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Supporting information

Reaction of Carbonyl Trinuclear Clusters with 2,5-bis(2-thienyl)-1-phenyl-phosphole as Ligand: A New Pathway to Ruthenacyclopentadiene and Cyclopentadienone Ruthenium Complexes

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1. FT-IR spectra

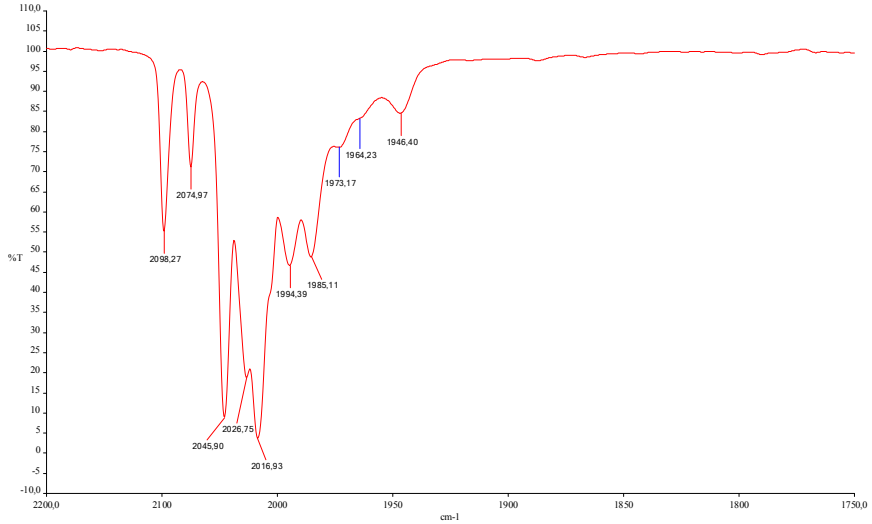

Figure 1. FT-IR spectrum of the νCO region of $[Ru_3(CO)_{11}(btpp)]$ (**1**).

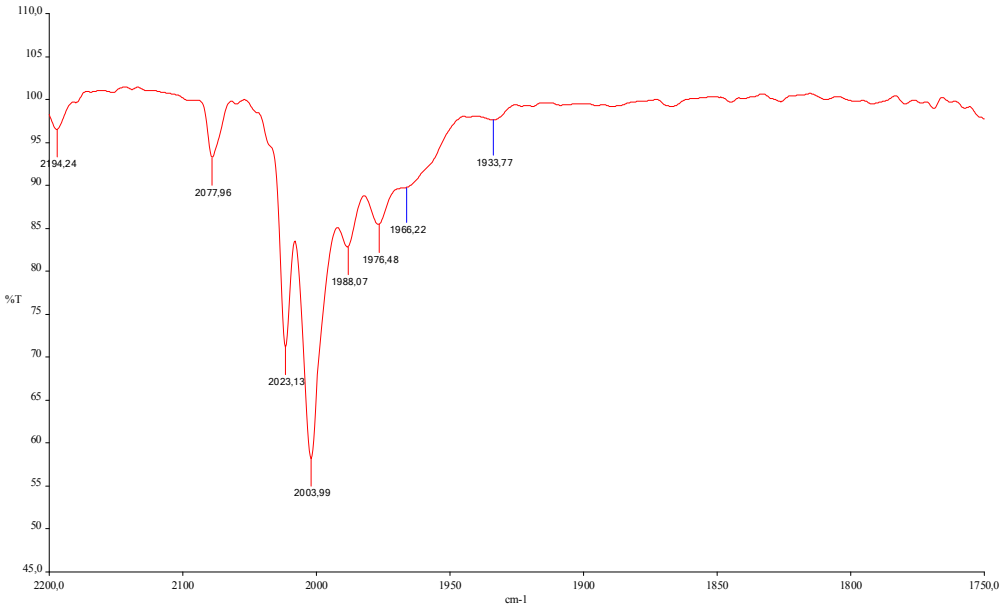

Figure 2. FT-IR spectrum of the νCO region of $[Ru_3(CO)_{10}(btpp)_2]$ (**2**).

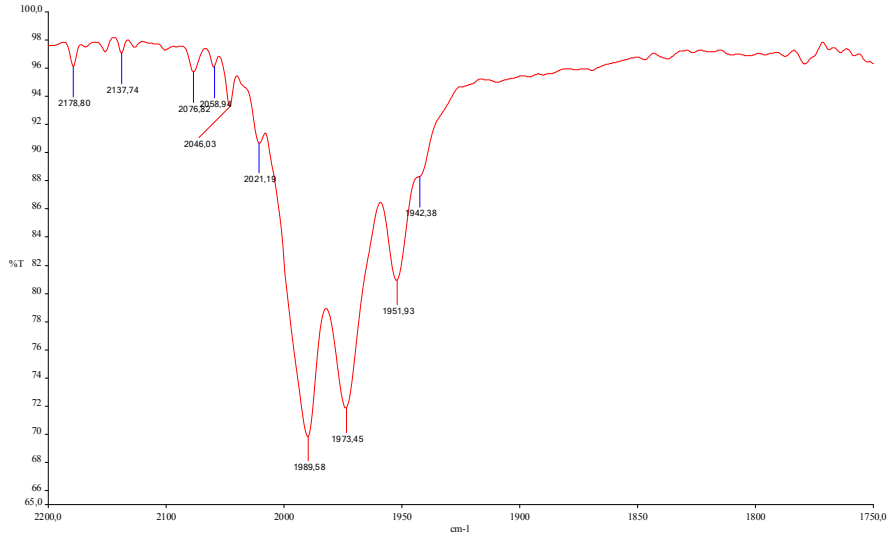

Figure 3. FT-IR spectrum of the νCO region for $[Ru_3(CO)_9(btpp)_3]$ (**3**).

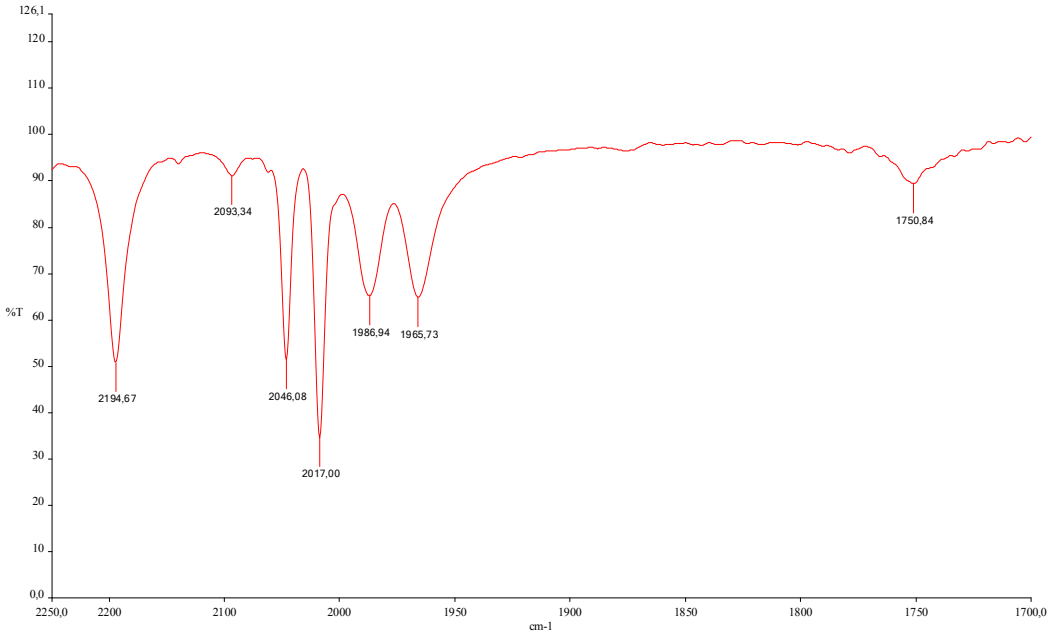

Figure 4. FT-IR spectrum of the νCO region of $[Ru_2(CO)_5(btpp)(\mu\text{-}\eta^1{:}\eta^1{:}\eta^4\text{-}C_{16}H_{14}S_2)]$ (**4**).

