at 360 MHz with a Bruker WM-360 superconducting FT-NMR spectrometer. Medium pressure liquid chromatography (MPLC) was performed on an EM LOBAR size C silica gel column at an eluent flow rate of 15 mL/min.

The method of Howe[12] was employed for preparation of the (*E*)-3-benzylidenephthalides.

(*E*)-3-Benzylidenephthalide: white crystals, mp 94.5–97 °C (lit.[13] mp 96 °C and olefinic H NMR signal at δ 6.8), 50% yield; NMR ($CDCl_3$) δ 7.83 (m, 1), 7.4 (m, 8), 6.8 (s, 1); IR (Nujol) 1770 cm^{-1}.

(*E*)-3-(4-Chlorobenzylidene)phthalide: white solid, mp 147.5–148.5 °C; 50% yield; NMR ($CDCl_3$) δ 7.83 (m, 1), 7.55–7.43 (m, 7), 6.86 (s, 1). Anal. Calcd for $C_{15}H_9ClO_2$: C, 70.19; H, 3.53. Found: C, 70.09; H, 3.53.

(*E*)-3-[3-(Trifluoromethyl)benzylidene]phthalide: white solid; mp 77.5–79 °C; 40% yield; NMR ($CDCl_3$) δ 8.0–7.4 (m, 8), 6.86 (s, 1). Anal. Calcd for $C_{16}H_9F_3O_2$: C, 66.21; H, 3.13. Found: C, 66.45; H, 3.16.

(*E*)-3-[4-(Trifluoromethyl)benzylidene]phthalide: 50% yield of 90:10 *E*:*Z* mixture; mp 101–111.5 °C. Three recrystallizations of a small amount of the mixture from cyclohexane gave 99% *E* isomer (GC analysis), mp 113.5–115 °C. Anal. Calcd for $C_{16}H_9F_3O_2$: C, 66.21; H, 3.13. Found: C, 66.06; H, 3.01.

3′,4′-Diphenylspiro[isobenzofuran-1(3*H*),5′(4′*H*)-isoxazol]-3-one (4a). To a solution of 9.40 g (0.0423 mol) of (*E*)-3-benzylidenephthalide and 6.54 g (0.0423 mol) of benzohydroxyamoyl chloride in 150 mL of ether stirred under nitrogen at 5 °C was added dropwise a solution of 4.28 g (0.0423 mol) of triethylamine in 20 mL of ether. The mixture was then stirred at 20 °C. After 42 h, no nitrile oxide remained (IR analysis), but NMR analysis of the ether solution showed residual (*E*)-3-benzylidenephthalide; no *Z* isomer had formed. The mixture was filtered. The collected solid was dissolved in 150 mL of chloroform, and the solution was washed twice with water, dried ($CaSO_4$), and concentrated to 3.55 g (24.6%) of solid that appeared to be pure spiro product (NMR analysis). This material was crystallized from toluene–methylcyclohexane to give 2.57 g (17.8%) of white, analytically pure spiro product: mp 187.5–188.5 °C; NMR ($CDCl_3$) δ 7.9–7.0 (m, 13), 6.27 (d, J = 7 Hz, of fine multiplets, 1), 5.06 (s, 1); IR (Nujol) 1780 cm^{-1}; MS, *m/e* (relative intensity) 341 (2.5), 222 (29), 194 (44.5), 193 (95.8), 192 (12.6), 166 (31.7), 165 (77.6), 116 (16.9), 105 (40), 104 (87.2), 103 (62.1), 91 (25.2), 90 (54.4), 89 (66.1), 77 (86.4), 76 (100.0). Anal. Calcd for $C_{22}H_{15}NO_3$: C, 77.41; H, 4.43. Found: C, 77.25; H, 4.46.

The ether filtrate from filtration of the reaction mixture was washed twice with water, dried ($CaSO_4$), and concentrated under vacuum to 9.0 g of oil; NMR, IR, and TLC analyses of the oil showed it to consist primarily of (*E*)-3-benzylidenephthalide and diphenylfurazan oxide, with a small amount of spiro adduct. A 2.0-g sample of the oil was separated by MPLC with toluene as eluent. The first material off the column consisted of 0.48 g of diphenylfurazan oxide, which corresponds to 2.16 g (43% yield) total in the 9.0 g of oil. The next material off the column was 1.10 g of (*E*)-3-benzylidenephthalide, which corresponds to 4.95 g (53% recovery) of starting material. Finally, 0.20 g of spiro adduct was obtained which corresponds to 0.90 g (6.2%) of spiro adduct. A total isolated yield of 30.8% of spiro adduct is thus indicated.

