and Cu^{++}, −26.5 e.u.[2] the value $S^\circ_{Cu^+} = +8.3 \pm 2.0$ e.u. is found.

In view of the relation of Powell and Latimer[5] connecting the ionic radii and the partial molal entropies of aqueous ions this value seems more reasonable than the Bureau of Standards value.

[5] R. E. Powell and W. M. Latimer, *J. Chem. Phys.*, **19**, 1139 (1951).

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The "Carbonyl" Frequency in Polycyclic Quinones

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In a recent communication Josien and Fuson[1] have pointed out that the "carbonyl" frequency in some polycyclic compounds, mainly quinones, has an abnormally low value in the infrared spectrum (*e.g.*, 6.1 μ or approximately 1640 cm.$^{-1}$ for 3,8- and 3,10-pyrenequinone). In connection with some work on coking substances and coal extracts, we have also studied the infrared spectra of a series of polynuclear quinones and some related hydrocarbons. A selection of the "carbonyl" frequencies that have been obtained in Nujol mulls of the quinones are listed below and may be compared with the values of 1660 cm.$^{-1}$ (6.01 μ) for *p*-benzoquinone and 1676 cm.$^{-1}$ (5.97 μ) for anthraquinone, obtained previously by Flett.[2]

	cm.$^{-1}$	μ
p-Naphthoquinone	1664	6.01
Pyranthrone	1655	6.04
Mesonaphthadianthrone	1649	6.06
Helianthrone	1646	6.08
1,2;6,7-Dibenzpyrene-3,8-quinone	1645	6.08
Dibenzanthrone	1638	6.10
Diphenoquinone	1626	6.16

It can be seen that the "carbonyl" frequencies of the polynuclear quinones listed above vary considerably in value. Taking into account these results and those of the earlier workers[1,2] it appears that paraquinones in which the two quinone carbonyl groups occur in the same ring absorb in the range 1660 to 1680 cm.$^{-1}$, and that extended quinones, in which the carbonyl groups are in different rings, usually absorb in the range 1635 to 1655 cm.$^{-1}$. In confirmation of this latter point we have found that benzanthrone has its "carbonyl" band at 1644 cm.$^{-1}$, and anthrone has been shown previously to absorb at 1654 cm.$^{-1}$ [2]; both of these molecules have single carbonyl groups coupled in a similar fashion to polycyclic ring systems. A single exception to the above rule concerning the "carbonyl" frequencies of extended quinones is provided by diphenoquinone. However this result may be abnormal on account of the unusual structure and chemical properties of this molecule. In any case the above correlations must only be considered as provisional and as subject to refinement when the spectra of a more extensive series of molecules of this type become available. Other quinone type molecules for which we have observed low "carbonyl" frequencies are 3,3′- and 4,4′-dibenzanthronyl (1626 and 1630 cm.$^{-1}$, respectively). An insufficient number of orthoquinones seem to have been studied spectroscopically to enable correlation rules to be drawn up at present.

In picking out the "carbonyl" frequencies we have listed the strong absorption band for each compound which lies at the highest frequency in the region 1550 to 1750 cm.$^{-1}$. It is of interest to note however that in some cases other equally strong absorption bands occur in the infrared spectra in the region 1570 to 1600 cm.$^{-1}$.[3] As the skeletal vibrations of polycyclic ring systems often occur in this range[4] it seems probable that, as might be expected, several of these modes of vibration also involve considerable vibrational motion of the carbonyl linkages. This coupling with ring skeletal vibrations would explain at the same time the high intensity of these lower frequency absorption bands and the variable nature of the so-called carbonyl frequency itself. In all cases that we have so far investigated only very much weaker bands are found in the region 1550–1750 cm.$^{-1}$ for the corresponding hydrocarbons.

On further comparison of the spectra of the quinones and related hydrocarbons, differences were also found in the regions of the spectra which are not close to the "carbonyl" frequency. Thus in the spectra of the quinones strong absorption bands were found in region 1200–1350 cm.$^{-1}$ which are not present in comparable strength in the hydrocarbon spectra, and presumably also arise from the coupling of the C=O vibration with those of the rest of the molecule. In addition the features in the spectra of the quinones and hydrocarbons between 900 and 700 cm.$^{-1}$ which can usually be attributed to the out-of-plane vibrations of the CH linkages attached to the aromatic skeleton[4] also showed considerable differences as would be expected from the changes in substitution pattern. Further spectroscopic work on these types of molecules is continuing.

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[1] M. L. Josien and N. Fuson, THIS JOURNAL, **73**, 478 (1951).

[2] M. St. C. Flett, *J. Chem. Soc.*, 1441 (1948).

[3] A similar effect has been noted previously as being caused by the conjugation of a C=O group to a phenyl ring (Randall, Fowler, Fuson and Dangl, "Infra-red Determination of Organic Structures," D. Van Nostrand and Co., New York, N. Y., 1949, p. 16).

[4] S. F. D. Orr and H. W. Thompson, *J. Chem. Soc.*, 218 (1950).

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Viscosity of Polytrifluorochloroethylene in o-Chlorobenzotrifluoride

BY H. TRACY HALL, EDWARD L. BRADY AND PAUL D. ZEMANY

Viscosity data for polytrifluorochloroethylene in a chlorofluorobutane solvent have been presented by H. S. Kaufman and M. S. Muthana.[1] We

[1] Paper No. 26, Division of High Polymer Chemistry, American Chemical Society Meeting, September 5, 1950.