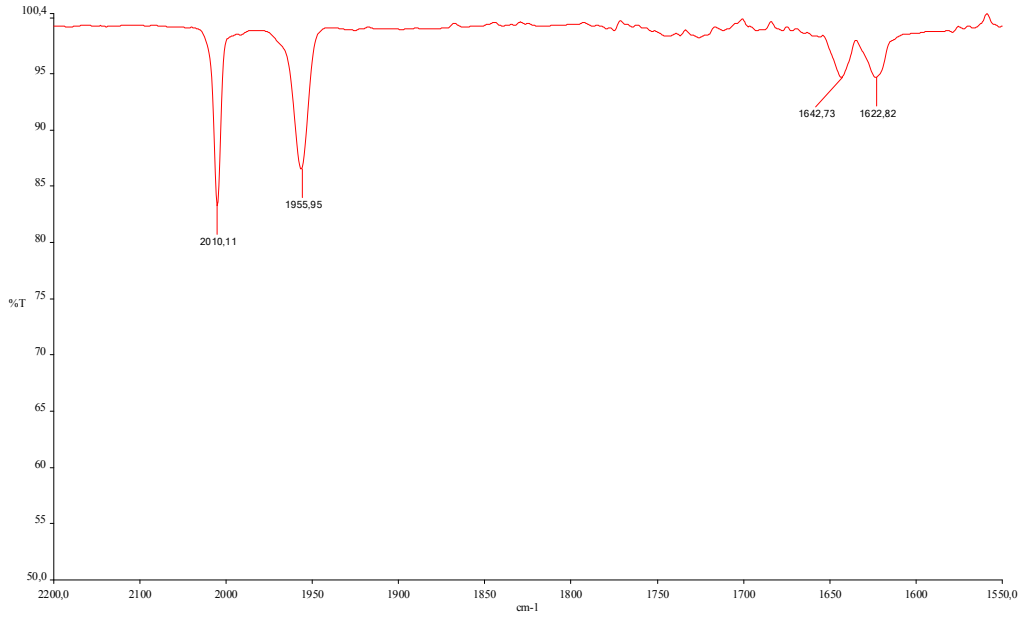

Figure 5. FT-IR spectrum of the νCO region of $[Ru(CO)_2(btpp)(\eta^4\text{-}COC_{16}H_{14}S_2)]$ (**5**).

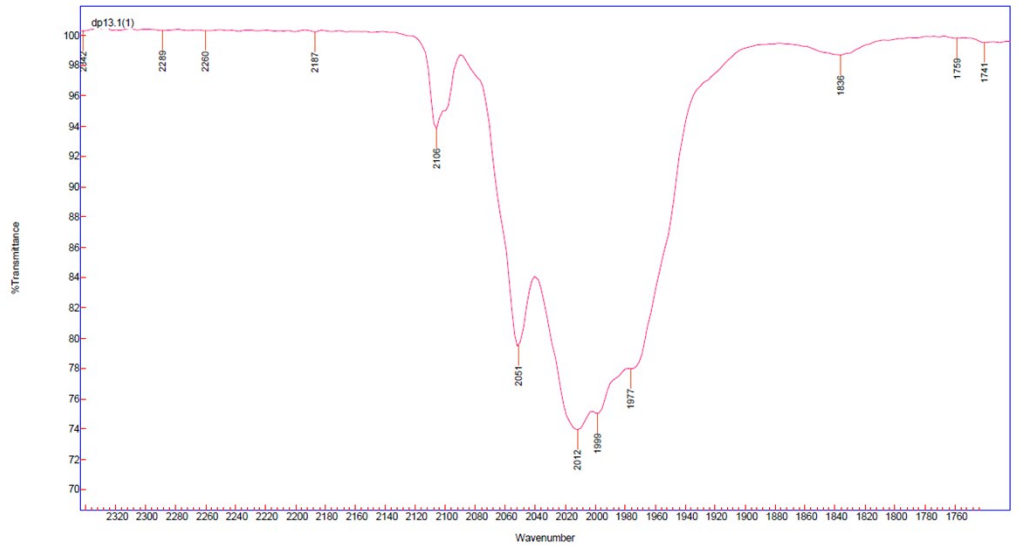

Figure 6. FT-IR spectrum of the νCO region for $[Os_3(CO)_{11}(btpp)]$ (**6**).

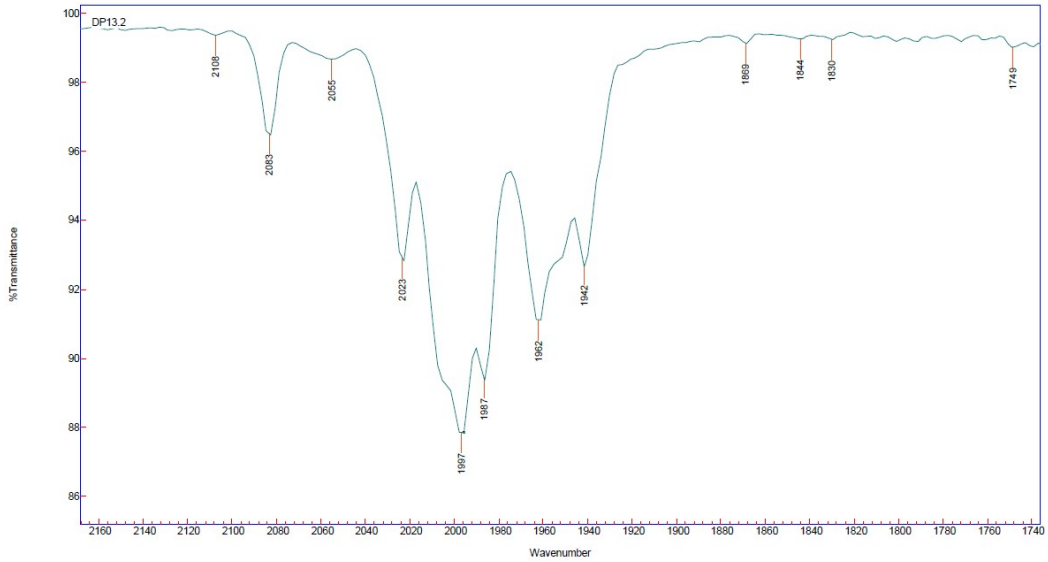

Figure 7. IR spectrum of the νCO region for $[Os_3(CO)_{10}(btpp)_2]$ (**7**).

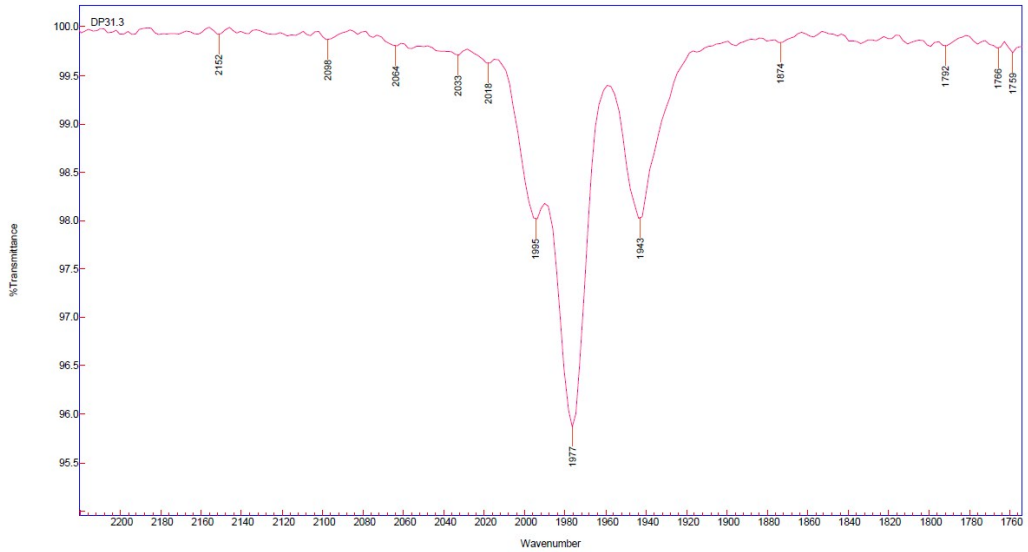

Figure 8. IR spectrum of the νCO region for $[Os_3(CO)_9(btpp)_3]$ (**8**).