3′-Phenyl-4′-(4-chlorophenyl)spiro[isobenzofuran-1-(3*H*),5′(4′*H*)-isoxazol]-3-one (4b). (*E*)-3-(4-Chlorobenzylidene)phthalide in methylene chloride solution was treated with an equivalent of benzonitrile oxide (from benzohydroxamoyl chloride and triethylamine) for 4 days at 20 °C and then with another equivalent of benzonitrile oxide for several days. The mixture then was diluted with methylene chloride to dissolve all solids and was washed twice with water, dried ($CaSO_4$), and concentrated under vacuum to an oil. MPLC of the oil with methylene chloride gave pure spiro adduct, mp 179–181.5 °C, in 35% yield: NMR ($CDCl_3$) δ 7.9–7.0 (m, 12), 6.37 (d, *J* = 7 Hz, of fine multiplets, 1), 5.02 (s, 1); IR (Nujol) 1770 cm^{-1}; MS, *m/e* (relative intensity) 377 (0.6, $M^+ + 2$), 375 (2, M^+), 256 (9.3), 229 (23.9), 227 (56.5). Anal. Calcd for $C_{22}H_{14}ClNO_3$: C, 70.31; H, 3.75. Found: C, 70.37; H, 3.83.

3′-Phenyl-4′-[3-(trifluoromethyl)phenyl]spiro[isobenzofuran-1(3*H*),5′(4′*H*)-isoxazol]-3-one (4c). Treatment of (*E*)-3-[3-(trifluoromethyl)benzylidene]phthalide in methylene chloride solution with a total of 3 equiv of benzonitrile oxide (1 equiv every 3 days) followed by workup as for **4b** and MPLC with toluene gave spiro adduct **4c**, mp 194.5–196 °C, in 42% yield: NMR ($CDCl_3$) δ 7.96–7.26 (m, 12), 6.20 (d, *J* = 7 Hz, of fine multiplets, 1), 5.15 (s, 1); IR (Nujol) 1780 cm^{-1}. Anal. Calcd for $C_{23}H_{14}F_3NO_3$: C, 67.48; H, 3.45. Found: C, 67.52; H, 3.56.

3′-Phenyl-4′-[4-(trifluoromethyl)phenyl]spiro[isobenzofuran-1(3*H*),5′(4′*H*)-isoxazol]-3-one (4d). A 90:10 mixture of (*E*)- and (*Z*)-3-[4-(trifluoromethyl)benzylidene]phthalides was treated with 3 equiv of benzonitrile oxide in nearly identical fashion with that employed in the preceding experiment. The spiro adduct, isolated by MPLC with toluene eluent, had mp 174–175.5 °C and was isolated in 43% yield: NMR ($CDCl_3$) δ 7.92–7.23 (m, 12), 6.27 (d, *J* = 7 Hz, of fine multiplets, 1), 5.16 (s, 1); IR (Nujol) 1780 cm^{-1}. Anal. Calcd for $C_{23}H_{14}F_3NO_3$: C, 67.48; H, 3.45. Found: C, 67.38; H, 3.54.

3′,4′-Bis(4-chlorophenyl)spiro[isobenzofuran-1(3*H*),5′-(4′*H*)-isoxazol]-3-one (4e). Treatment of (*E*)-3-(4-chlorobenzylidene)phthalide in methylene chloride solution with a total of 4 equiv of 4-chlorobenzonitrile oxide (1 equiv every 24 h) gave, after workup and MPLC with toluene, solid spiro adduct, mp 136.5–144 °C, in 43% yield. Crystallization of this solid from cyclohexane gave 3.92 g (39.3%) of white solid: mp 155.5–157.5 °C; NMR ($CDCl_3$) δ 7.94–7.00 (m, 11), 6.36 (d, *J* = 7 Hz, of fine multiplets, 1), 5.00 (s, 1); IR (Nujol) 1780 cm^{-1}. The product tended to retain traces of solvent; for analysis, a sample was powdered and dried at 80 °C (0.1 torr) for several h. Anal. Calcd for $C_{22}H_{13}Cl_2NO_3$: C, 64.41; H, 3.19. Found: C, 64.48; H, 3.23.

