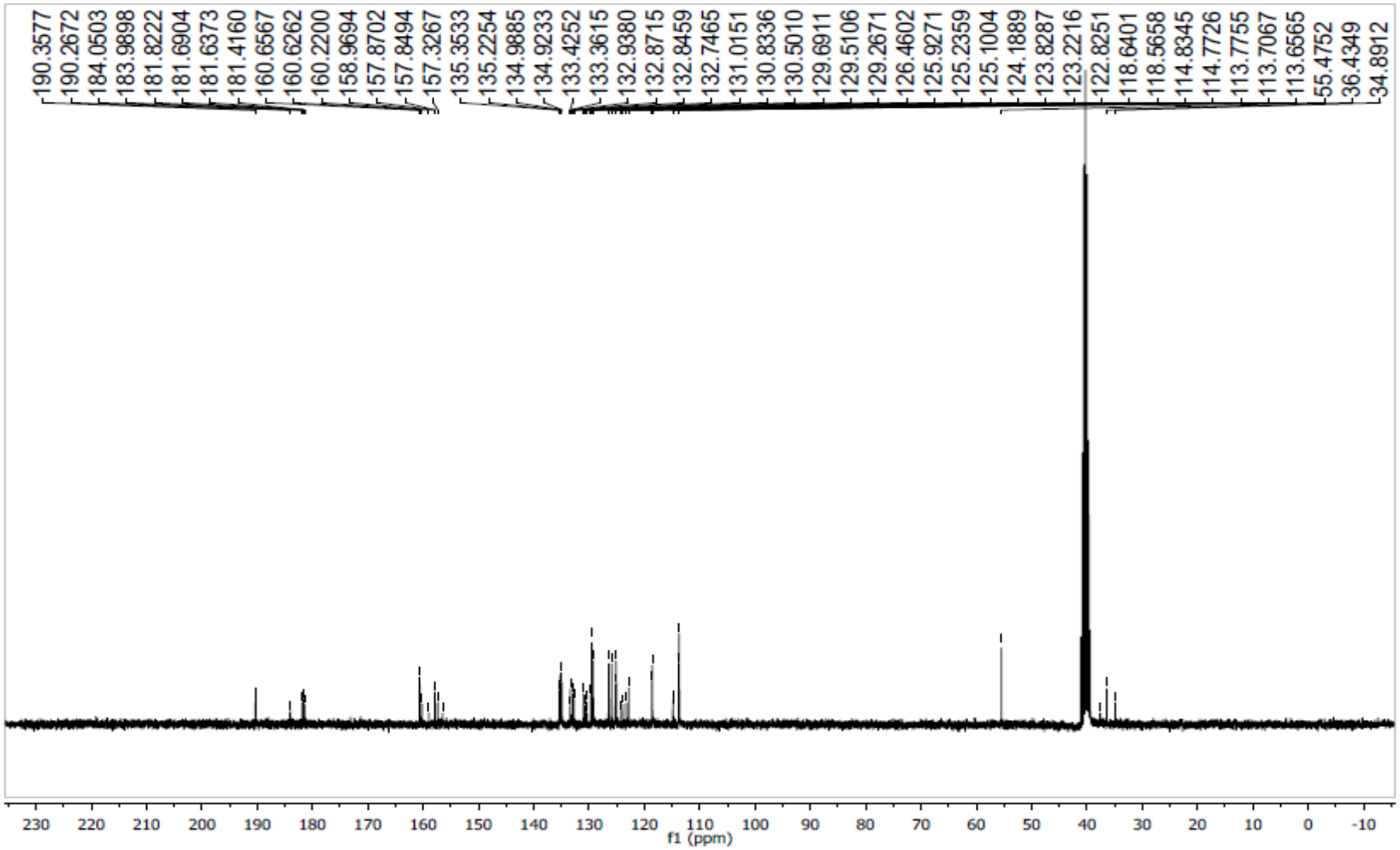

Figure S58. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15h**.

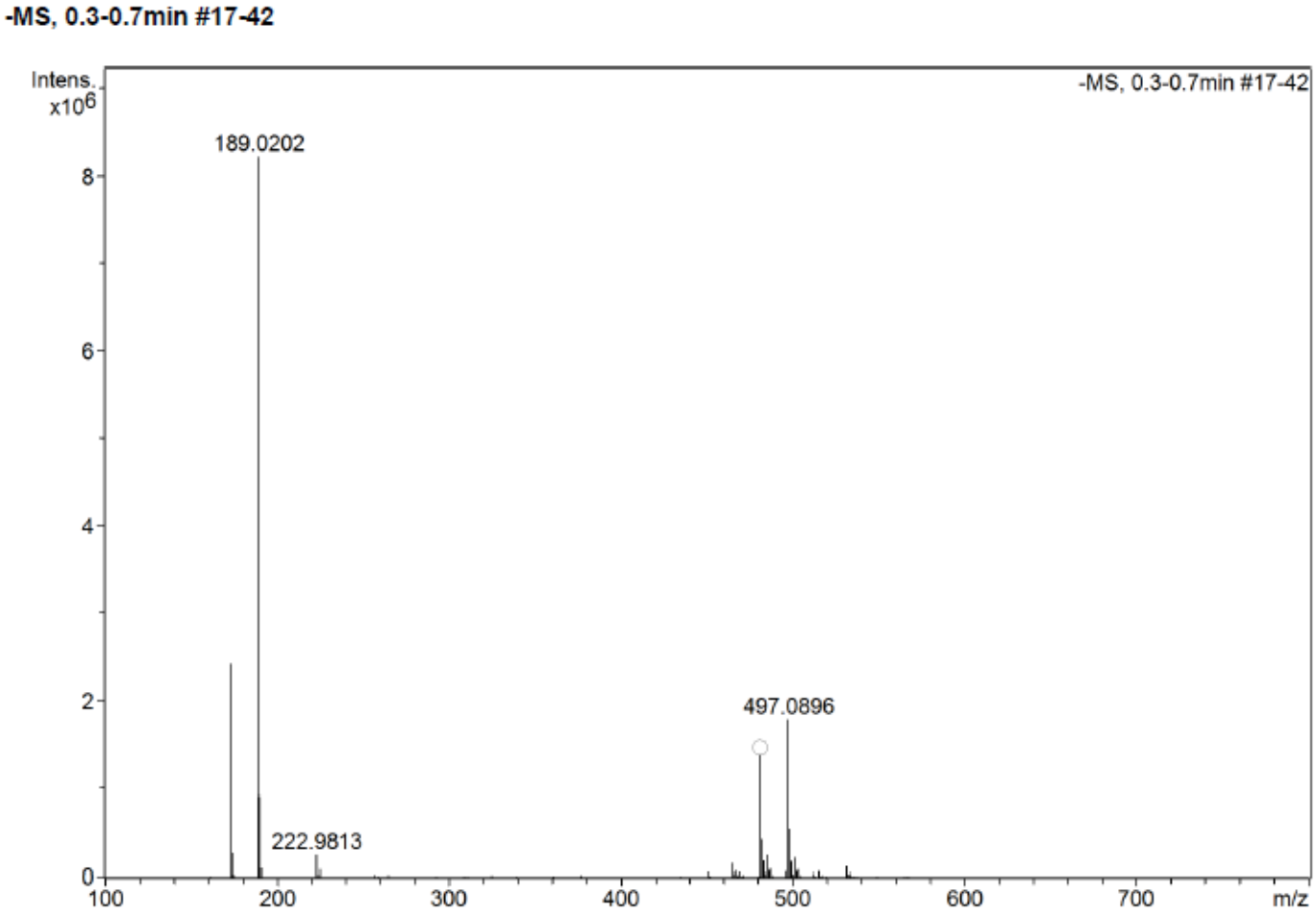

Figure S59. Mass spectrum of compound **15h**.