2. NMR spectra

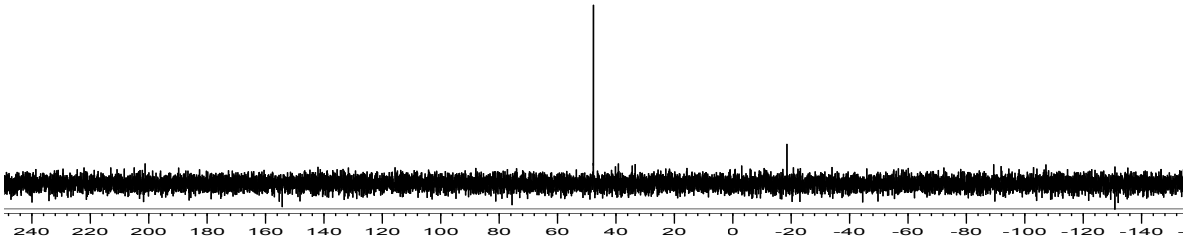

Figure 9. ^{31}P NMR spectrum of $[Ru_3(CO)_{11}(btpp)]$ (**1**) in $CDCl_3$.

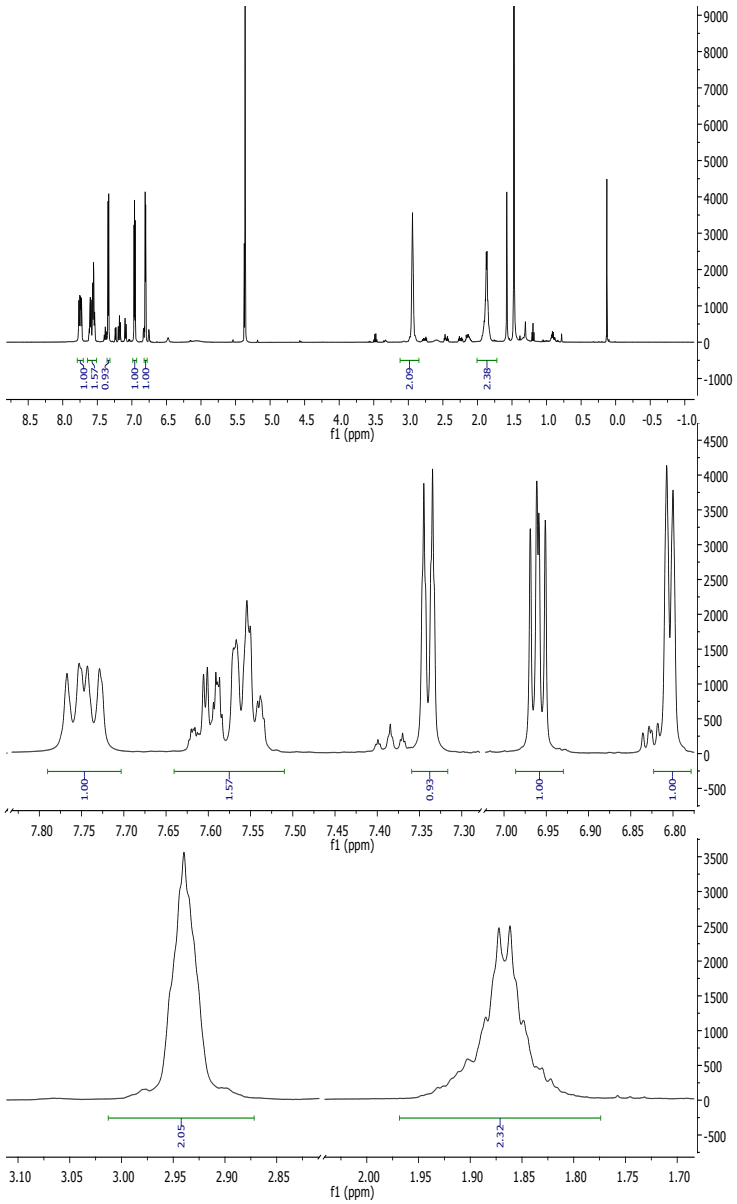

Figure 10. ^{1}H NMR spectrum of $[Ru_3(CO)_{11}(btpp)]$ (**1**) in CD_2Cl_2.

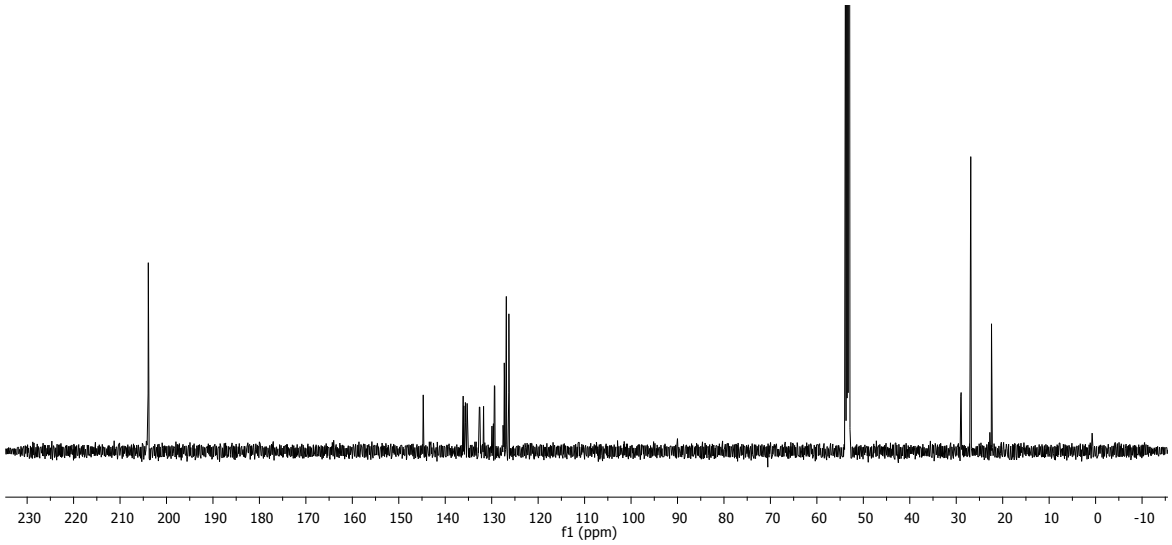

Figure 11. ^{13}C NMR spectrum of $[Ru_3(CO)_{11}(btpp)]$ (**1**) in CD_2Cl_2.

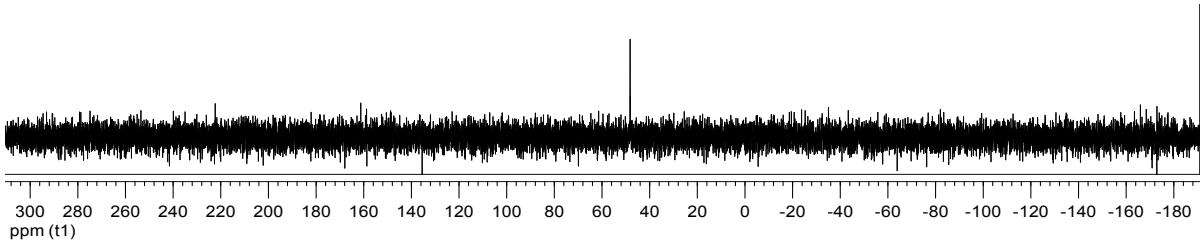

Figure 12. ^{31}P NMR spectrum of $[Ru_3(CO)_{10}(btpp)_2]$ (**2**) in $CDCl_3$.