Methyl 2-(3,4-Diphenyl-5-isoxazolyl)benzoate (6a). A solution of 1.80 g (0.005 27 mol) of 3′,4′-diphenylspiro[isobenzofuran-1(3*H*),5′(4′*H*)-isoxazol]-3-one, 125 mL of methanol, and 0.5 mL of concentrated H_2SO_4 was stirred at reflux for 40 h, cooled, and added to 400 mL of ice water. The mixture was extracted with 300 mL of ether. The ether was washed twice with aqueous sodium bicarbonate and once with water, dried ($CaSO_4$), and concentrated under vacuum to 1.7 g of clear viscous oil. Addition of a small amount of toluene and hexane caused the oil to crystallize to a white solid, mp 100.5–101.5 °C, which was recrystallized from toluene–hexane to give 1.29 g (69%) of white solid: mp 101.5–102.5 °C; NMR ($CDCl_3$) δ 7.93 (m, 1), 7.6–7.16 (m, 13), 3.73 (s, 3); IR (Nujol) 1730 cm^{-1}. Anal. Calcd for $C_{23}H_{17}NO_3$: C, 77.73; H, 4.82. Found: C, 77.57; H, 4.93.

Methyl 2-[3-Phenyl-4-[3-(trifluoromethyl)phenyl]-5-isoxazolyl]benzoate (6b). Similar conditions starting with **4c** gave 1.17 g (61%) of white solid, mp 97–98 °C. A small amount was recrystallized from ether–hexane to give solid: mp 97.5–98.5 °C; NMR ($CDCl_3$) δ 8.0 (m, 1), 7.66–7.26 (m, 12), 3.73 (s, 3); IR (Nujol) 1730 cm^{-1}. Anal. Calcd for $C_{24}H_{16}F_3NO_3$: C, 68.08; H, 3.81. Found: C, 68.03; H, 3.89.

Methyl 2-[3,4-Bis(4-chlorophenyl)isoxazol-5-yl]benzoate (6c). The crude product was crystallized once from ether–hexane to give 1.01 g (76%) of white solid: mp 146–147 °C; NMR ($CDCl_3$) δ 7.93 (m, 1), 7.73–6.9 (m, 11), 3.76 (s, 3); IR (Nujol) 1725 cm^{-1}. Anal. Calcd for $C_{23}H_{15}Cl_2NO_3$: C, 65.11; H, 3.56. Found: C, 65.30; H, 3.70.

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Regioselectivity of 1,3-Dipolar Cycloaddition Reactions of Nitrilimines with Aryl Vinyl Sulfones

