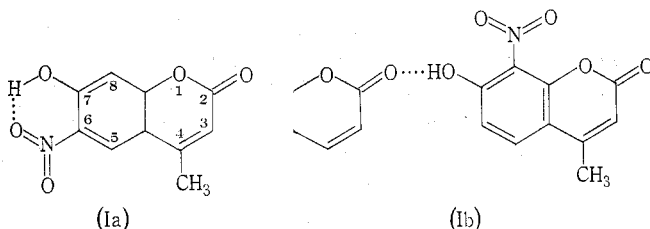


HYDROGEN BONDING IN NITRO-7-HYDROXYCOUMARINS*

By R. H. LABY†‡ and T. C. MORTON†§

The strength of intramolecular hydrogen bonds in *o*-nitrophenols is influenced by the steric interaction of neighbouring groups in an interesting manner. A methyl group in the 3- or 6- position of 2-nitrophenol forces the nitro or hydroxyl groups into orientations in which the bonding is stronger than in the unsubstituted nitrophenol. The hydrogen bond is further strengthened in 3,6-dimethyl-2-nitrophenol.¹ However, larger atoms and groups, e.g. chloro, *t*-butyl, and trifluoromethyl, adjacent to the nitro group force it too far out of the plane of the aromatic nucleus for strong intramolecular hydrogen bonding.^{2,3}

It was found in the present work that these steric effects apply to nitro-substituted 7-hydroxy-4-methylcoumarin, and 7-hydroxy-4,8-dimethylcoumarin. In addition, the intermolecular hydrogen bonding between the hydroxyl and the lactone carbonyl groups observed in crystalline 7-hydroxycoumarin⁴ also occurs in crystalline 7-hydroxy-4-methyl-8-nitrocoumarin. In this compound the nitro group is forced out of the plane of the aromatic nucleus by interaction with the heterocyclic oxygen and is presumably not favourably oriented for strong intramolecular hydrogen bonding. The alternative forms of hydrogen bonding observed in the nitrocoumarins studied are portrayed in (Ia) and (Ib).



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† State Laboratories, Department of Agriculture, Melbourne.

‡ Present address: Division of Applied Mineralogy, CSIRO Chemical Research Laboratories, Melbourne.

§ Present address: Russell Grimwade School of Biochemistry, University of Melbourne.

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Hydroxyl Stretching Vibrations

These are given in Table 1.

Only the 6-nitro derivatives are sufficiently soluble in carbon tetrachloride to permit the observation of the hydroxyl stretching bands. Both of these compounds show intramolecular hydrogen bonding in solution, with the 4,8-dimethyl derivative the more strongly bonded as a result of the steric influence of the 8-methyl group.

TABLE 1
HYDROXYL AND CARBONYL STRETCHING VIBRATIONS (cm^{-1}) FOR 7-HYDROXYCOUMARINS
AND NITRO-7-HYDROXYCOUMARINS
Numbers in brackets refer to shoulders

Substituents at				Hydroxyl		Carbonyl	
C 4	C 6	C 7	C 8	Solid	In CCl_4	Solid	In CCl_4
Me		OH	Me	3226	*	1686 (1701, 1656)	1735
Me		Ts	Me			1710 (1718)	1737
Me		OH		3110	*	1667	1732 (1750)
Me		Ts				1723	1740
Me	NO_2	OH	Me	3220	3183 (3104)	1733	1761
Me	NO_2	Ts	Me			1721	1756 (1745)
Me	NO_2	OH		3242	3212	1724	1758
Me		OH	NO_2	3275	*	1700 (1728)	1762
Me		Ts	NO_2			1747	1765 (1770)

* Not observed in a cell of 1-cm thickness filled with saturated solution.

Carbonyl Stretching Vibrations

Examination of the carbonyl stretching frequencies given in Table 1 reveals that intermolecular hydrogen bonding involving the lactone carbonyl occurs in all crystalline phenols studied except the 6-nitro derivatives, where the intramolecular hydrogen bonding revealed in their carbon tetrachloride solutions probably occurs. This is evident from the elevation in carbonyl stretching frequencies for the crystalline phenols on forming either the carbon tetrachloride solutions ($49\text{--}65\text{ cm}^{-1}$) or the *p*-toluenesulphonyl esters ($24\text{--}56\text{ cm}^{-1}$). The corresponding elevations for the 6-nitro compounds are $28\text{--}34\text{ cm}^{-1}$ and -12 cm^{-1} (for 7-hydroxy-4,8-dimethyl-6-nitro-coumarin).

*Experimental**7-Hydroxy-4-methylcoumarin*

This compound was prepared from ethyl acetoacetate and resorcinol⁵ and had m.p. $191\text{--}193^\circ$ (lit.⁶ $185\text{--}186^\circ$). The acetate had m.p. $152\text{--}154^\circ$ (lit.⁶ 150°).

⁵ Vogel, A. I., "A Textbook of Practical Organic Chemistry." 3rd Edn, p. 854. (Longmans: London 1956.)

⁶ Heilbron, I. (Ed.) "Dictionary of Organic Compounds." 4th Edn, Vol. III, p. 1724. (Eyre & Spottiswoode: London 1965.)

7-Hydroxy-4,8-dimethylcoumarin

This compound was prepared from ethyl acetoacetate and 2-methylresorcinol and had m.p. 265–266° (lit.⁷ 258°). The acetate had m.p. 136–138° (lit.⁷ 135–136°).

7-Hydroxy-4,8-dimethyl-6-nitrocoumarin

This was prepared⁸ by nitration of 7-hydroxy-4,8-dimethylcoumarin and had m.p. 226–227° (lit.⁸ 229.5–231.5°).

7-Hydroxy-4-methyl-6-nitrocoumarin and 7-Hydroxy-4-methyl-8-nitrocoumarin

These compounds were prepared by nitration of 7-hydroxy-4-methylcoumarin following the procedure of Shah and Mehta⁹ with separation procedures modified from the published method as follows.

The product from nitration was recrystallized once from ethanol, the insoluble product being set aside. The ethanol-soluble material was recrystallized 3 times from benzene to give the 6-nitro derivative, m.p. 263–265° (lit.⁹ 262°). This product travelled as one spot (R_F 0.61) on a paper chromatogram with the developing solvent Bu¹OH/NH₄OH/H₂O (8 : 30 : 62, volume basis).

The insoluble residue from the ethanol recrystallization was extracted twice under reflux with benzene. The residue was then recrystallized from ethyl methyl ketone to give the 8-nitro compound, m.p. 257° (dec.) (lit.⁹ 256°). This product travelled as one spot (R_F 0.75) on a paper chromatogram with the same developing solvent.

Infrared spectra were obtained using a Perkin–Elmer 421 grating spectrometer. Single-beam water-vapour spectra were included on each chart as internal frequency standards. Reproducibility was ± 1 to ± 3 cm⁻¹ depending on the width of the absorption band. Analytical reagent grade carbon tetrachloride was used for solution spectra. Cell thicknesses were 0.1 mm and 1 cm. Analytical reagent grade potassium chloride dried at 350° was used in the preparation of disks containing the solid coumarin compounds studied.

⁷ Rangaswami, S., and Seshadri, T. R., *Proc. Indian Acad. Sci.*, 1938, **7A**, 8.

⁸ Moffett, R. B., *J. mednl pharm. Chem.*, 1962, **5**, 335.

⁹ Shah, N. M., and Mehta, D. H., *J. Indian chem. Soc.*, 1954, **31**, 784.