

Lack of Manifestation of the Exo-Anomeric Effect in S-C-P(:) System

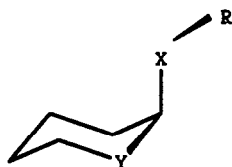
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Abstract: The absence of the shielding effect of the phenyl ring in 2-phosphino-1,3-dithianes containing axial Ph(R)P(:) group (R= Me, Ph), as well as a large (7-8 Hz) coupling constant between axial phosphorus and carbons C(4,6) suggest the *endo* position of the phosphorus lone electron pair. The *exo*-anomeric effect, which could be governed by $n_P-\sigma^*_{C-S}$ negative hyperconjugation is not manifested in this system. The observed rotational behavior can be sufficiently explained on steric grounds.

Two definitions of the *exo*-anomeric effect are present in the literature. Usually, the *exo*-anomeric effect is defined¹ as the preference for the *gauche* conformation around the exocyclic C-OR bond in 2-alkoxytetrahydropyran derivatives (i.e. *sc,sc* and *ap,-sc* are the energetically preferred species), or generally as the *gauche* preference in Y-C-X-R system in 2-substituted heteroanes 1 and 2. Thus, the preferred species should be 1(*sc,sc*) and 2(*ap,-sc*).

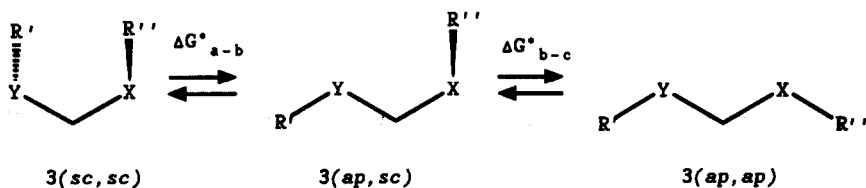


1(*sc,sc*)



2(*ap,-sc*)

The second definition, which emphasizes energetic consequences of the anomeric interactions and their directionality, was presented by Praly and Lemieux². For equilibria in R'-Y-CH₂-X-R'' system 3 (Scheme 1) one has two possible partial anomeric effects: one concerning the preference for *sc* arrangement of X-C bond, and the second dealing with the conformation around C-Y bond. The observed anomeric effect for the molecule as a whole is dependent on the relative strength of these partial anomeric

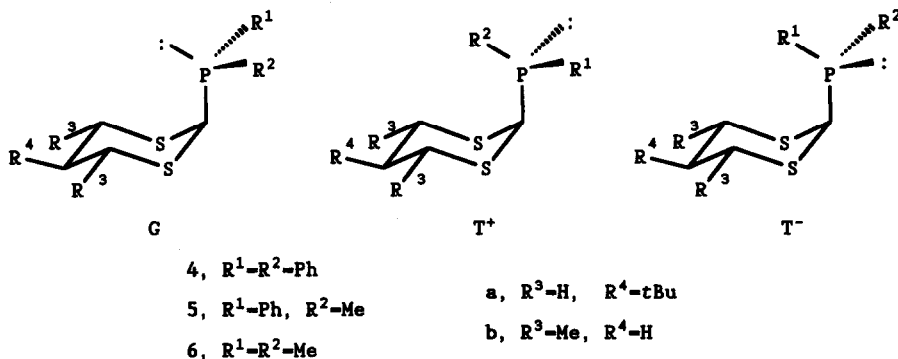


Scheme 1. Conformational equilibria in $R'-Y-CH_2-X-R''$ system.

effects, which could compete with each other. When C-Y bond is a part of a ring, then the magnitude of the anomeric effect about the C-X bond describes the *exo*-anomeric effect.

The rationalization of rotational behavior about the exocyclic C-X bond is usually based on $n_Y-\sigma^*_{C-X}$ negative hyperconjugation, which is most effective in the *gauche* arrangement of the Y-C-X-R system. Such point of view is not without its critics³, which emphasize the steric origin of the observed rotational preference.

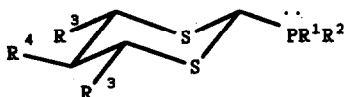
The nature of the anomeric interactions involving the second-row atoms and the importance of the $n_Y-\sigma^*_{C-X}$ negative hyperconjugation for such atoms has been a subject of intensive debate for the past ten years⁴⁻⁶. In this context, in order to estimate qualitatively the role of the $n_P-\sigma^*_{C-S}$ negative hyperconjugation we decided to study the rotational isomerism of axial 2-phosphino-1,3-dithianes 4-6⁷ by means of NMR methods. We



