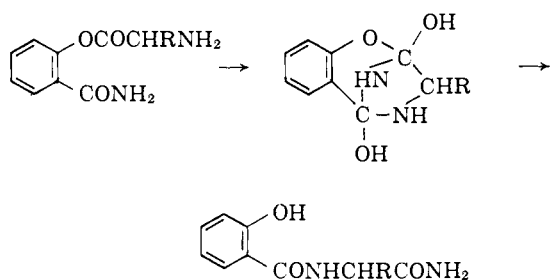
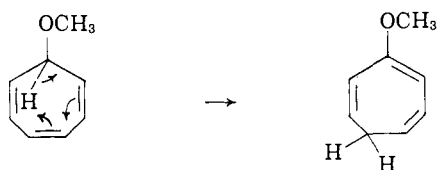


acyl insertion" reaction of aminoacylated salicylamide and related compounds.⁵ As shown below the postulated⁵ mechanism involves initially a 1,5-dicarbonyl compound.



The thermal isomerization of 7-methoxycycloheptatriene to 3-methoxycycloheptatriene and related isomerizations⁶ may also be postulated to proceed *via* the 3,2,1-bicyclic path in which the two carbons forming the leaving and arriving sites for the migrating hydrogen are the bridgehead atoms.



We are carrying out other studies to test the generality of this path.⁷

(5) M. Brenner and J. P. Zimmermann, *Helv. Chim. Acta*, **40**, 1933 (1957); **41**, 467 (1958); M. Brenner and J. Wehrmüller, *ibid.*, **40**, 2374 (1957); H. Dahn, R. Menasse, J. Rosenthaler, and M. Brenner, *ibid.*, **42**, 2249 (1959). We thank Dr. F. Kagan of the Upjohn Company for bringing this reaction to our attention.

(6) E. Weth and A. S. Dreiding, *Proc. Chem. Soc.*, 59 (1964). We thank Dr. N. Nelson of the Upjohn Company for bringing this reaction to our attention.

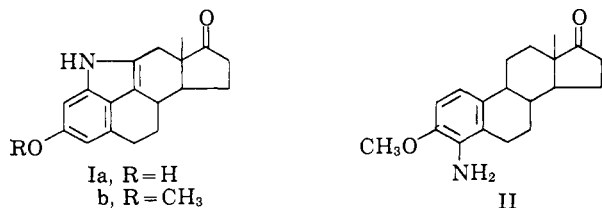
(7) This work has been supported by a grant from the National Science Foundation.

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RECEIVED MAY 2, 1964

The Synthesis of a Novel Steroid Heterocyclic System *Sir*:

We wish to report the synthesis of a novel heterocyclic steroid, 3-hydroxy-1,11-iminoestra-1,3,5(10),9-(11)-tetraen-17-one (Ia) by a pathway whose key feature was the generation of a nitrene intermediate appropriately situated for ring formation.



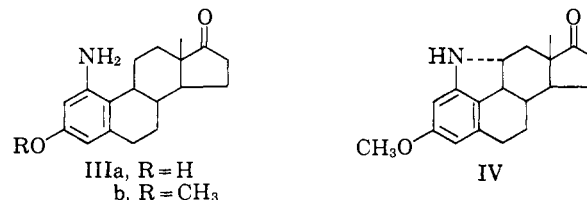
4-Amino-3-methoxyestra-1,3,5(10)-trien-17-one (II)¹ in acetic acid was coupled with *p*-nitrophenyldiazonium chloride to give directly the 4-amino-3-methoxy-1-*p*-nitrophenylazo compound (87% yield),² m.p. 243–244°

(1) S. Kraychy, *J. Am. Chem. Soc.*, **81**, 1702 (1959).

(2) The yields reported are for material after initial purification.

dec., λ_{\max} 280 (ϵ 10,100) and 406 $m\mu$ (24,750); $[\alpha]_{6907}^A -468^\circ$.³ Diazotization of the latter followed by the reduction of the diazonium salt with 50% aqueous hypophosphorous acid gave the 3-methoxy-1-*p*-nitrophenylazo compound (89% yield), m.p. 223–224°; λ_{\max} 279 (ϵ 9500) and 350 $m\mu$ (16,200); $[\alpha]_{6907}^A -348^\circ$. Reductive cleavage of the azo compound with zinc dust and glacial acetic acid provided 1-amino-3-methoxyestra-1,3,5(10)-trien-17-one (IIIb, 73% yield), m.p. 213–214°; λ_{\max} 245 (sh, ϵ 6720) and 291 $m\mu$ (3000); $[\alpha]_D +301^\circ$.⁴ The free 1-amino-3-hydroxy-17-one IIIa was obtained by demethylation of IIIb with pyridine hydrochloride (66% yield), m.p. 280–288° dec., λ_{\max} 212 (ϵ 40,000), 240 (sh, 7850), and 292 $m\mu$ (3080); ν_{\max}^{KBr} 3412, 3380, 1725, and 828 cm^{-1} ; $[\alpha]_{25}^D +264^\circ$ (pyridine).