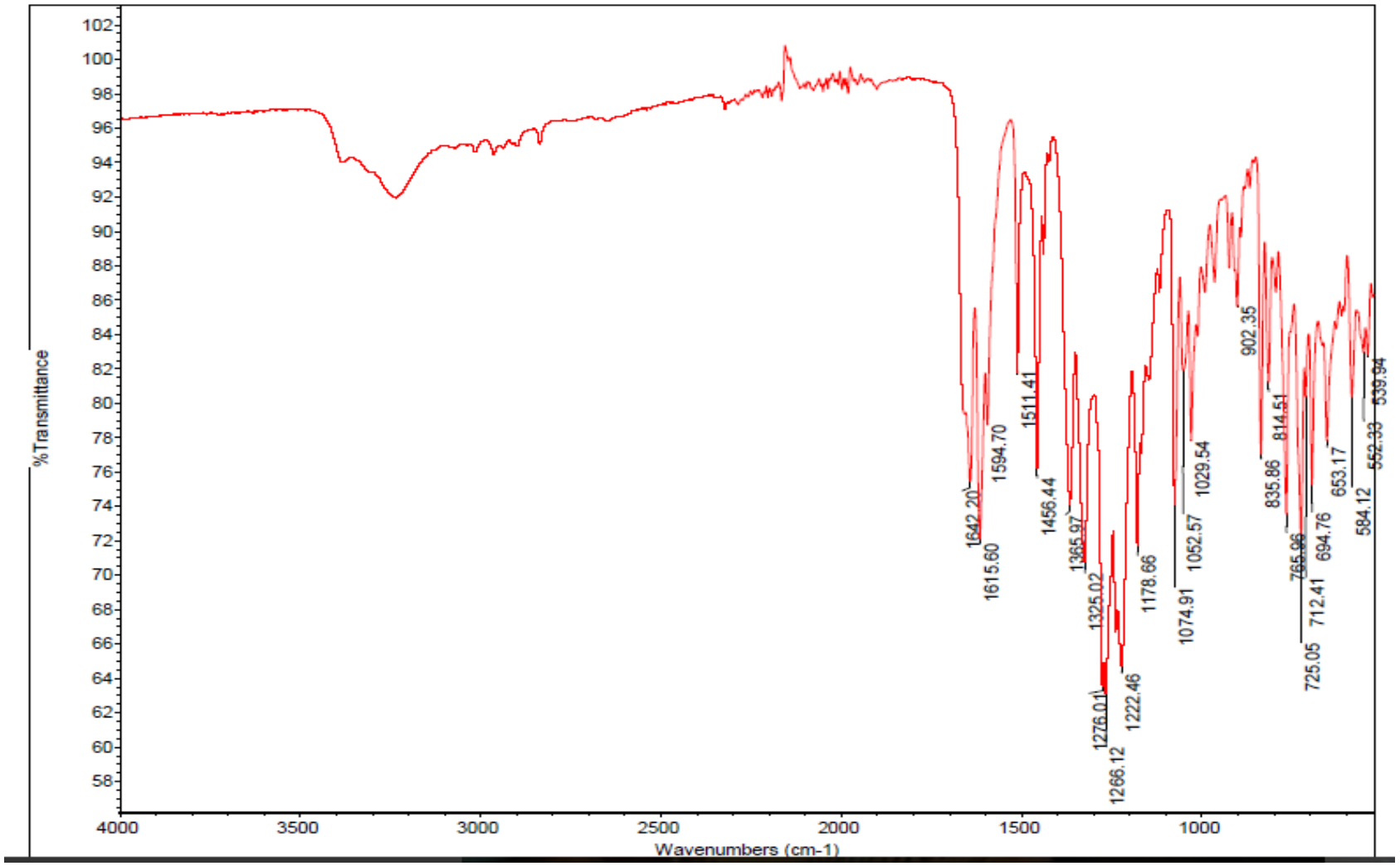

Figure S60. FTIR (KBr) spectrum of compound **15h**.