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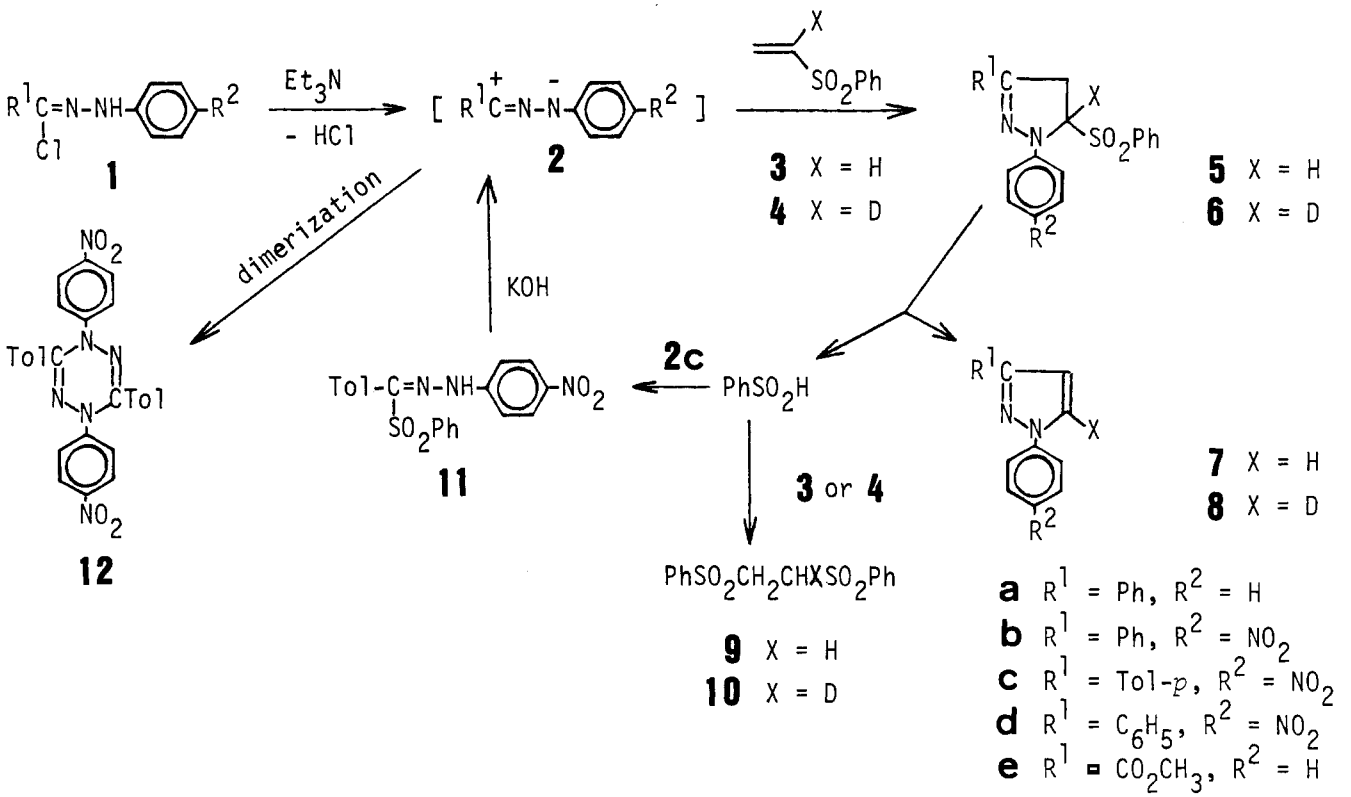
Nitrilimines have been known to react with various types of monosubstituted olefins to give predominantly 5-sub-

0022-3263/85/1950-0904$01.50/0

Scheme I



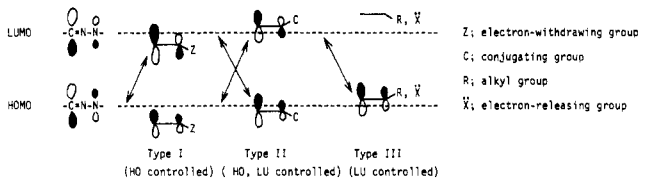
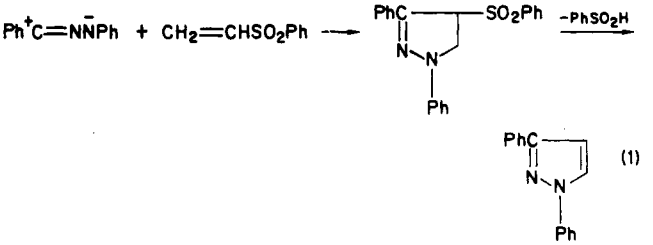


Figure 1. Classification of the interactions operated in the reaction of nitrilimines with monosubstituted olefins.

stituted 2-pyrazolines.[1-3] The regioselectivity of the reaction can be satisfactorily explained by taking into account the HOMO of the nitrilimines where the coefficient of the carbon atom may be slightly larger than that of nitrogen atom.[3,4] It is well-known in 1,3-dipolar cycloadditions that dipole-LUMO/dipolarophile-HOMO interaction controls the regioselectivity with electron-rich olefins and dipole-HOMO/dipolarophile-LUMO interaction controls it with electron-poor olefins, while both interactions may be operative with conjugated olefins.[2] If the frontier molecular orbitals of nitrilimines are as shown in Figure 1, then the regioselectivity of the reaction may be controlled only by the shape of the frontier molecular orbitals of dipolarophiles. The formation of the two regioisomers in the reaction of nitrilimines with unsymmetrically substituted olefins can be ascribed to a reversal of the magnitude of the coefficient at each carbon atom of the dipolarophile in the HOMO and LUMO, i.e., the possibility of both dipole-HOMO/dipolarophile-LUMO and dipole-LUMO/dipolarophile-HOMO.