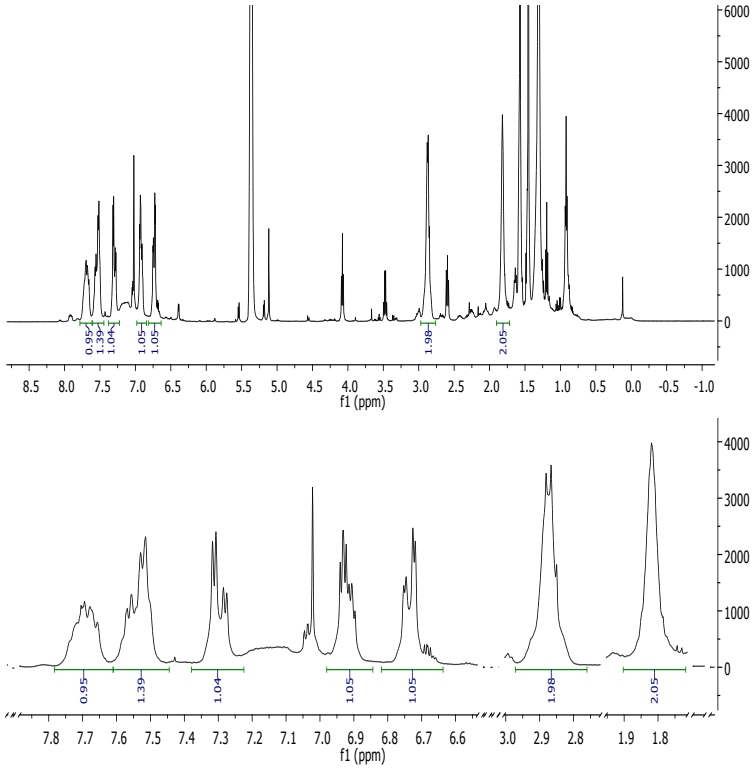

Figure 13. ^{1}H NMR spectrum of $[Ru_3(CO)_{10}(btpp)_2]$ (**2**) in CD_2Cl_2.

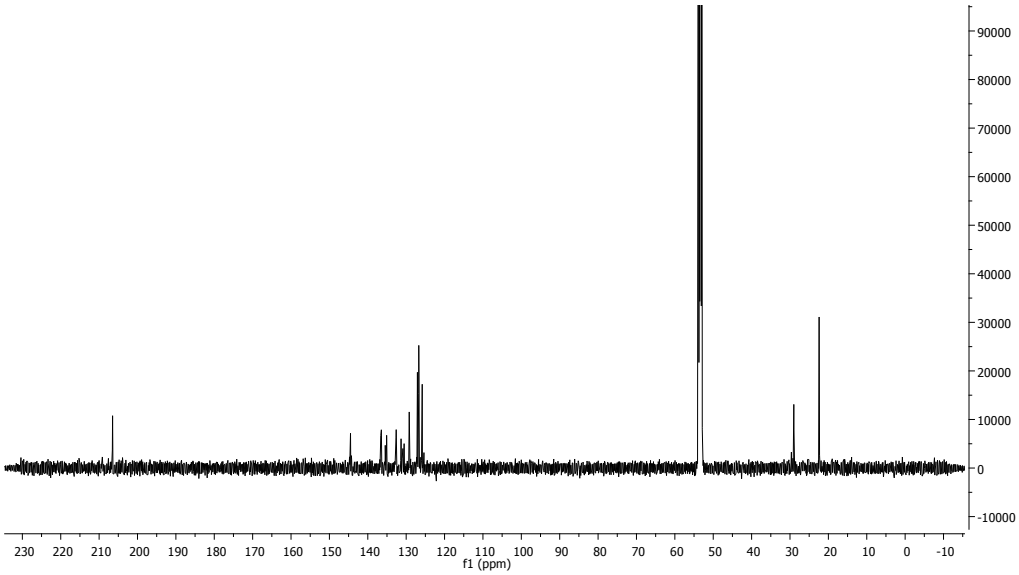

Figure 14. ^{13}C NMR spectrum of $[Ru_3(CO)_{10}(btpp)_2]$ (**2**) in CD_2Cl_2.

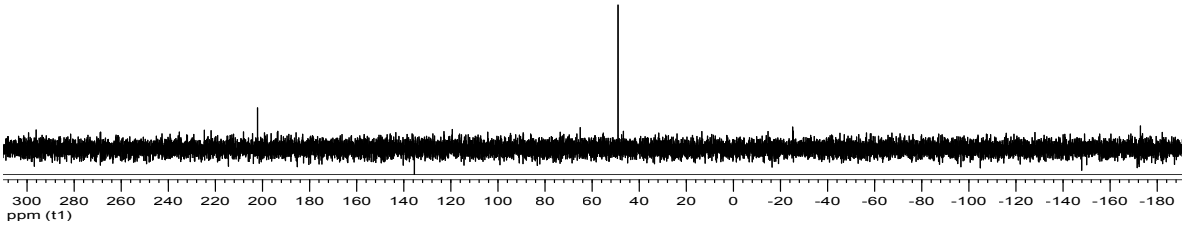

Figure 15. ^{31}P NMR spectrum of $[Ru_3(CO)_9(btpp)_3]$ (**3**) in $CDCl_3$.

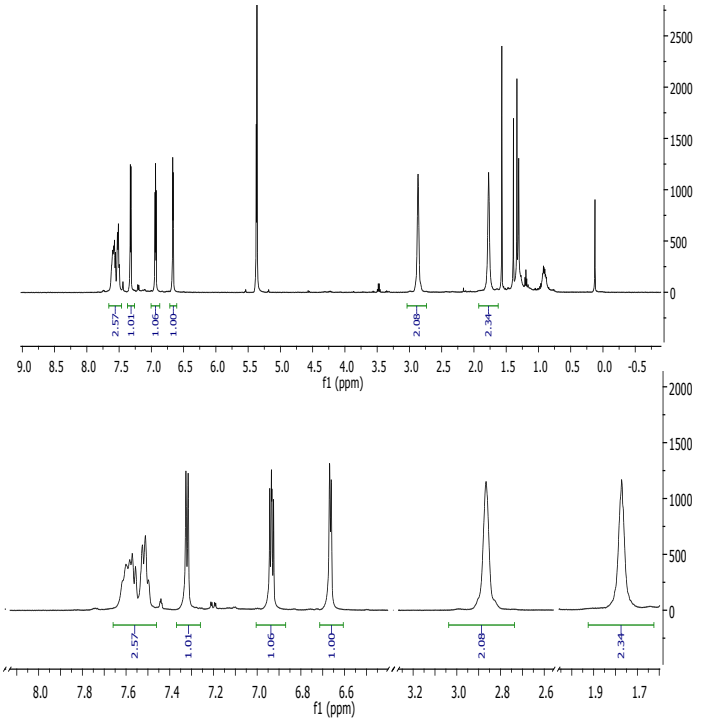

Figure 16. ^{1}H NMR spectrum of $[Ru_3(CO)_9(btpp)_3]$ (**3**) in CD_2Cl_2.

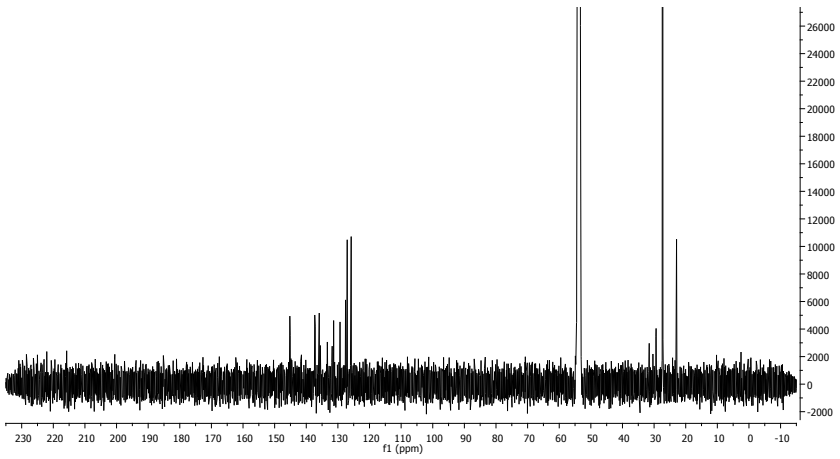

Figure 17. ^{13}C NMR spectrum of $[Ru_3(CO)_9(btpp)_3]$ (**3**) in CD_2Cl_2.