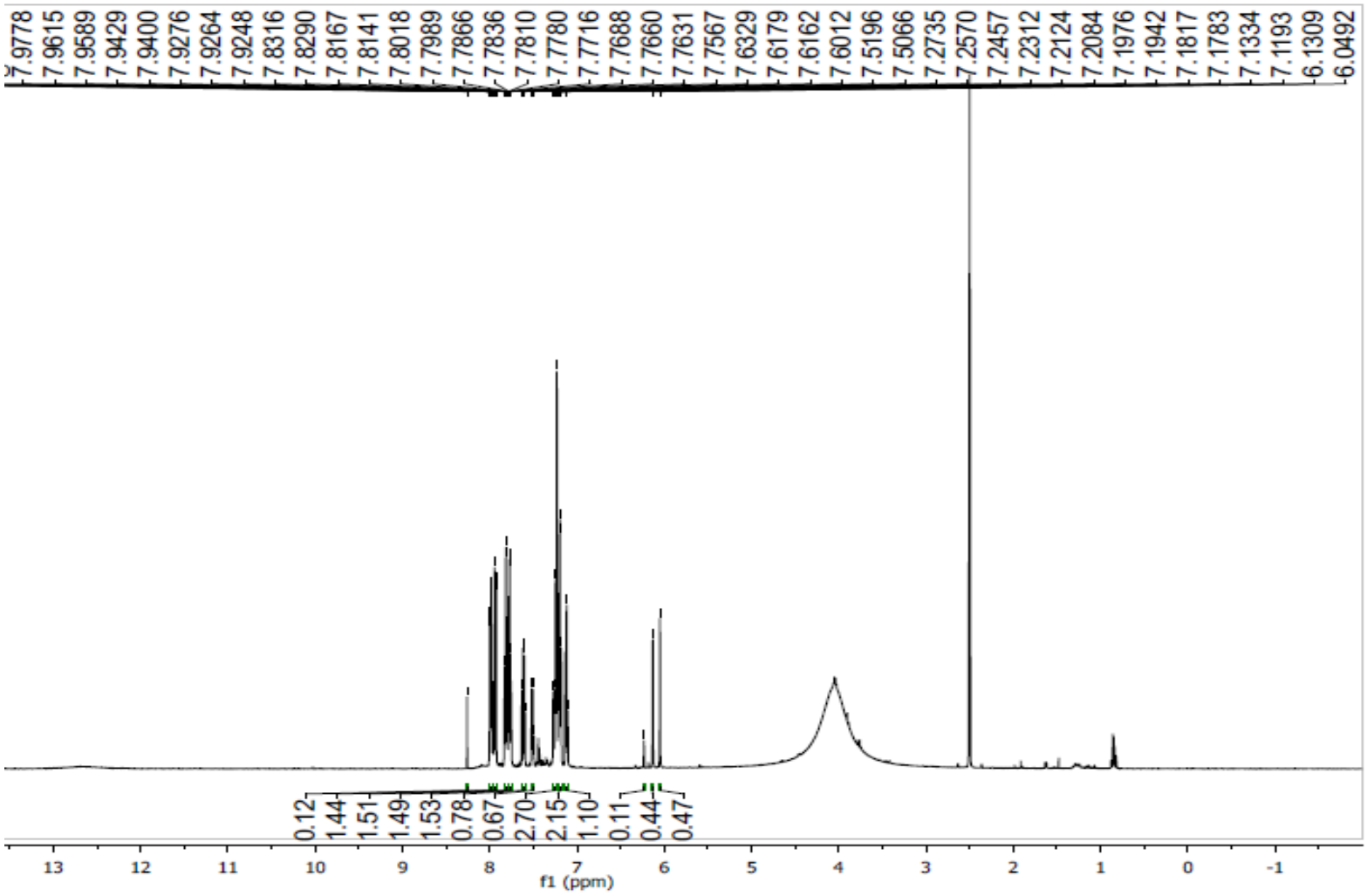

Figure S61. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15i**.

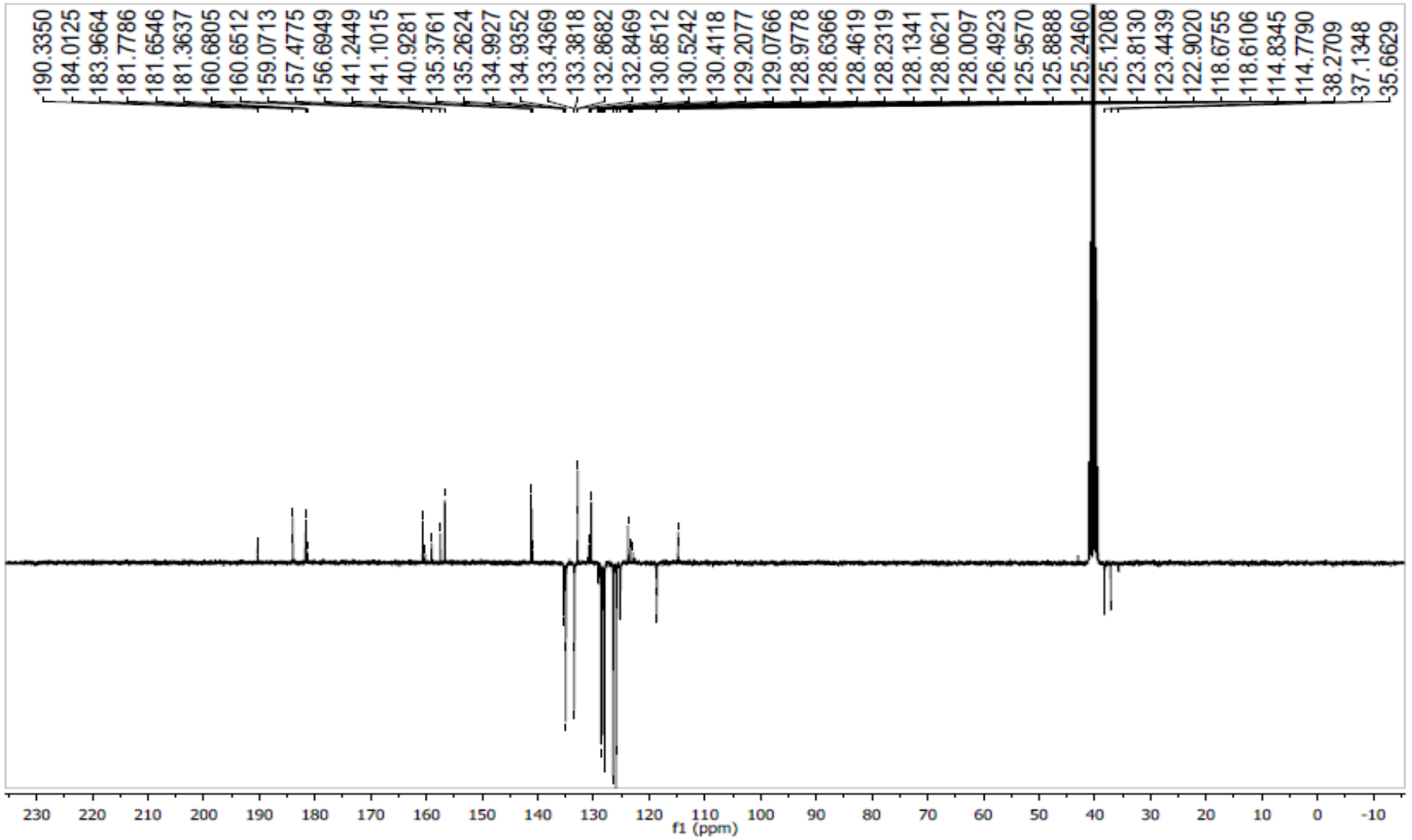

Figure S62. ^{13}C NMR spectrum (125 MHz, DMSO-d_6) of compound **15i**.