Recently, the details of the reaction of nitrilimine with vinyl sulfones were reported and the formation of 4,5-unsubstituted pyrazole via an elimination of benzenesulfinic acid from initial cycloadduct, 4-(phenylsulfonyl)-2-pyrazoline, was described.[5] The regioselectivity is contrary to our expectation, therefore, we examined the reaction 1 using 1-deuteriovinyl phenyl sulfone.



Results and Discussion

1-Deuteriovinyl phenyl sulfone was prepared via a base-induced deuterium exchange reaction of 2-(phenylsulfonyl)ethanol to 2-(phenylsulfonyl)-2,2-dideuterioethanol followed by chlorination and then dehydrochlorination. An equimolar reaction of chlorohydrazones 1

$$PhSO_2CH_2CH_2OH \xrightarrow[NaOH]{D_2O} PhSO_2CD_2CH_2OD \xrightarrow{SOCl_2} PhSO_2CD_2CH_2Cl \xrightarrow[Et_3N]{} \underset{4}{PhSO_2CD{=}CH_2}$$

with phenyl vinyl sulfone (3) or its deuterio derivative (4) were carried out at room temperature for 20–40 h in the presence of triethylamine (Scheme I). The isolated yields of 1,3-disubstituted pyrazoles 7 and its 5-deuterio derivatives 8 are shown in Table I. None of the 4-deuterio-

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Table I. Yield, Melting and Boiling Points, and ^{1}H NMR Spectral Data of the Cycloadducts 7 and 8

	R^1	R^2	yield, %	mp (bp), °C	NMR (δ)[a] solvent	4-H	5-H	others
7a	Ph	H	62	79–82[b]	$CDCl_3$	6.7 (d) (J = 2.5)	7.9 (d) (J = 2.5)	7.1–8.0 (m, 10 H)
7b	Ph	NO_2	42	165–166[c]	Me_2SO-d_6	7.1 (d) (J = 2.5)	8.7 (d) (J = 2.5)	7.3–7.6 (m, 3 H), 7.8–8.1 (m, 2 H), 8.1 (d, 2 H, J = 9), 8.35 (d, 2 H, J = 9)
7c	Tol-*p*	NO_2	32	129–131	$CDCl_3$	6.75 (d) (J = 2.7)	7.97 (d) (J = 2.7)	2.38 (s, 3 H), 7.23 (d, 2 H, J = 8.5), 7.8 (d, 2 H, J = 8.5), 7.85 (d, 2 H, J = 9.5), 8.28 (d, 2 H, J = 9.5)
7d	C_6D_5	NO_2	35	164–165	Me_2SO-d_6	7.1 (d) (J = 2.8)	8.7 (d) (J = 2.8)	8.1 (d, 2 H, J = 9.5), 8.35 (d, 2 H, J = 9.5)
7e	CO_2CH_3	H	25	74–76[d] (130–135/3 mm)	$CDCl_3$	6.8 (d) (J = 2.7)	7.93 (d) (J = 2.7)	3.85 (s, 3 H), 7.2–7.9 (m, 5 H)
8a	Ph	H	48	78–80	$CDCl_3$	6.73 (s)		7.2–8.05 (m, 10 H)
8b	Ph	NO_2	38	165–167	Me_2SO-d_6	7.13 (s)		7.3–7.6 (m, 3 H), 7.85–8.1 (m, 2 H), 8.15 (d, 2 H, J = 9), 8.4 (d, 2 H, J = 9)
8c	Tol-*p*	NO_2	30	126–128	$CDCl_3$	6.77 (s)		2.38 (s, 3 H), 7.23 (d, 2 H, J = 8.5), 7.8 (d, 2 H, J = 8.5), 7.87 (d, 2 H, J = 9.5), 8.28 (d, 2 H, J = 9.5)
8d	C_6D_5	NO_2	37	163–165	Me_2SO-d_6	7.1 (s)		8.1 (d, 2 H, J = 9.5), 8.35 (d, 2 H, J = 9.5)
8e	CO_2CH_3	H	40	74–76 (120–125/2 mm)	$CDCl_3$	6.97 (s)		3.93 (s, 3 H), 7.1–8.0 (m, 5 H)

[a] J in hertz. [b] Lit.[6a] mp 84–85 °C. [c] Lit.[6b] mp 169 °C. [d] Lit.[6c] mp 77 °C.