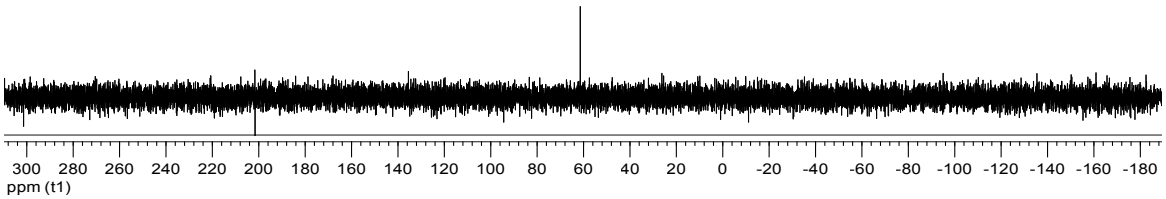

Figure 18. ^{31}P NMR spectrum of $[Ru_2(CO)_5(btpp)(\mu\text{-}\eta^1{:}\eta^1{:}\eta^4\text{-}C_{16}H_{14}S_2)]$ (**4**) in $CDCl_3$.

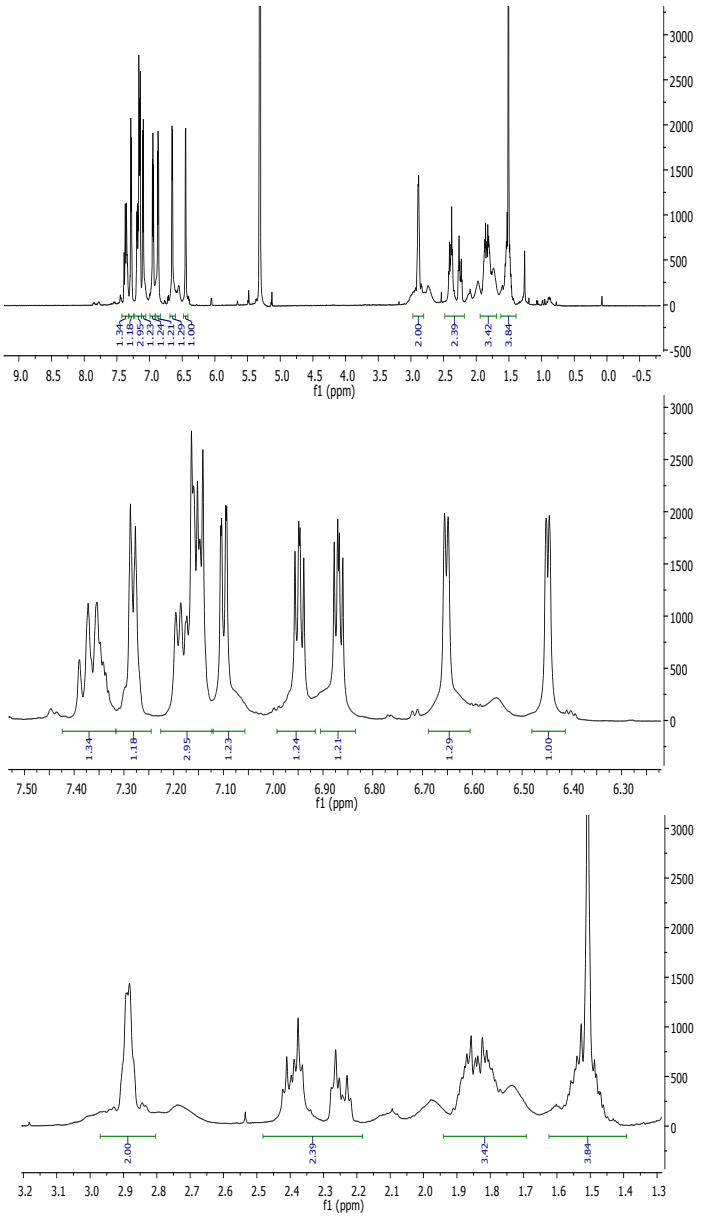

Figure 19. ^1H NMR spectrum of $[Ru_2(CO)_5(btpp)(\mu\text{-}\eta^1{:}\eta^1{:}\eta^4\text{-}C_{16}H_{14}S_2)]$ (**4**) in CD_2Cl_2.

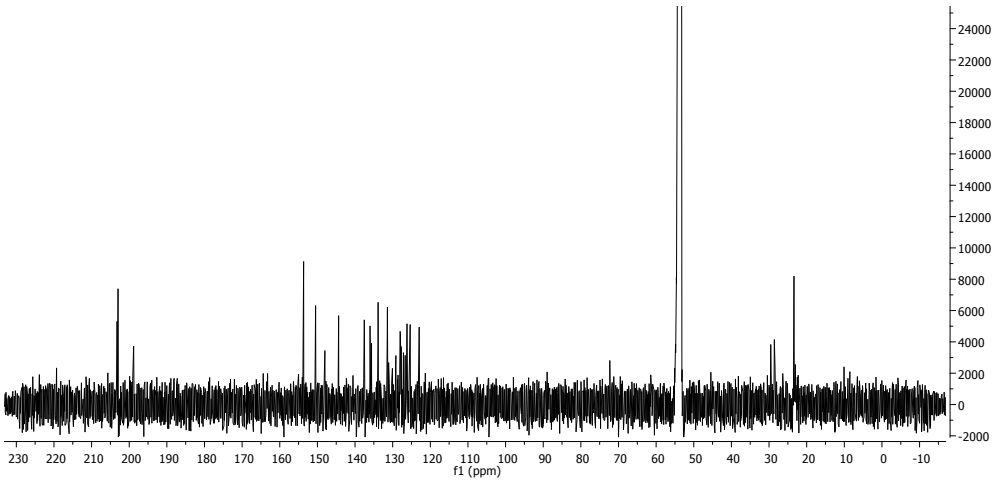

Figure 20. ^{13}C NMR spectrum of $[Ru_2(CO)_5(btpp)(\mu\text{-}\eta^1{:}\eta^1{:}\eta^4\text{-}C_{16}H_{14}S_2)]$ (**4**) in CD_2Cl_2.

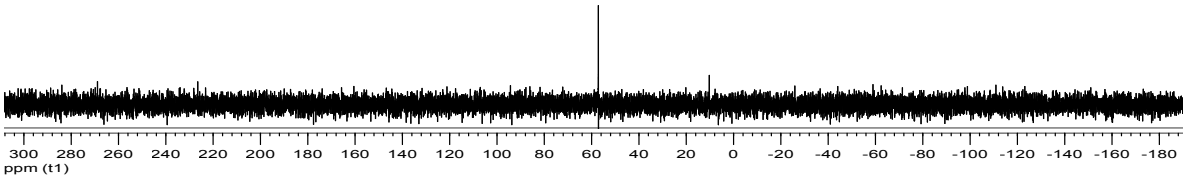

Figure 21. ^{31}P NMR spectrum of $[Ru(CO)_2(btpp)(\eta^4\text{-}COC_{16}H_{14}S_2)]$ (**5**) in $CDCl_3$.