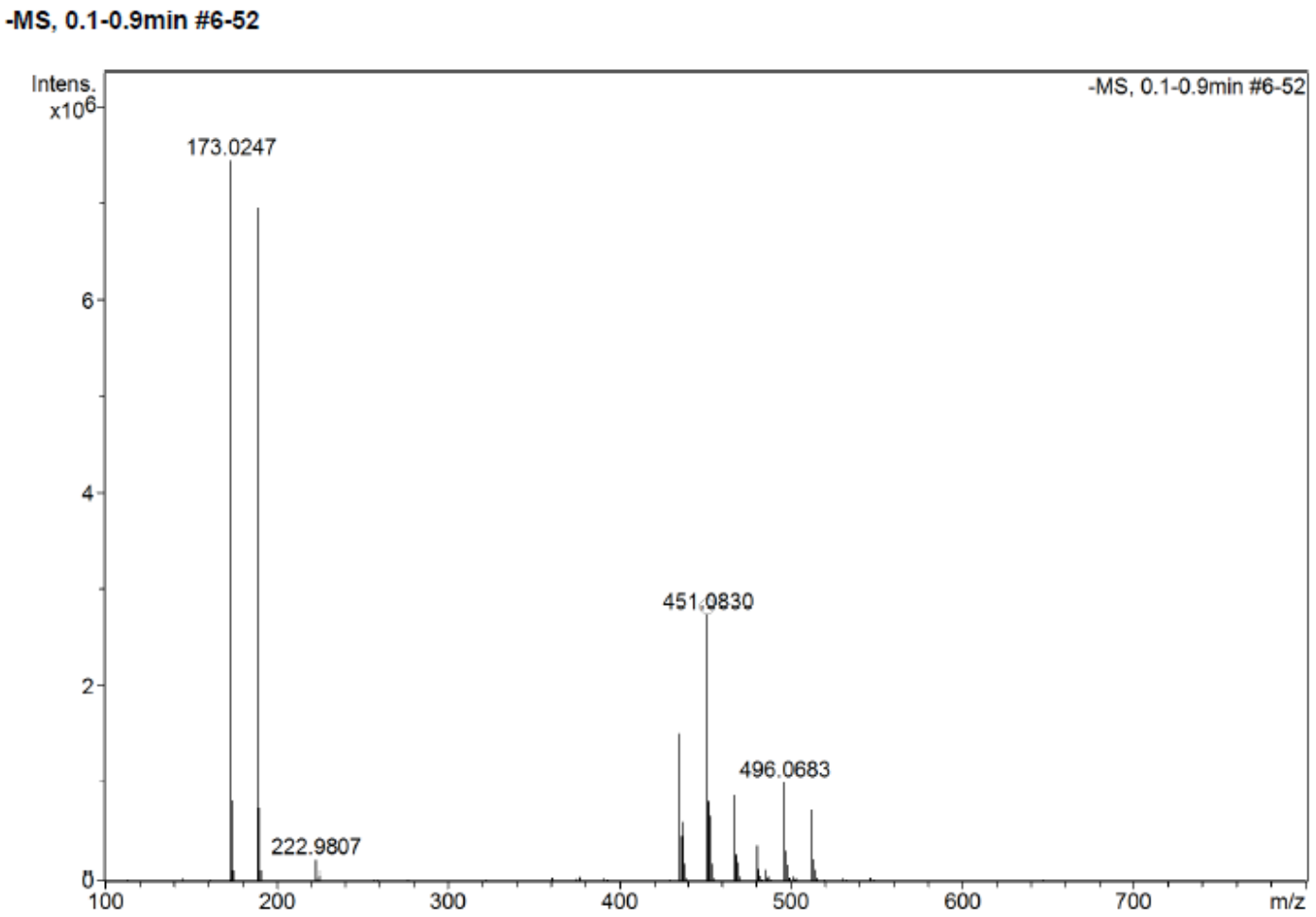

Figure S63. Mass spectrum of compound **15i**.

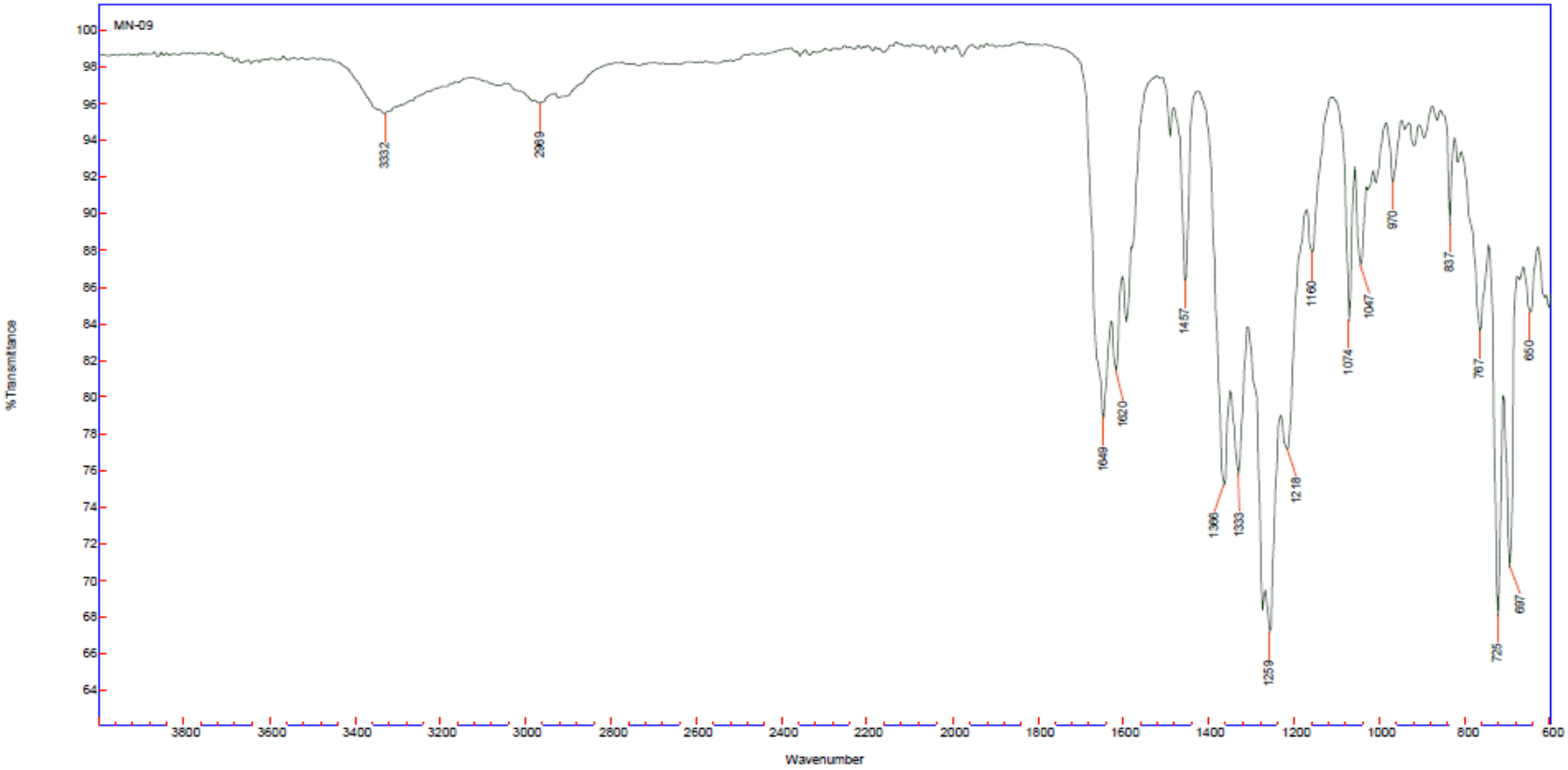

Figure S64. FTIR (KBr) spectrum of compound **15i**.

