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THE APPLICATION OF A NEW AROMATICITY INDEX TO SOME BICYCLIC HETEROCYCLES

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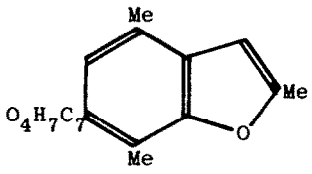
Abstract-The aromatic character of a range of bicyclic heterocycles has been assessed using a previously described aromaticity index. Apart from providing a rationale for the relative stabilities observed for some heterocyclic ring systems, the results also indicate substantial aromatic character for such 'orthoquinonoid' compounds as isoindole.

Recent papers[1,2] have presented a new index of aromatic character based upon a statistical evaluation of the deviations in peripheral bond order of a putative aromatic compound. These bond orders can in turn be readily derived from experimentally measured bond lengths. The apparent success of this approach in accounting for a variety of aromaticity related properties of five and six-membered ring heterocycles has prompted the present paper in which attention is directed to bicyclic systems in which a five membered ring is fused to another five or six-membered ring.

The aromaticity indices calculated for a range of benzo-fused five-membered ring heterocycles are shown in Figure 1. In many instances the parent heterocycle is not a solid and it has been necessary to use the dimensions reported for derivatives, however there still remain some ring systems for which no data are available or, in a few cases, the information is way below presently accepted levels of accuracy. As might have been expected the same general order of aromaticity is observed for these benzo-derivatives as for the monocyclic heterocycles[1,3] with indole>benzo[b]thiophene>benzo[b]furan, and benzimidazole > benzothiazole > benzoxazole. The relative aromaticities of the corresponding benzo[b]- and [c]-fused systems has been a matter for periodic examination by theoretical chemists who have always concluded[4,5] that the [c] fused isomers will be much less aromatic than their [b]-fused isomers. However, analysis of the structural data that has recently become available for isoindoles[6,7] and isobenzofuran indicates that they enjoy similar aromaticities to indole and benzo[b]furan respectively. This conclusion also finds support in the similar aromaticity indices obtained for 1H- and 2H-benzotriazoles, and the identical values of $I_{5,6}$ for 1,2- and 2,1-benzisothiazole. The $I_{5,6}$ of 54 for 2,1-benzisoxazole is also noteworthy in this context.



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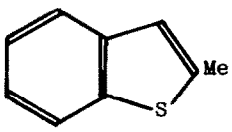

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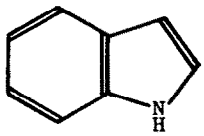

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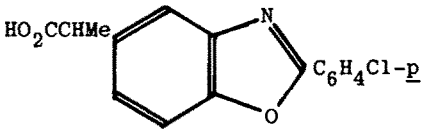

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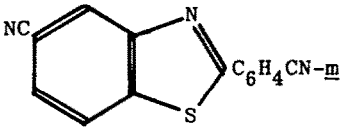

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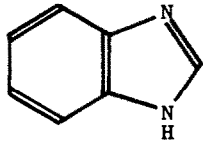

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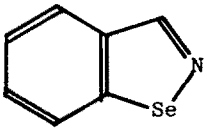

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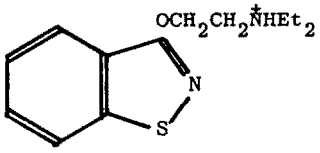

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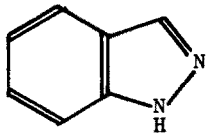

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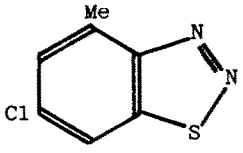

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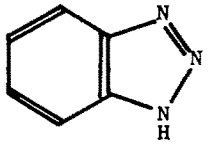

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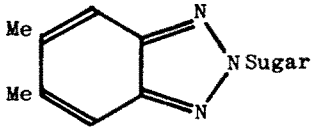

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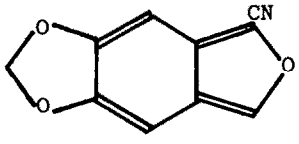