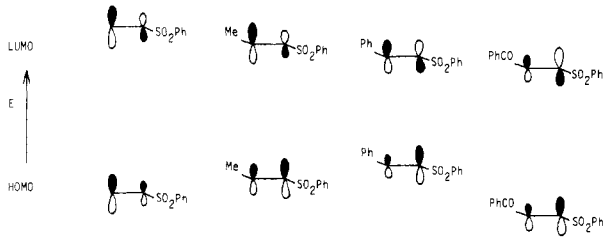


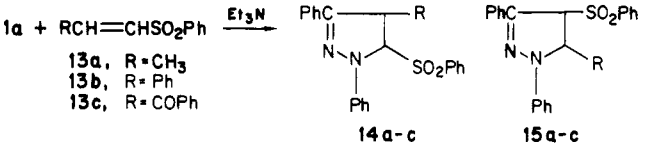
Figure 2. Frontier molecular orbitals of vinyl sulfones.[8]

pyrazoles could be isolated in the series of the reaction with **4**. The structures of the cycloadducts were established on the basis of analytical and spectral data. Pyrazols **7a**, **7b**, and **7e** show physical properties identical with the authentic ones.[6] The regiochemistry of deuteriopyrazoles **8** was established by a comparison of the chemical shifts of the pyrazole ring protons with those in the literature.[7] The chemical shifts observed at δ 6.7–7.1 in ^{1}H NMR spectra of **8** correspond well with the reported values (δ 6.8–7.1)[7] of the pyrazole ring proton at 4-position and not with the values (δ 7.7–8.0)[7] of the pyrazole ring proton at 5-position.

In all reactions, 1,2-bis(phenylsulfonyl)ethane (**9**) or its monodeuterio derivative **10** were obtained in 20–40% yield. α-(Phenylsulfonyl)-*p*-tolualdehyde *p*-nitrophenylhydrazone (**11**) was also obtained in the reaction of **1c** with **2** or **3**. The structure of **11** was assigned on the basis of elemental analysis and spectral data. The structure was further supported by the fact that **11** was also obtained from the reaction of **1c** with $PhSO_2Na$ and this material transformed to 1,4-bis(*p*-nitrophenyl)-3,6-di-*p*-tolyl-1,4-dihydro-1,2,4,5-tetrazine (**12**) presumably via a nitrilimine intermediate (**2c**) by the treatment with alcoholic KOH (see Scheme I).

The formation of these byproducts (**9**–**11**) can be explained by the nucleophilic addition of benzenesulfinic acid eliminated from initial cycloadducts, 1,3-disubstituted 5-(phenylsulfonyl)-2-pyrazolines **5** and its 5-deuterio derivatives **6**, to nitrilimines **2** and vinyl sulfones **3** and **4**.

The exclusive formation of 5-(phenylsulfonyl)-2-pyrazolines **5** and **6** in the reaction of nitrilimines with phenyl vinyl sulfones is contrary to the results previously reported in the literature.[5] The erroneous assignment[5] of the regiochemistry of the products would result from the view that the coefficient on nitrogen in the HOMO of diphenylnitrilimine is larger than that of the carbon atom. The formation of two regioisomers in the reaction (eq 2)



(2)

of diphenylnitrilimine with 2-substituted vinyl sulfones **13a**–**c**[5] can also be explained on the basis of the HOMO energy levels and the magnitude of the coefficients at C=C double bonds in **3** and **13a**–**c** (see Figure 2). The frontier molecular orbitals on **3**, **13a**, and **13b** calculated recently[8] are summarized in Figure 2. In the reaction with **13a**, the formation of two regioisomers can be expected because **13a** has a reverse magnitude of coefficients between HOMO and LUMO and has a higher HOMO energy level than that of **3**. The formation of **15b** as the major product can be expected in the reaction with **13b** as a result of the higher HOMO energy level of **13b** to **13a** and an absence of differences in the coefficients at the LUMO. In the case of **13c**, the molecular orbital calculation has not been reported; FMO shown in Figure 2 can be estimated by a simple qualitative frontier approach.[9] Thus an exclusive formation of **15c** can be expected by dipole-HOMO/dipolarophile-LUMO interaction. Consequently, the facility of the formation of 5-substituted 4-(phenylsulfonyl)-2-pyrazolines **15** can be estimated to be R = PhCO > Ph > CH_3 ≫ H. These expectations are in full agreement with the results reported.[5]

Experimental Section

All melting and boiling points are uncorrected. The IR spectra were determined on a Hitachi 215 infrared spectrophotometer. The ^{1}H NMR spectra were measured on a Varian T-60A in-

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strument with Me_4Si as an internal standard; chemical shifts are given in δ units: s = singlet; d = doublet; m = multiplet.