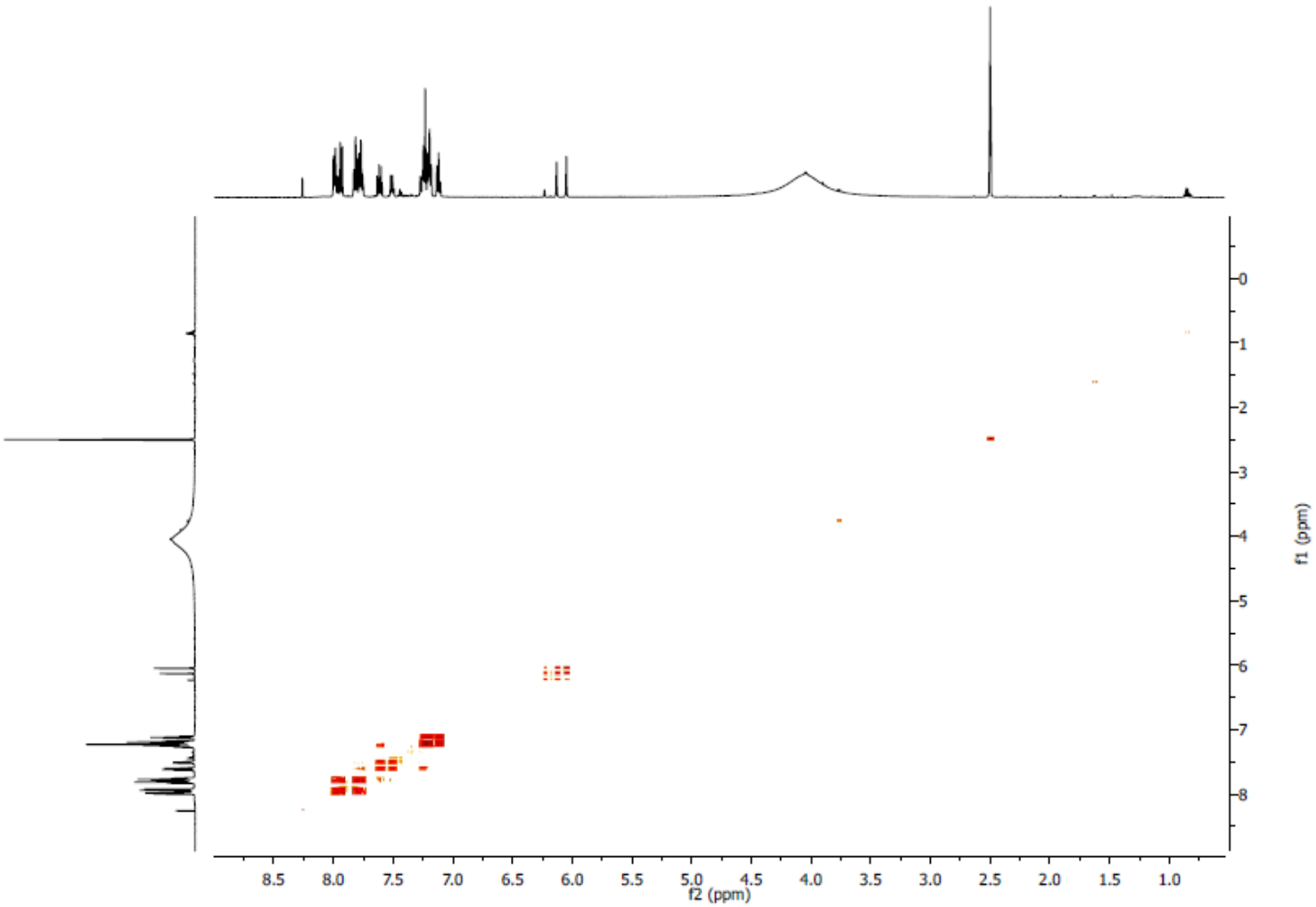

Figure S65. COSY spectrum (1H × 1H coupling) of compound **15i**.

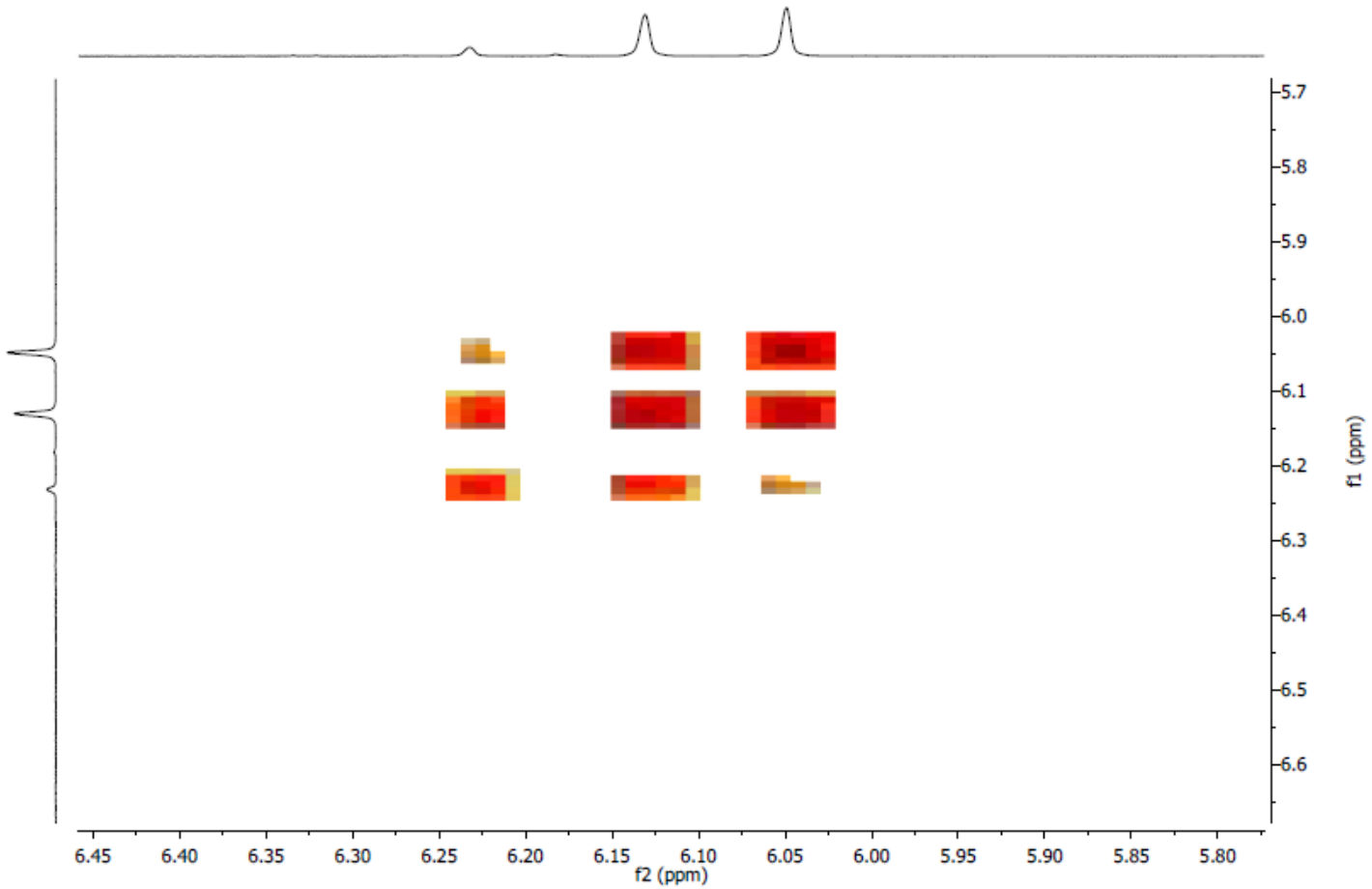

Figure S66. COSY spectrum (1H × 1H coupling) of compound **15i**.