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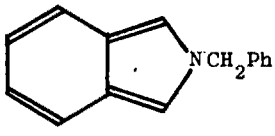

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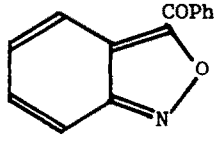

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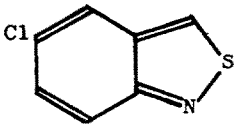

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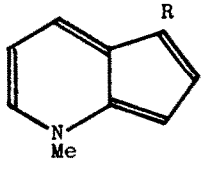
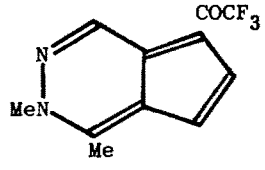


68 [25]

(R = 1-Methyl-1-azoniaindan-6-yl)



77 [26]

FIGURE 1 Aromaticity indices ($I_{5,6}$) for bicyclic heterocycles. (The references are to the source of bond lengths used for their calculation).

There is as yet very limited structural information available on so-called 'pseudoazulenes', in which the heteroatom(s) is located in the six- rather than the five-membered ring. However the last two entries in Figure 1 indicate that such compounds can have comparable aromaticities to the isomeric benzazoles.

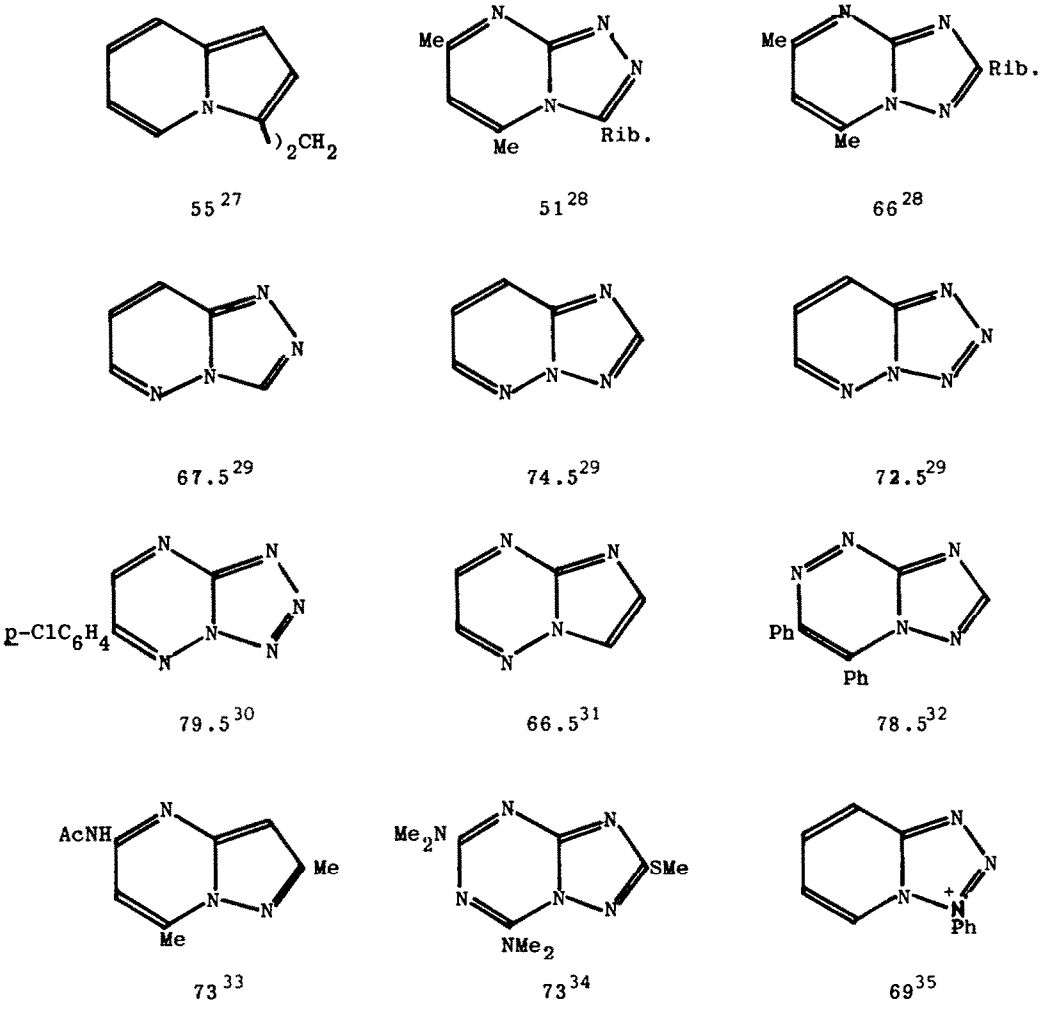


FIGURE 2 Aromaticity indices ($I_{5,6}$) for bicyclic heterocycles with a bridgehead nitrogen atom. (The references are to the source of bond lengths used for their calculation).

