INFRARED SPECTRA OF $(CO_2)_n$ - (RARE GAS)$_m$ TRIMERS AND TETRAMER, (n, m) = (1,2), (1,3), (2,1)

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(*n*,*m*) = (1,2). CO_2-Ar_2 has previously been studied in the microwave[a] and infrared.[b] Its structure has two Ar atoms occupying equivalent positions around the 'equator' of the CO_2, giving C_{2v} symmetry. Here we report observation of analogous infrared spectra of CO_2-Ne_2 and CO_2-Xe_2. Meanwhile, for CO_2-Ar_2 we observe a new a-type combination band giving an intermolecular bending frequency of 32.2 cm^{-1}. Unlike the fundamental band, the combination band is free of interference from stronger CO_2-Ar transitions. Also, we observe CO_2-Ar_2 in the CO_2 (01^11) - (01^10) hot band region, as well as weak fundamental band spectra of the mixed trimers CO_2-Rg-He, with Rg = Ne, Ar, Xe.

(*n*,*m*) = (1,3). An interesting band near 2345.2 cm^{-1} is assigned to CO_2-Xe_3, whose structure appears to have C_s symmetry containing a xenon trimer (near equilateral triangle) and a CO_2 positioned so that two of the Xe atoms are in equivalent near equatorial positions.

(*n*,*m*) = (2,1). We have assigned spectra of new trimers, $(CO_2)_2$-Rg. The Xe-containing species was noticed first, and this led us to identify weaker spectra with Ar and (even weaker) Ne. Their structures resemble having a CO_2 dimer (planar slipped parallel) with the Rg atom located 'above' the dimer plane on (or close to) the dimer symmetry axis, analogous to $(CO_2)_2$-CO.[c] In the future, it should be possible to assign the various Kr clusters and to optimize each cluster by varying the expansion gas mixtures.

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[a] Y. Xu, W. Jäger, and M.C.L. Gerry, *J. Mol. Spectrosc.* **157**, 132 (1993).

[b] J.M. Sperhac, M.J. Weida, and D.J. Nesbitt, *J. Chem. Phys.* **104** 2202 (1996).

[c] A.J. Barclay, A.R.W. McKellar, and N. Moazzen-Ahmadi, *Chem. Phys. Lett.* **677**, 127 (2017).