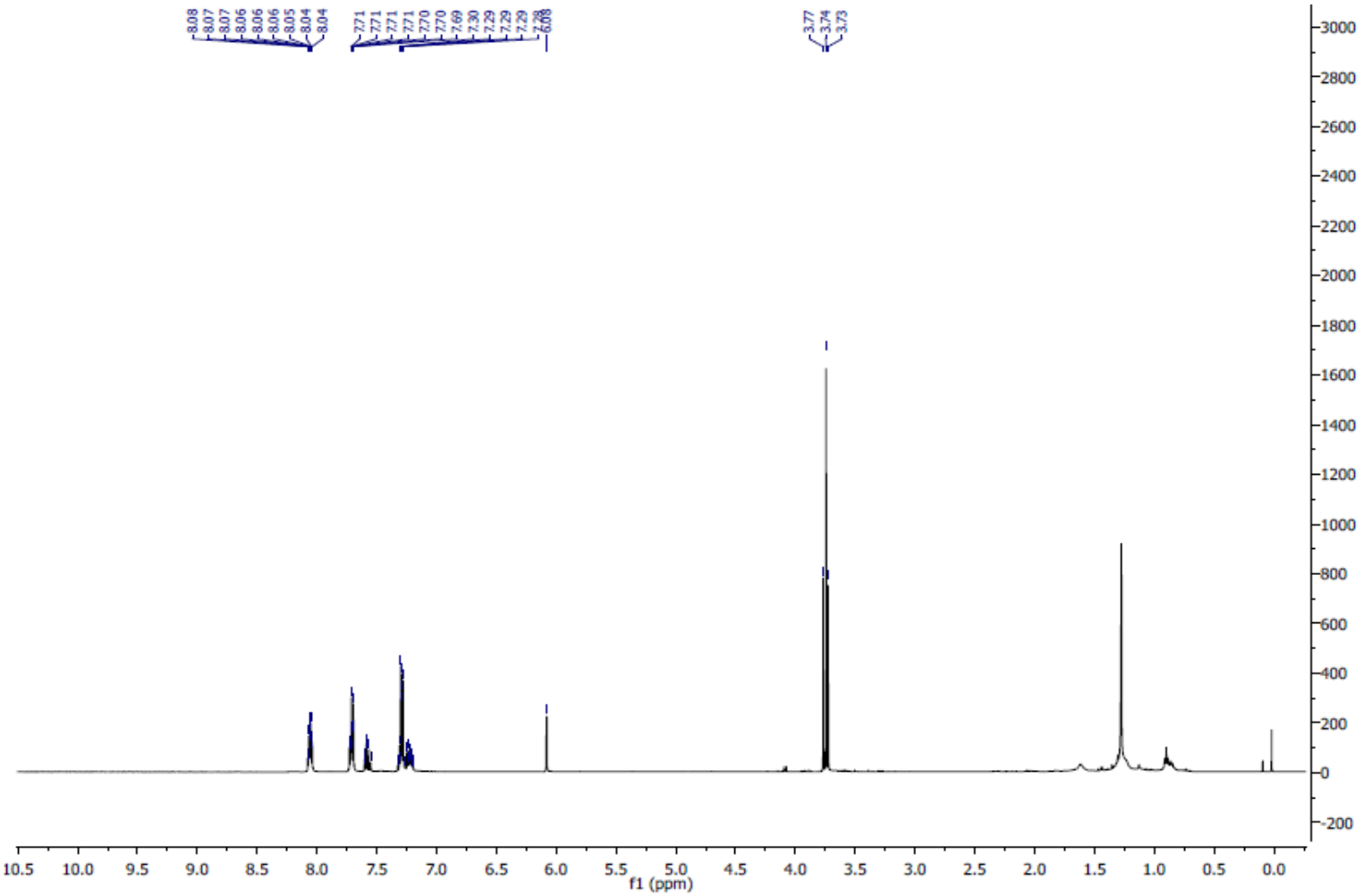

Figure S67. ^{1}H NMR spectrum (500 MHz, $CDCl_3$) of methylation of **15i** with diazomethane.