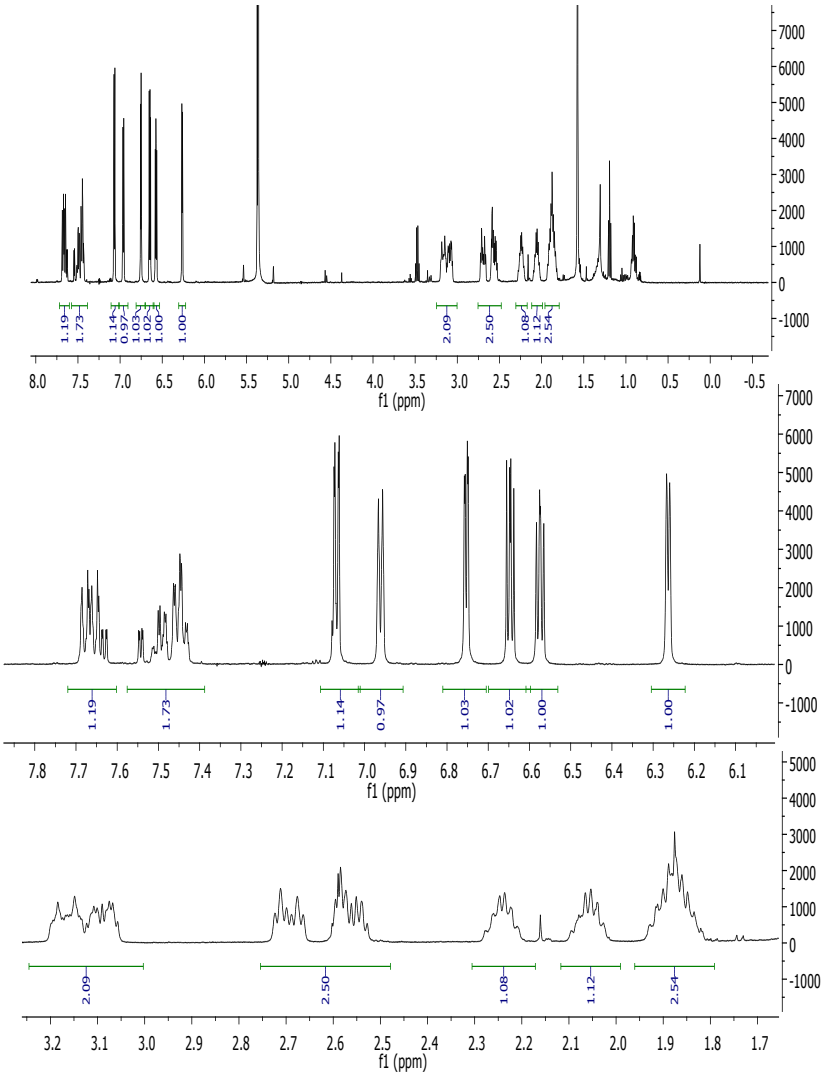

Figure 22. ^{1}H NMR spectrum of $[Ru(CO)_2(btpp)(\eta^4\text{-}COC_{16}H_{14}S_2)]$ (**5**) in CD_2Cl_2.

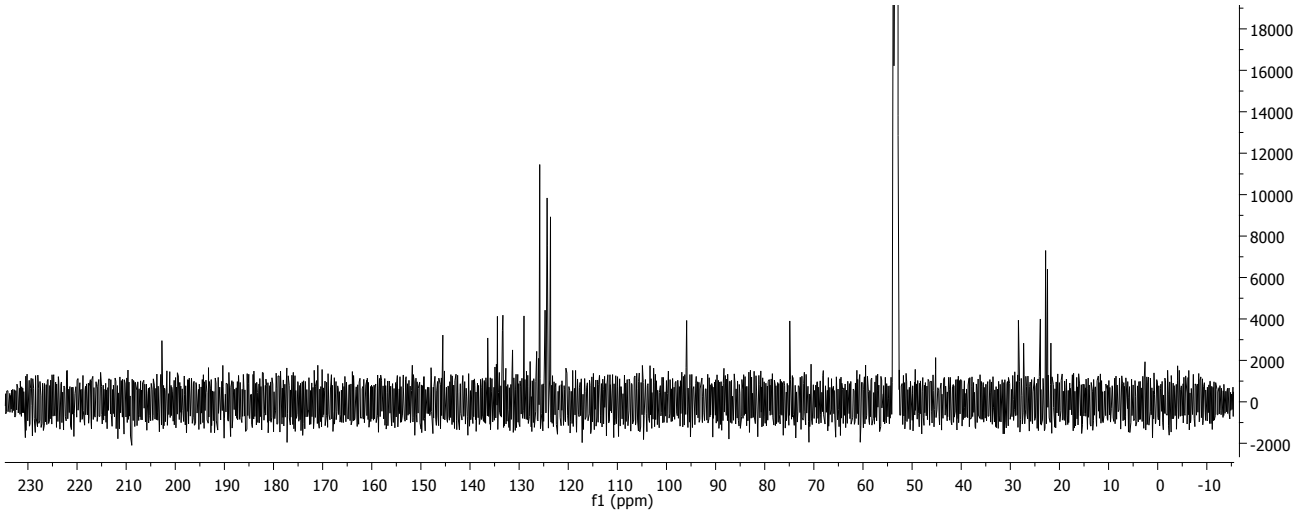

Figure 23. ^{13}C NMR spectrum of $[Ru(CO)_2(btpp)(\eta^4\text{-}COC_{16}H_{14}S_2)]$ (**5**) in CD_2Cl_2.

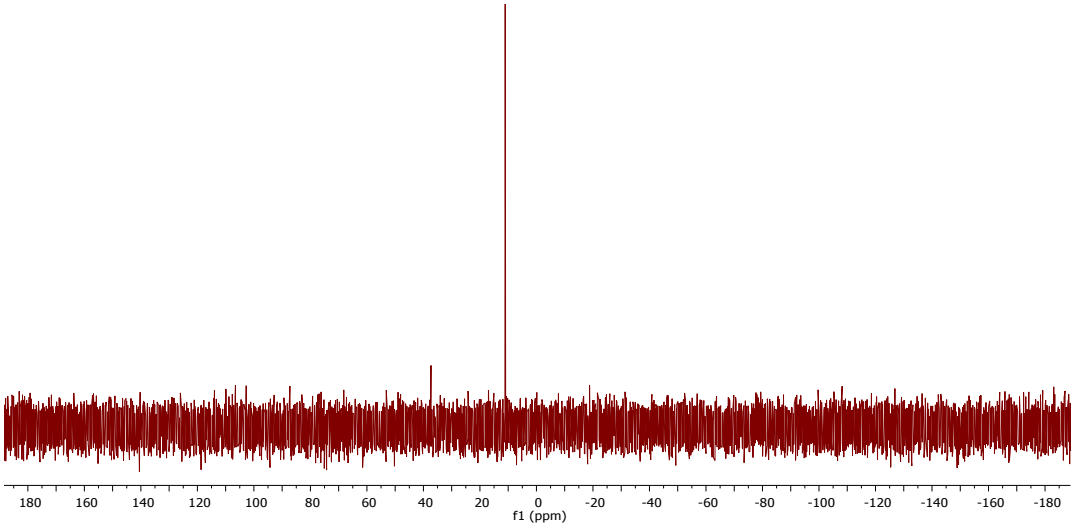

Figure 24. ^{31}P NMR spectrum of $[Os_3(CO)_{11}(btpp)]$ **(6)** in CD_2Cl_2.

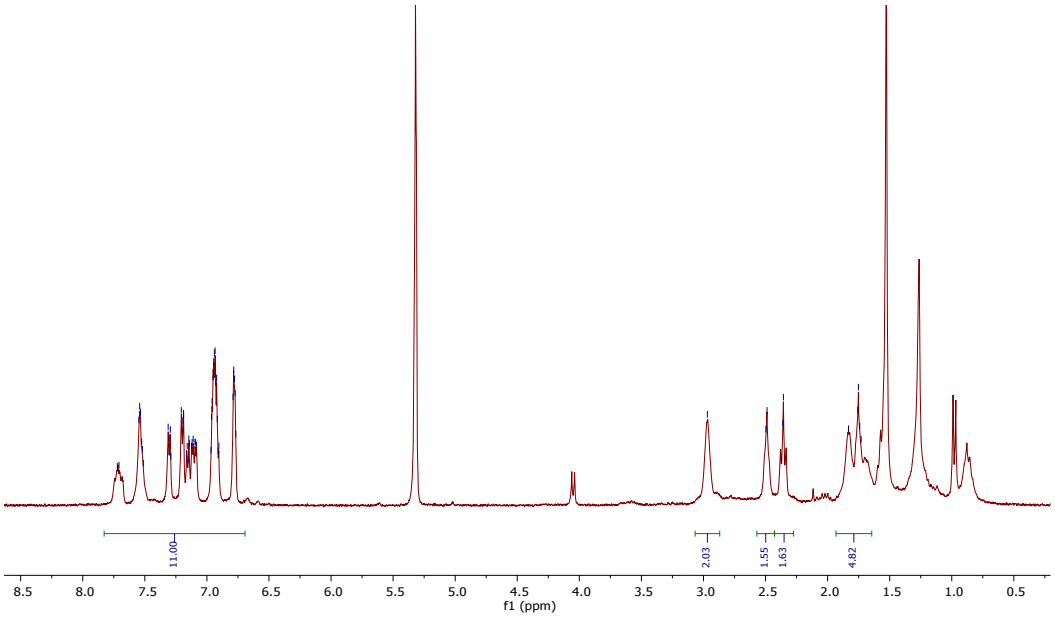

Figure 25. ^{1}H NMR spectrum of $[Os_3(CO)_{11}(btpp)]$ **(6)** in CD_2Cl_2.