Materials. 1-(α-Chlorobenzal)-2-phenylhydrazine (**1a**),[10] methyl chloroglyoxalate phenylhydrazone (**1e**),[11] and phenyl vinyl sulfone (**3**)[12] were prepared according to the reported methods. 1-(α-Chlorobenzal)-2-(p-nitrophenyl)hydrazine (**1b**), 1-(α-chloro-p-tolual)-2-(p-nitrophenyl)hydrazine (**1c**), 1-(α-chloro-2,3,4,5,6-pentadeuteriobenzal)-2-(p-nitrophenyl)hydrazine (**1d**) were prepared according to the method similar to that of **1a**.

1-Deuteriovinyl phenyl sulfone (4) was prepared according to the method reported,[13] except for a modification by an introduction of a deuterium exchange step. The deuterium exchange reaction was carried out as follows: 10 g (54 mmol) of 2-(phenylsulfonyl)ethanol was added to a solution of a few pellets (ca. 5 mmol) of NaOH in 10 mL of deuterium oxide at room temperature with stirring. The heterogeneous mixture was stirred at room temperature overnight and then extracted twice with chloroform (2 × 30 mL). The chloroform layer was dried with sodium sulfate and then evaporated. Distillation in vacuo gave 6.0 g of 2-(phenylsulfonyl)-2,2-dideuterioethanol; bp 130–135 °C (0.1 mmHg).

The Reaction of 1 with 3 or 4 in the Presence of Triethylamine. Triethylamine (5 mmol) was added to a chloroform solution (50 mL) of **1** (5 mmol) and **3** (or **4**) (5 mmol), and the mixture was stirred for 40 h at room temperature. The dark brown mixture was washed with water several times and the chloroform layer was dried over sodium sulfate and evaporated. The crystalline residue was chromatographed on silica gel with chloroform to give 1,3-disubstituted pyrazoles **7** or **8** and 1,2-bis(phenylsulfonyl)ethanes **9**[14] or **10**. α-(Phenylsulfonyl)-p-tolualdehyde p-nitrophenylhydrazone (**11**) was also obtained in the reaction of **1c** with **3** or **4** in 25% and 30% yields, respectively; mp 219–224 °C; ^1H NMR (Me_2SO-d_6) δ 2.4 (s, 3 H), 7.1 (d, 2 H, J = 9 Hz), 7.3 (s, 4 H), 7.55–8.0 (m, 5 H), 8.02 (d, 2 H, J = 9 Hz), 10.55 (s, 1 H, NH). Anal. **7c** (calcd for $C_{16}H_{13}N_3O_2$: C, 68.80; H, 4.69; N, 15.05; and found: C, 68.81; H, 4.57; N, 15.12); **7d** (calcd for $C_{15}H_6D_5N_3O_2$: C, 66.65; H and D, 5.97; N, 15.54; and found: C, 66.91; H and D, 5.89; N, 15.79); **8a** (calcd for $C_{15}H_{11}DN_2$: C, 81.46; H and D, 5.88; N, 12.66; and found: C, 81.49; H and D, 5.91; N, 12.70); **8b** (calcd for $C_{15}H_{10}DN_3O_2$: C, 67.67; H and D, 4.51; N, 15.79; and found: C, 67.47; H and D, 4.30; N, 15.75); **8c** (calcd for $C_{16}H_{12}DN_3O_2$: C, 68.56; H and D, 5.03; N, 14.99; and found: C, 68.70; H and D, 4.96; N, 15.01); **8d** (calcd for $C_{15}H_5D_6N_3O_2$: C, 66.44; H and D, 6.27; N, 15.49; and found: C, 66.43; H and D, 6.29; N, 15.52); **8e** (calcd for $C_{11}H_9DN_2O_2$: C, 65.04; H and D, 5.42; N, 13.79; and found: C, 65.28; H and D, 5.39; N, 13.81); **10** (calcd for $C_{14}H_{13}DO_2S_2$: C, 54.02; H and D, 4.82; and found: C, 54.07; H and D, 4.87); **11** (calcd for $C_{20}H_{17}N_3O_4S$: C, 60.75; H, 4.33; N, 10.63; and found: C, 60.62; H, 4.35; N, 10.59).