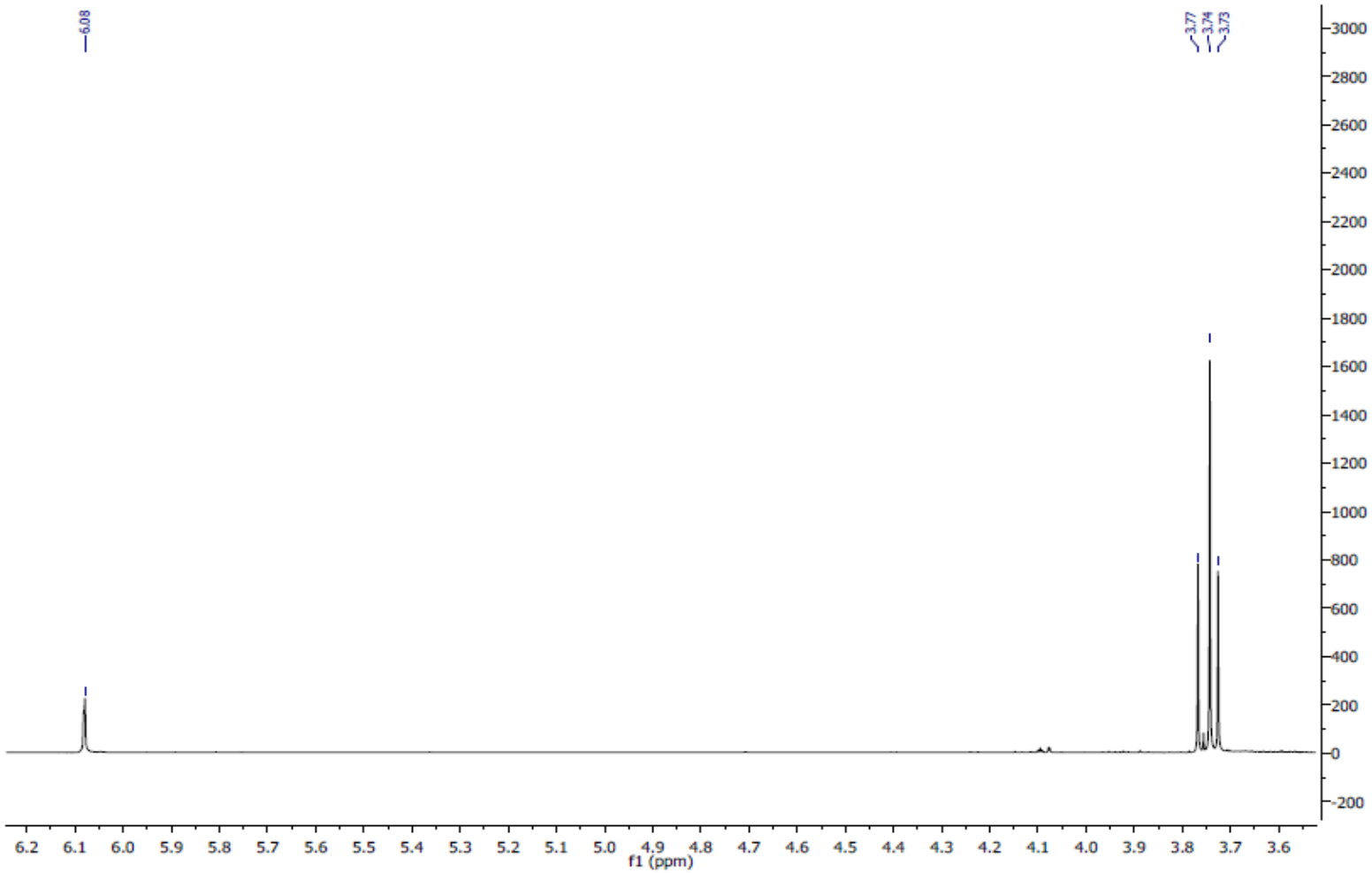

Figure S68. ^{1}H NMR spectrum (500 MHz, $CDCl_3$) of methylation of **15i** with diazomethane.

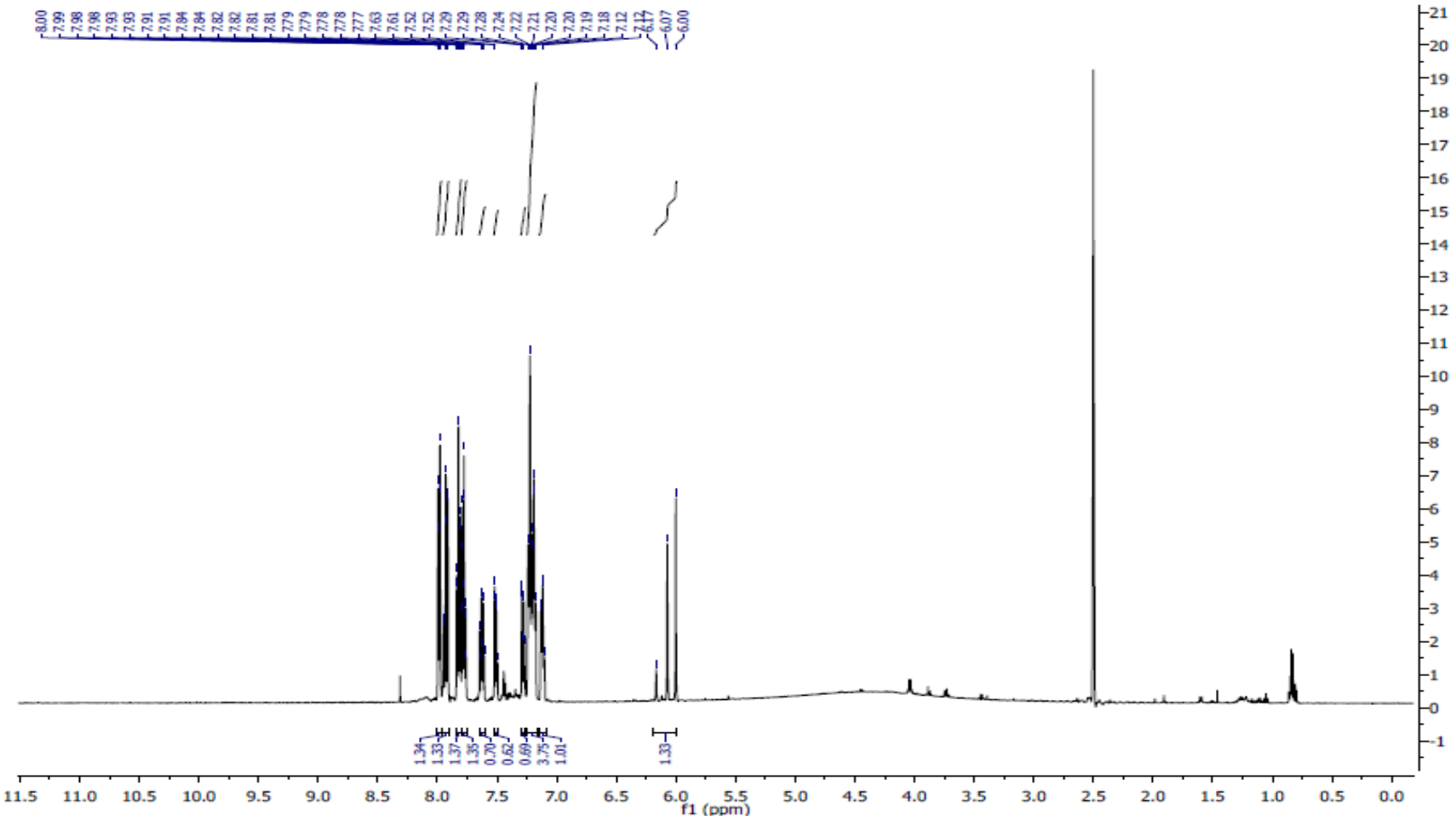

Figure S69. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15i** obtained at 25 °C.