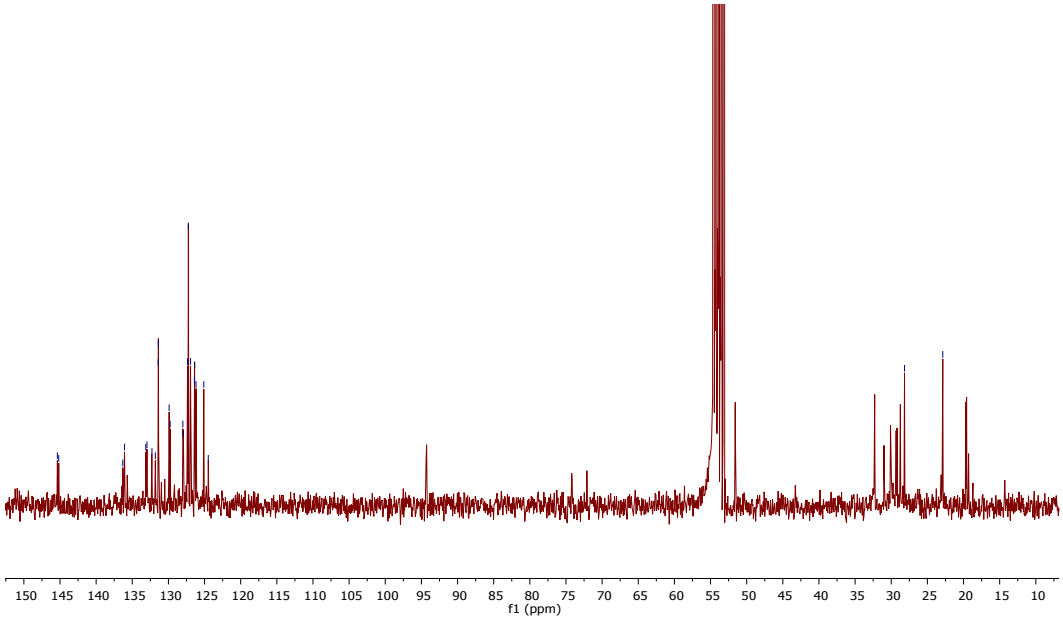

Figure 26. ^{13}C NMR spectrum of $[Os_3(CO)_{11}(btpp)]$ (**6**) in CD_2Cl_2.

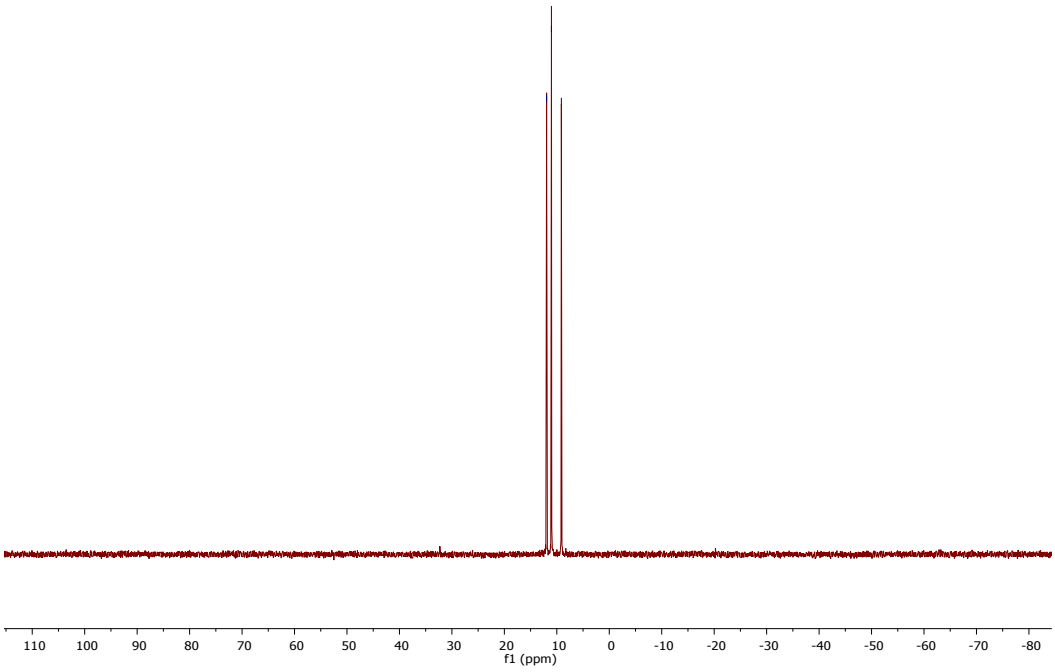

Figure 27. ^{31}P NMR spectrum of $[Os_3(CO)_{10}(btpp)_2]$ (**7**) in $CDCl_3$.

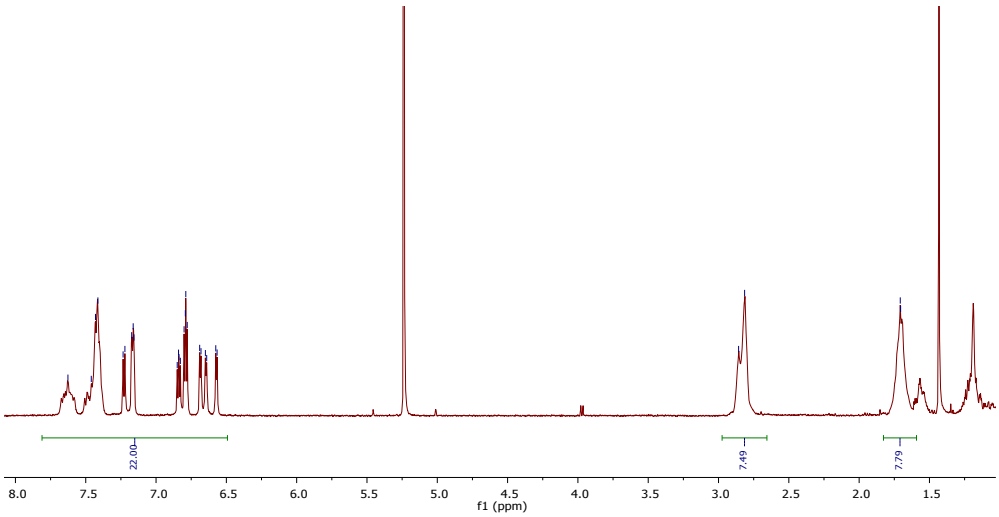

Figure 28. ^{1}H NMR spectrum of $[Os_3(CO)_{10}(btpp)_2]$ (**7**) in CD_2Cl_2.

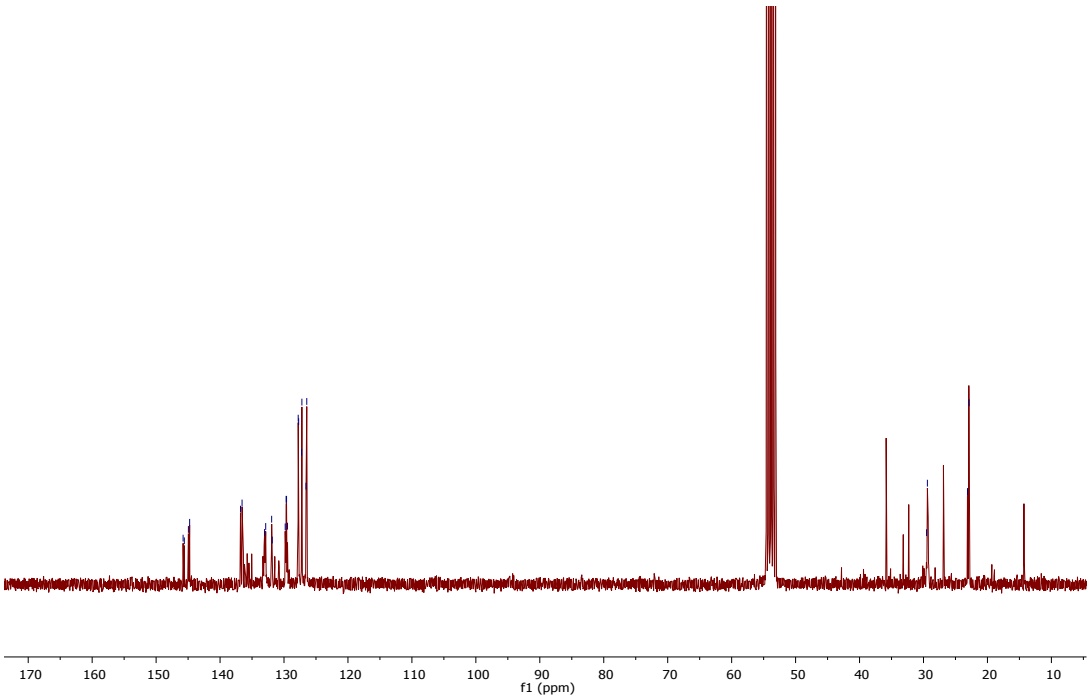

Figure 29. ^{13}C NMR spectrum of $[Os_3(CO)_{10}(btpp)_2]$ (**7**) in CD_2Cl_2.