In accord with perceptions largely based on reactivity differences indolizine is found to have an appreciably lower aromaticity index (cf. Figure 2) than the isomeric indole or isoindole, although introduction of additional ring nitrogen atoms generally results in increases of the index. A feature of the chemistry of some of these polyazaindolizines is the intervention of Dimroth-type rearrangements as exemplified by the conversion of s-triazolo[4,3-a]pyrimidine to the isomeric s-triazolo[1,5-a]pyrimidine[8]. Comparison of the aromaticity indices of 51 and 66 respectively for these two ring systems suggests that the major driving force for the rearrangement is the increased aromatic character of the product heterocycle. Similar conclusions have been reached from molecular orbital calculations.

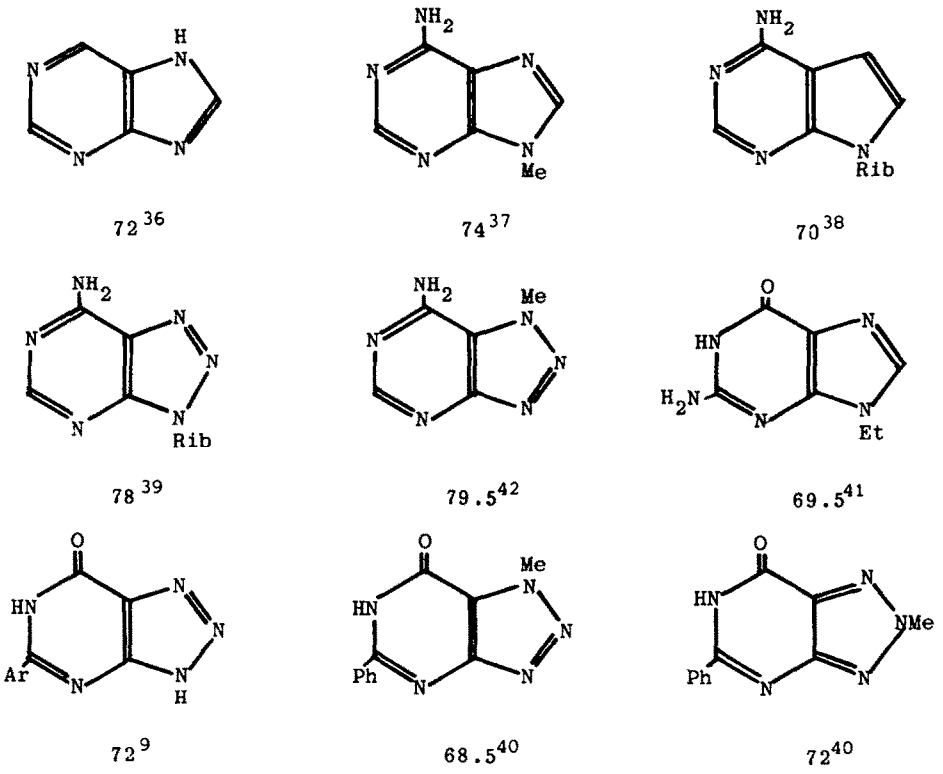


FIGURE 3 Aromaticity indices ($I_{5,6}$) for some purine derivatives. (The references are to the source of bond lengths used for their calculation).