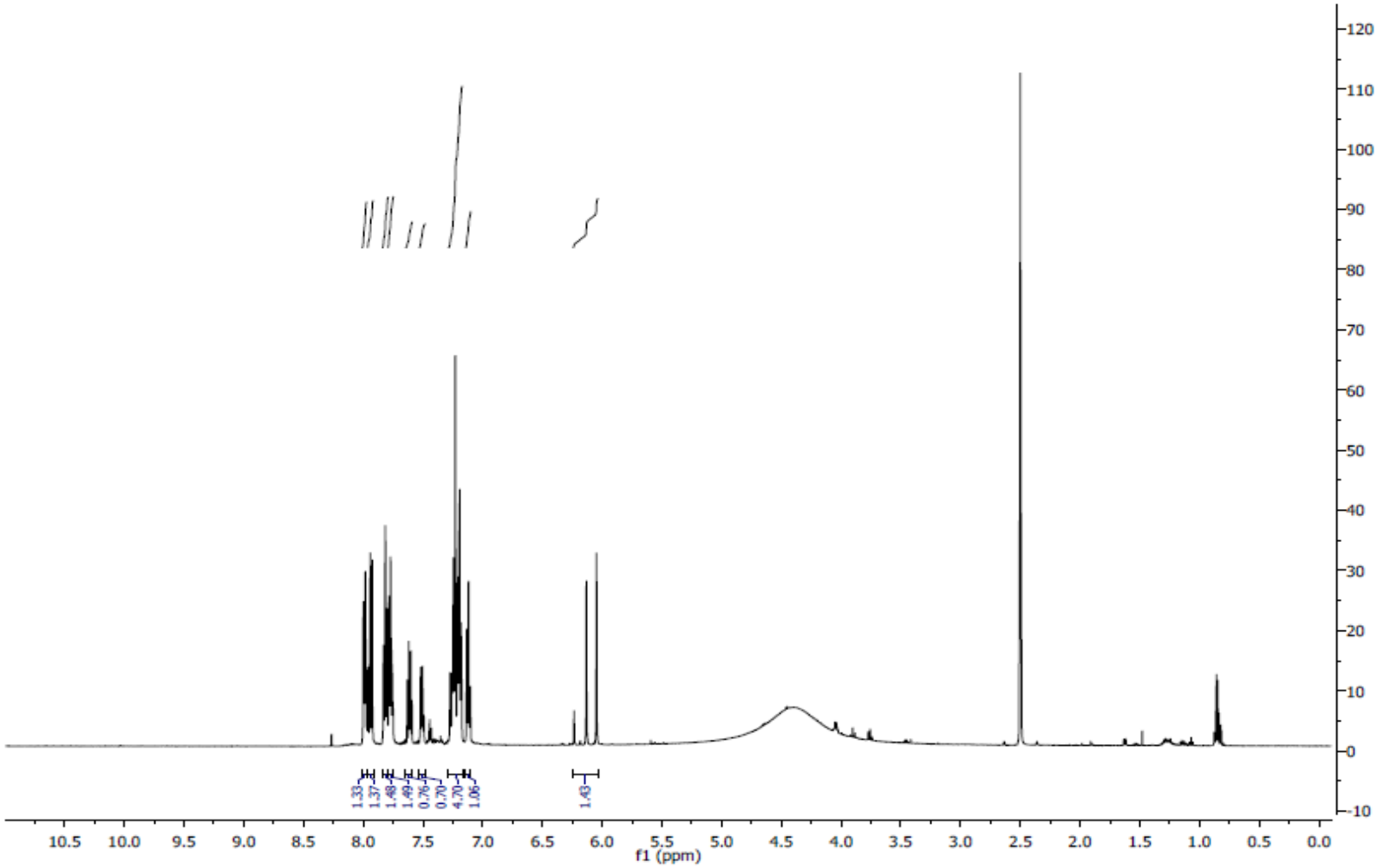

Figure S70. ^{1}H NMR spectrum (500 MHz, DMSO-d_6) of compound **15i** obtained at 60 °C.

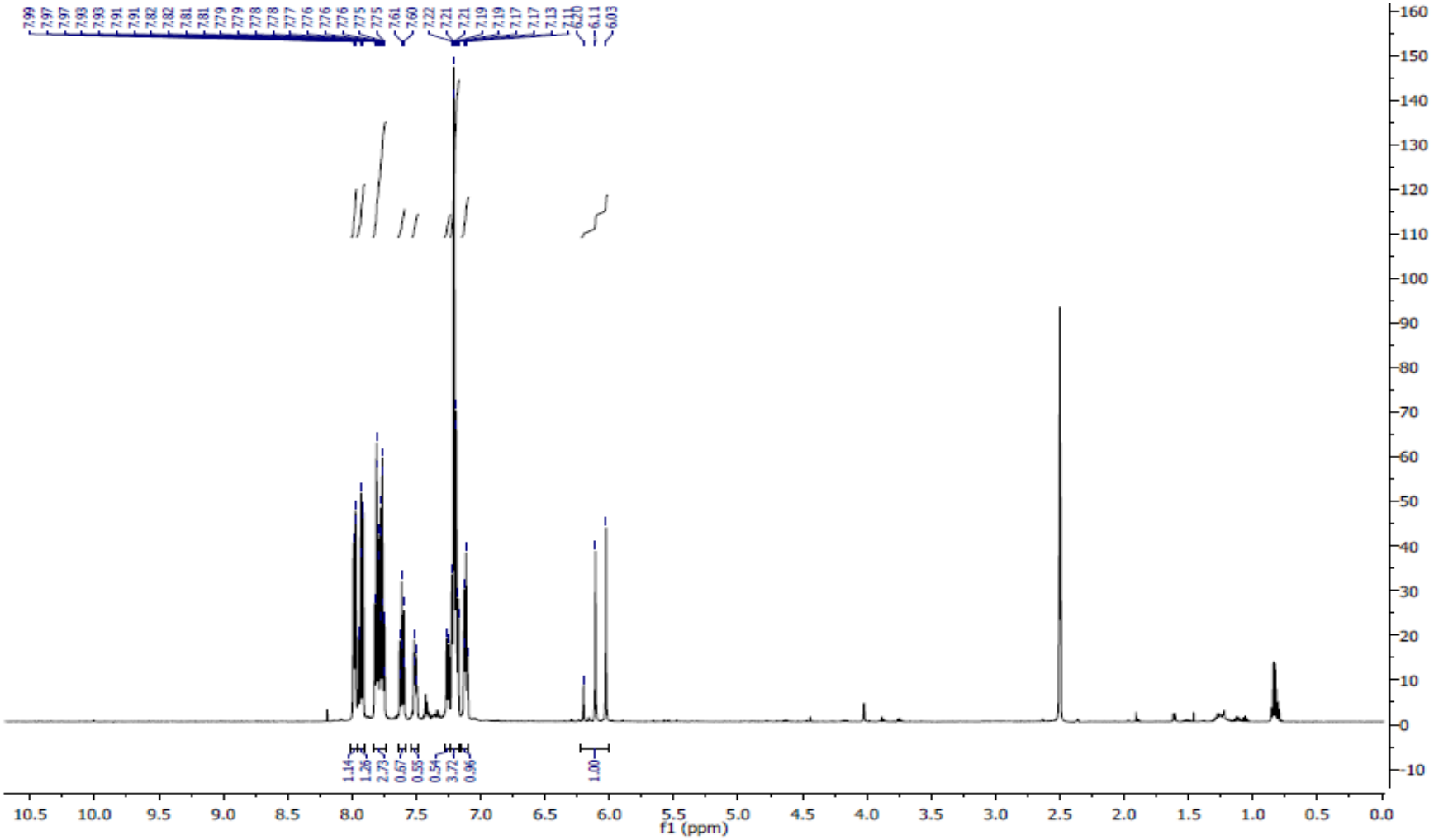

Figure S71. ^{1}H NMR spectrum (500 MHz, DMSO-d_6, with one drop of D_2O) of compound **15i**.