Infrared Spectrum of Carbon Monoxide Chemisorbed on Nickel at 44 K by a Matrix Isolation Technique

By GEORGE BLYHOLDER,* MASAKO TANAKA, and JOHN D. RICHARDSON
(*Department of Chemistry, University of Arkansas, Fayetteville, Arkansas* 72701)

Summary The i.r. spectrum of the interaction complex formed by CO and Ni particles in an Ar matrix at 44 K has band maxima at 2070 and 1890 cm^{-1}.

A NEW technique to observe i.r. spectra of the interaction complex formed by metal particles and gases at low temperatures has been developed and is here applied to the CO–Ni system. In this method, the metal is evaporated from a heated filament and condensed in an Ar matrix at 20 K. The deposition surface temperature is maintained by a miniature two-stage Joule–Thompson liquifier as described by White and Mann.[1] This device offers some temperature control over the range 16—300 K. A mixture of 5% CO in Ar is condensed on top of the Ar–metal matrix. Curve 1 in the Figure shows the spectrum after deposition at 20 K with a large band due to matrix CO at 2140 cm^{-1}. Upon warming to 44 K the CO diffuses into contact with the metal. A spectrum recorded at 20 K using this procedure is shown in curve 2. This spectrum is recorded without scale expansion, thus indicating a much greater band intensity than has been reported for any other clean evaporated metal procedure.

The evaporated metal surface is expected to be clean except for noble gas contact even though the system used here only maintains pressures in the 10^{-6}—10^{-7} torr range. During the evaporation procedure contaminants from the cell walls will be swept away by the Ar flow since only a fraction of the Ar stream is condensed. After evaporation of the metal, it is effectively protected by the matrix. We are now constructing an ultra-high vacuum cell to work with the films left after the matrix Ar is evaporated. After the matrix is evaporated away sintering of the film becomes a major process. A main function of the matrix useful in obtaining i.r. spectra is the maintaining of the very small particle size. One disadvantage of this technique is that work with single crystal faces is not possible.

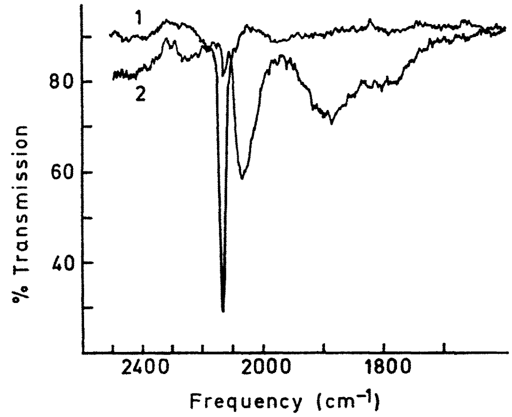

FIGURE. *I.r. spectrum of* CO *chemisorbed on* Ni *at* 44 K *in an* Ar *matrix.*

The most notable feature of the spectrum is its resemblance to spectra for CO chemisorbed on silica-supported Ni[2] and oil matrix supported Ni.[3] This indicates that electronic states accessible to the system at room temperature are accessible at 44 K, at least for chemisorption on very small particles. From the work of Hardeveld and Hartog[4] these are most likely C_6 and C_7 type sites (the subscript denotes the co-ordination number of the surface metal atom).

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