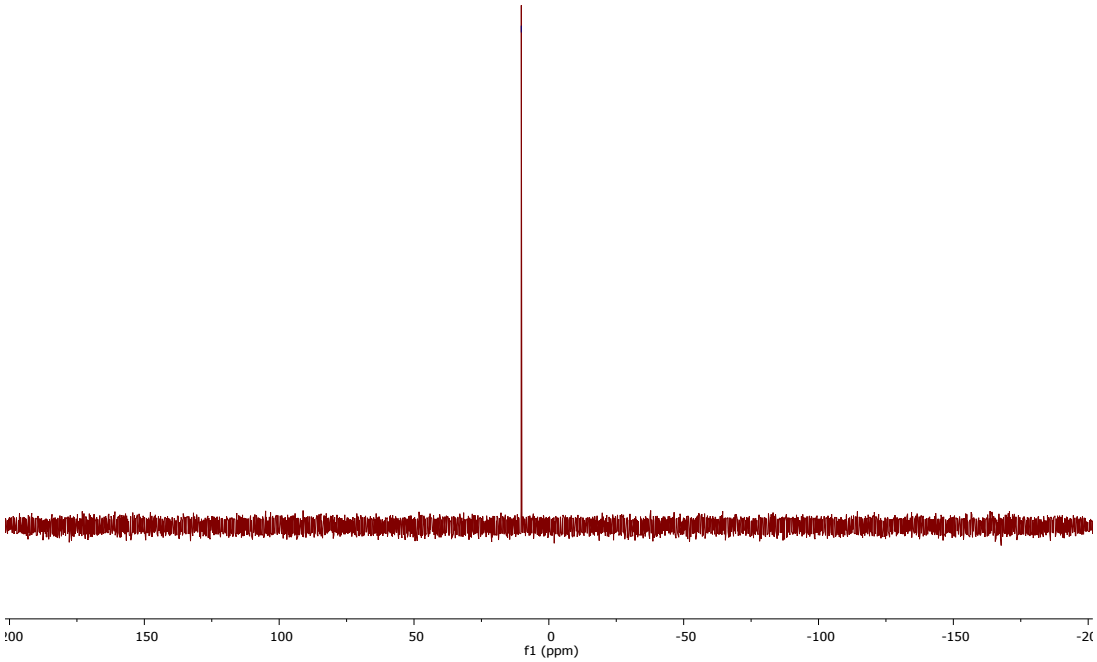

Figure 30. ^{31}P NMR spectrum of $[Os_3(CO)_9(btpp)_3]$ (**8**) in CD_2Cl_2.

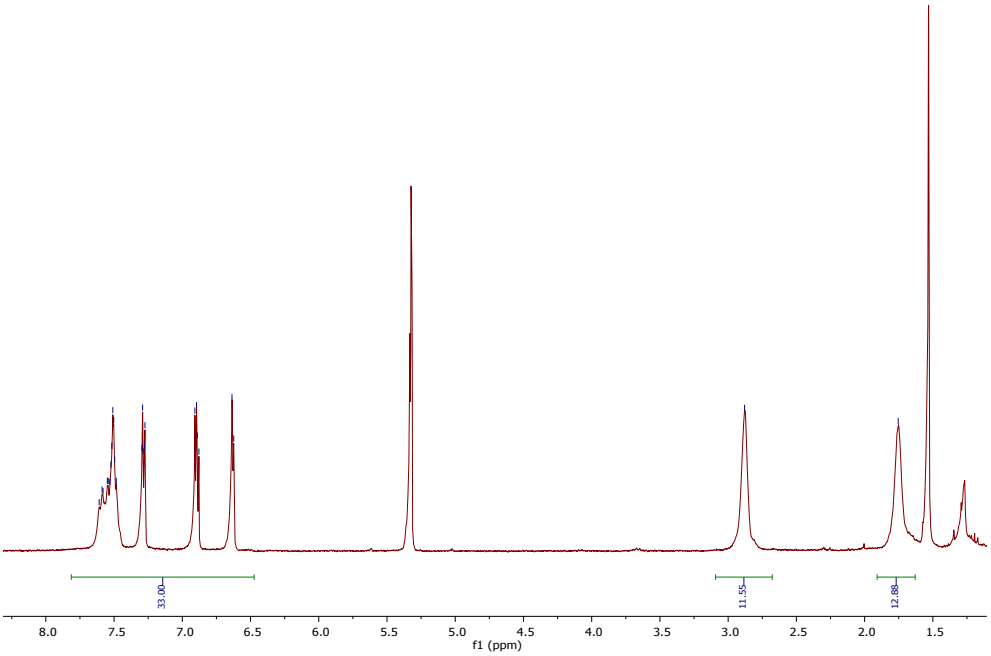

Figure 31. ^{1}H NMR spectrum of $[Os_3(CO)_9(btpp)_3]$ (**8**) in CD_2Cl_2.

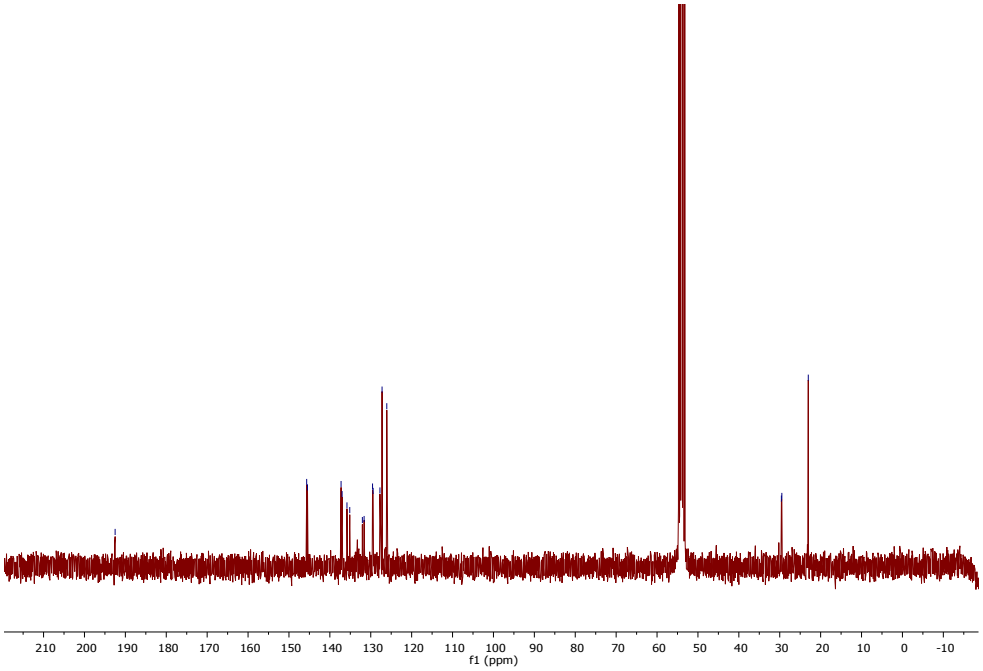

Figure 32. ^{13}C NMR spectrum of $[Os_3(CO)_9(btpp)_3]$ (**8**) in CD_2Cl_2.