Preparation of an Authentic Specimen of 11. A mixture of **1c** (0.01 mol) and sodium benzenesulfinate (0.02 mol) was stirred for 20 h at room temperature in tetrahydrofuran (30 mL) containing a small amount of water (ca. 1–2 mL). The reaction mixture was evaporated and the residue was well mixed with chloroform and water. The organic layer was dried over sodium sulfate and evaporated to give yellow crystals which was recrystallized from ethanol to give **11** in 40% yield; mp 219–222 °C dec. Owing to the polymorphism, the IR and NMR spectra of this authentic specimen are different from those of the compound **11** obtained from **1c** and **3** (or **4**). The identity of these materials was established by the observation that the authentic sample showed the identical NMR spectra with **11** after mixing with a small amount of **11** in Me_2SO-d_6 and standing for a week.

Treatment of 11 with Alcoholic KOH. **11** (1 mmol) was added into stirred ethanol solution (20 mL) containing 6 mmol of KOH and a few drops of water at room temperature. Instantly, the solution became dark purple. After the mixture was stirred for 15 h, the solvent was evaporated and water (30 mL) was added to the residue, which was neutralized with dilute hydrochloric acid. Yellow crystals precipitated and were extracted with chloroform, the organic layer was dried over sodium sulfate and then evaporated to give orange colored crystals (**12**) in 45% yield: mp 319–320 °C. Anal. Calcd for $C_{28}H_{22}N_6O_4$: H, 4.38; C, 66.39; N, 16.59. Found: H, 4.33; C, 66.39; N, 16.57.

Preparation of an Authentic Specimen of 12. **12** is identical with an authentic specimen prepared from the treatment of a chloroform solution (20 mL) of **1c** (1 mmol) with 0.5 mL of triethylamine at 60 °C for 2 h.

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Pseudorotation Barriers in *cis*-4,5-Dimethyl- and *cis*-3,4,5,6-Tetramethyl-9,10-dihydroxy-9,10-dihydrophenanthrene: Measurement of the Buttressing Effect

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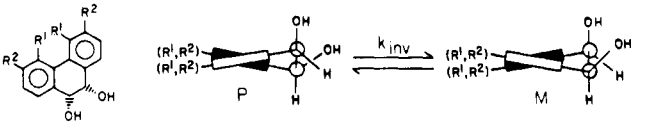
Recent interest[1] in determining the stereoselectivity and conformer specificity of the enzyme UDP-glucuronosyltransferase toward vicinal dihydrodiols of polycyclic aromatic hydrocarbons lead to an investigation[2] of the use of kinetically stable, conformationally locked, dihydrodiols as substrates for the enzyme. For this reason, the kinetic stability of sterically hindered 4,5-dimethyl- and 3,4,5,6-tetramethyl-9,10-dihydroxy-9,10-dihydrophenanthrenes is of considerable interest. The *cis* isomers **1** and **2** exist as slowly interconverting mixtures of two conformational enantiomers **1M** and **1P** and **2M** and **2P**, respectively, which differ in the helicity (M or P) of the biphenyl chromophore (Scheme I). These molecules provide then a convenient means to ascertain the activation barrier for pseudorotation in the hindered biphenyl system and, more interestingly, the magnitude of the buttressing effect[3,4] of the methyl groups at the 3 and 6 positions on this process.

Racemic **1** and **2** are easily prepared by OsO_4 oxidation of 4,5-dimethyl- and 3,4,5,6-tetramethylphenanthrene, respectively. The antipodes **1M** and **1P** can be partially resolved by HPLC at room temperature on a Pirkle type IA column.[5] Isomers **2M** and **2P** are more readily resolved on the same column due, in part, to the increased stability of the conformational antipodes at ambient temperature. In both cases the isomer of P helicity was eluted first. Absolute configurations of the biphenyl systems can be assigned on the basis of the sign of the very intense dis-

Scheme I



1 $R^1 = CH_3, R^2 = H$

2 $R^1 = R^2 = CH_3$

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