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SPIN-SPIN COUPLING BETWEEN H_2 AND H_6 IN BENZOTHIOPHENES AND INDOLES

M. Martin-Smith*, S. T. Reid* and S. Sternhell+

* Department of Pharmacy, University of Strathclyde, Glasgow C.1. United Kingdom. +Department of Organic Chemistry, University of Sydney, Sydney, N.S.W., Australia.

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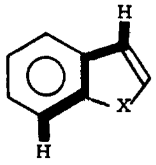
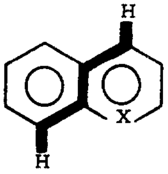
Long-range spin-spin coupling[1] between protons situated on different rings of polynuclear systems has been reported in the parent systems, or the derivatives of, indene[2,3], benzofuran[3,4,5], benzothiophene[4,6], indole[1,4,7], indazole[8], indolizine[9], azaindolizines[9a], diazanaphthalenes[9b], thienopyrroles[10-13], thienothiophene[14], quinoline[15-18], isoquinoline[4], naphthalene[1,19], anthracene[1,19], acridine[20], acridone[20], dipyridoimidazolinium cation[21], indenyl anion[22a], chromene[4] and borazonaphthalene[22b].

Typically, such coupling is between protons separated by five bonds in a straight zig-zag pattern as in [I] and [II], although other interactions have also been reported. This coupling and its relation to certain types of benzylic coupling have been discussed by several authors[1,4,23-25].

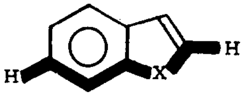
We now wish to report some evidence for the presence of a *small long-range interaction between H_2 and H_6 in some derivatives of benzothiophene and indole*.



[I]



[II]



[III]

The NMR spectrum* of 3-methoxy-5-nitrobenzothiophene in deuterochloroform consists of a singlet at 241 c/s [methoxyl], an unresolved signal at 389 c/s [H_2], a doublet of doublets at 465 and 474 c/s with splittings of 8.8 and 0.7 c/s [H_7], a doublet of doublets of doublets at 458 and 467 c/s with splittings of 8.8, 2.3 and 0.5 c/s [H_6] and a doublet of doublets at 520 c/s with splittings of 2.3 and 0.7 c/s [H_4]. The additional splitting of 0.5 c/s in the signal assigned to H_6 can only be due to an interaction with H_2. The lack of resolution in H_2 could be due to a very small additional splitting by the methoxyl group.[26,27]

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* At 60 Mc, chemical shift in c/s downfield from internal TMS.

Similarly, H_6 in 5-nitrobenzothiophene also gives rise to a doublet of doublets of doublets with the smallest splitting of about 0.4 c/s. In 4-bromo-5-aminobenzothiophene the signal due to H_2 is a doublet of doublets with splittings of 5.7 [$J_{2,3}$] and approximately 0.5 c/s while the signal due to H_6 is a broadened doublet [W_H = 1 c/s at a resolution at which the signal due to TMS had W_H = 0.4 c/s] with the principal splitting equal to 8.8 c/s [$J_{6,7}$].

The NMR spectra of N-deuterated 5-methoxyindole[7] in acetone or deuterochloroform show the signal assigned to H_6 as a doublet of doublets of doublets with splittings of 8.7, 2.5 and 0.4 c/s, the signal assigned to H_2 is a doublet of doublets with splittings of 3.2 and 0.4 c/s, the signal assigned to H_3 as a doublet of doublets with splittings of 3.2 and 0.8 c/s; the signals assigned to H_4 and H_7 overlap partially, but H_7 appears to give rise to a doublet of triplets with the doublet splitting of approximately 9 c/s and triplet splitting of approximately 0.8 c/s. This spectrum is compatible with the following [first order] coupling constants: $J_{6,7}$: 8.7 c/s, $J_{6,4}$: 2.5 c/s, $J_{6,2}$: 0.4 c/s, $J_{7,3}$: 0.8 c/s, $J_{2,3}$: 3.2 c/s, $J_{7,4}$: 0.8 c/s.

It thus may be considered as tentatively established that an appreciable H_2, H_6 coupling may be a general feature in benzothiophene and indole spectra. As analogous interactions have also been tentatively proposed in indolizines[9a] and diazanaphthalenes[9b] and may correspond to those established in thienopyrroles[10-13] it is likely that long range coupling along the path indicated in [III] is general, like that along the paths indicated in [I] and [II]. It is noteworthy that H_2 and H_6 in [III] are connected by a "straight zig-zag path"[23] which is conjugated in a number of canonical forms[4].

Few of the lines observed are as narrow as those due to TMS and residual chloroform and this could indicate still further long-range interactions. However, at the resolution available it is difficult to ascertain that point.

The coupling between H_2 and H_6 in other benzothiophenes has been independently noted by Takahashi[28]. Other NMR data on a number of benzothiophenes and indoles will be published elsewhere.

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