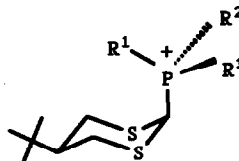
expected that, if *exo* anomeric interactions in S-C-P(:) system were strong, the preferred rotamers should be T⁺ and T⁻ having R² or R¹ located over the 1,3-dithiane ring. Surprisingly, analysis of the ¹H NMR spectrum of 4a revealed that the shielding effect of the phenyl group is not observed (see Table 1). In particular, the chemical shift of the *t*Bu protons in 4a is δ_{tBu} 0.92 ppm, while in its epimer 7a and in the parent, unsubstituted 5-*t*-butyl-1,3-dithiane it was equal to 0.87 and 0.92 (in CDCl₃) ppm, respectively. Therefore, both phenyl substituents in 4a should be located *exo* that means it has the G-conformation. On the other hand, in all salts 10-12, containing at least one phenyl group connected with the axial phosphorus such a shielding by 0.3 ppm is indeed observed (cf Table 1). For instance, the chemical shift of the *t*Bu group in 12 is equal to 0.59 ppm, which strongly suggests the *endo* position of the phenyl group. Of course, in the absence of the phenyl group at phosphorus the chemical shift δ_{tBu} is not influenced and it is equal to 0.91 ppm in 13. Therefore, it is reasonable to assume that the

Table 1. The chemical shift δ_{tBu} of tBu group in 1H NMR(300 MHz, CD_2Cl_2) spectra of phosphines 4-9a and phosphonium salts 10-13.

Compound No	δ_{tBu} [ppm]	Compound No	δ_{tBu} [ppm]	Compound No	δ_{tBu} [ppm]
4a	0.92	7a	0.87	10	0.59
5a	0.91	8a	0.87	11	0.61
6a	0.89	9a	0.90	12	0.59
				13	0.91



- 7, $R^1-R^2=Ph$
 8, $R^1=Ph$, $R^2=Me$ a, $R^3=H$, $R^4=tBu$
 b, $R^3=Me$, $R^4=H$
 9, $R^1-R^2=Me$



- 10, $R^1-R^2-R^3=Ph$
 11, $R^1-R^2=Ph$, $R^3=Me$
 12, $R^1=Ph$, $R^2-R^3=Me$
 13, $R^1-R^2-R^3=Me$

effective "size" of the phenyl group attached to the axial phosphorus is smaller than that of the methyl group. For this reason the structure T⁺-5 with the methyl group located over the 1,3-dithiane ring must be excluded. Hence, lack of the shielding effect of the phenyl group in 5 is consistent only with the rotamer G-5.

Analogous relationship can also be observed for other nuclei of the C(4)-C(5)-C(6) region.

A very strong support to the conclusions presented above and based on the shielding effect of the phenyl rings is provided by coupling constant $^3J_{C(4,6)-P}$ in the ^{13}C NMR spectra of 2-phosphino-1,3-dithianes 4-6 (Table 2). Interestingly, this coupling constant is large (ca 7-8 Hz), in contrast to what is observed⁶ for the relevant axial 2-phosphonic- and 2-phosphoryl-1,3-dithianes, where it is equal to zero. This observation can be attributed to the presence of a lone electron pair in 4-6 located *endo*, and it is due to the orientational effect of the phosphorus lone pair on C-P coupling. It was demonstrated both by experiment⁸ and theoretically⁹ that the P lone pair is an efficient spin information transmitter. Thus, because of the spatial proximity of the P and C(4,6) atoms in G-1, the magnitude of such coupling seems to be governed by through-space interaction, which should be in maximum for lone pair lying over the 1,3-dithiane ring.

Therefore, the *exo-anomeric* effect is not manifested in the S-C-P(:) system, though

Table 2. Coupling constant ${}^3J_{C-P}$ between C(4,6) and P in ${}^{13}C$ NMR(75.45 MHz, CD_2Cl_2) spectra of phosphines 4-9.

Compound No	${}^3J_{C-P}$ [Hz]	Compound No	${}^3J_{C-P}$ [Hz]	Compound No	${}^3J_{C-P}$ [Hz]	Compound No	${}^3J_{C-P}$ [Hz]
4a	7.2	4b	8.7	7a	7.9	7b	7.4
5a	7.0	5b	8.1	8a	7.1	8b	6.4
6a	7.9	6b	8.6	9a	6.3	9b	6.4

it cannot be excluded for derivatives containing the equatorial phosphino group¹⁰. Our findings have their serious consequences, as far as the origin of the anomeric effect in this system is concerned. In particular, the $n_P-\sigma^*_{C-S}$ negative hyperconjugation does not seem to be an important factor in the S-C-P anomeric interactions. The rotational behavior of axial phosphino groups seems to be governed by destabilizing interactions, and can be sufficiently explained on the grounds of classical steric effects.

Finally, it should be noted that 2-phosphino-1,3-dithianes provide very interesting example of non-competitive hyperconjugative anomeric interactions in a system where both heteroatoms Y and X possess lone electron pairs. In the equatorial form the *endo*-interactions cannot operate, while in the axial species the *exo*-effect was shown to be unimportant.

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