Although purine crystallises as the 7H-tautomer the closely similar energies ascribed to the 7H- and 9H-tautomers in solution finds ready support in the closely similar aromaticity indices derived for purine and 9-methyladenine as shown in Figure 3. A parallel situation to this also appertains in the corresponding 8-aza system. Surprisingly little aromatic character is lost in proceeding from purine to 9-ethylguanine, although there is a much larger difference in the 8-azahypoxanthine series. A notable feature of these later compounds is that the aromaticity indices indicate that the 7H-, 8H- and 9H-tautomers are of similar stability and indeed an example of the preferential adoption of the 8H form in the crystal lattice has been reported for an 8-azahypoxanthine derivative[9].

In contrast to the situation with systems comprising fused five and six-membered rings, there is a marked paucity of structural data on compounds consisting of two fused five-membered rings apart from derivatives of 1,6,6$\kappa\lambda^4$-trithiapentalene. The virtually zero bond orders between adjacent sulfur atoms are not readily accomodated by the present aromaticity index approach and it is hoped to return to this aspect at a later date. Aromaticity indices ($I_{5,5}$) for most of the remaining derivatives are shown in Figure 4. Of particular note, in view of current interest, is the substantial aromatic character displayed by thieno[3,4-c]thiophen, relative to its [3,2-b]-fused counterpart, and the thiadiazolo[3,4-c]thiadiazole.

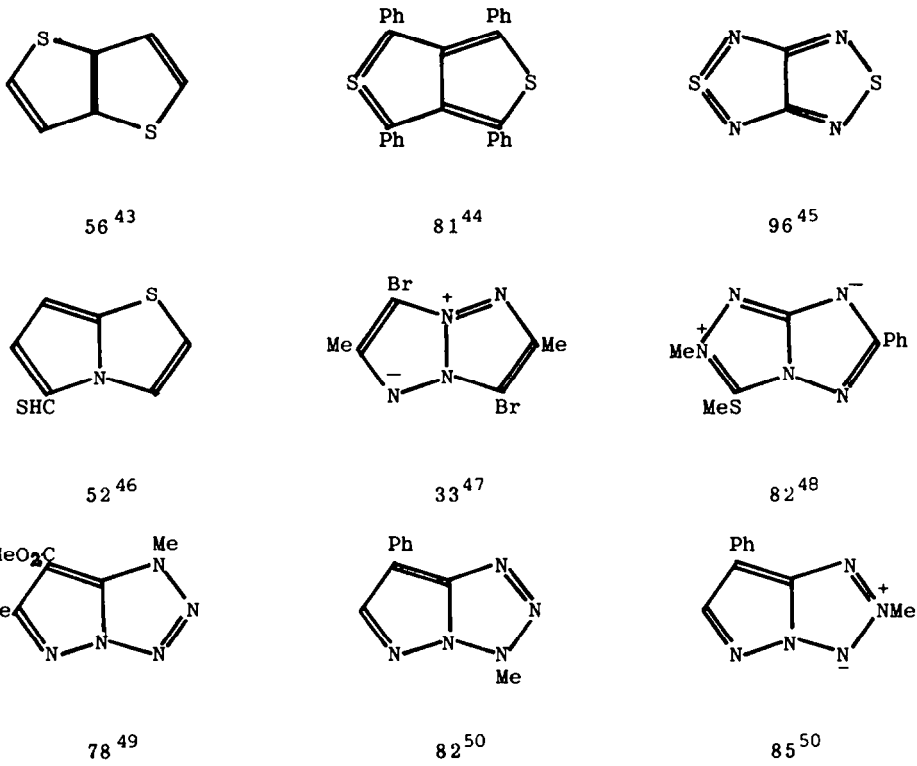


FIGURE 4 Aromaticity indices ($I_{5,5}$) for some fused five-membered ring heterocycles. (The references are to the source of bond lengths used for their calculation).

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