The 1-amino-3-methoxy compound IIIb on diazotization at -25° (sodium nitrite, glacial acetic acid, and 1 *N* sulfuric acid) followed by the addition of sodium azide in water at -25° was converted into the 1-azide (85% yield), m.p. 147–149°; λ_{\max} 218 (ϵ 23,000), 255 (6500), 293 (3620), and 303 $m\mu$ (sh 3000); ν_{\max}^{KBr} 2100 and 831 cm^{-1} . The latter, on being heated in *n*-hexadecane for 5 min. at 200°, gave the indoline, 1,11 α -



imino-3-methoxyestra-1,3,5(10)-trien-17-one (IV, 65% yield),⁵ m.p. 199–201°; λ_{\max} 212 (ϵ 28,000), 235 (sh, 5800), and 293 $m\mu$ (3550); ν_{\max}^{KBr} 3300, 824, and 728 cm^{-1} ; $[\alpha]_D +164^\circ$. Dehydrogenation of IV with palladium-charcoal in xylene (1 hr. reflux) gave the indole, 1,11-imino-3-methoxyestra-1,3,5(10),9(11)-tetraen-17-one (Ib, 90% yield), m.p. 203–205°; λ_{\max} 229

(3) The ultraviolet absorption spectra are for a methanol solution. The optical rotations are for a chloroform solution at 25° unless noted otherwise. All new compounds reported here gave satisfactory elemental analyses. The n.m.r. spectra were taken in deuteriochloroform, and the chemical shifts were measured with respect to TMS. (Varian A60 spectrometer).

(4) The n.m.r. spectrum of the 1-amino-3-methyl ether IIIb showed two aryl protons barely separated from one another at 366 and 367 c.p.s. In contrast the C-1 and C-4 protons of the corresponding 2-amino-3-methyl ether¹ were seen as singlets at 388 and 397 c.p.s., and the 4-amino-3-methyl ether II showed a single sharp line at 400 c.p.s. which had an integrated value of two protons.

(5) G. Smolinsky, *J. Am. Chem. Soc.*, **82**, 4717 (1960), has shown that aryl azides on thermal or photolytic decomposition yield nitrenes which, either by a direct insertion (singlet process) or by abstraction of hydrogen and subsequent closure of the resulting diradical (triplet process), yield cyclic products.

An examination of molecular models indicates that, in the formation of IV, insertion could occur either 11 α or 11 β , with the former being slightly favored when ring B assumes a normal half-chair conformation. However if the biradical two-step process pertains then C-11 α -N bond formation would be favored since the C-18 methyl group would be expected to exert a stronger orienting effect than in the singlet process. The n.m.r. spectrum of IV does not indicate whether the C-9 and -11 hydrogens have a *cis* or *trans* relationship, which feature was not resolved by an initial attempt with spin-spin decoupling [S. L. Manatt and D. D. Elleman, *ibid.*, **83**, 4095 (1961)]. However, it is known that an 11 β -hydroxyl group^{6,7} shifts the C-18 methyl absorption *ca.* 15 c.p.s. downfield from its normal position while an 11 α -hydroxyl group⁶ produces a similar shift of only 2 c.p.s. The position of the C-18 methyl group of IV (59 c.p.s.) is shifted only 2 c.p.s. downfield from that of the unbridged precursor IIIb (57 c.p.s.) which supports the α assignment of the C-11-N bond.

(6) Y. Kawazoe, Y. Sato, M. Natsume, H. Hasegawa, T. Okamoto, and K. Tsuda, *Chem. Pharm. Bull.*, **10**, 338 (1962).

(7) E. Capsi, T. A. Wittstruck, and P. K. Grover, *Chem. Ind. (London)*, 1716 (1962).

(ϵ 34,000), 272 (5470), and 298 $m\mu$ (3690); λ_{\min} 252 (ϵ 4280) and 286 $m\mu$ (3250)⁸; ν_{\max}^{KBr} 3350, 819, and 802 cm^{-1} ; $[\alpha]_D +225$.⁹ Demethylation of Ib with pyridine hydrochloride gave 3-hydroxy-1,11-iminoestra-1,3,5(10),9(11)-tetraen-17-one (Ia, 81% yield), m.p. 290–300° dec.; λ_{\max} 229 (ϵ 32,000), 270 (5050), and 301 $m\mu$ (3530); ν_{\max}^{KBr} 3380, 1725, and 828 cm^{-1} ; $[\alpha]_D +331^\circ$ (pyridine).

Further work is in progress on the synthesis of steroids containing an indole nucleus.

(8) The ultraviolet absorption spectrum of Ib compared very favorably with that of 2,3-dimethyl-6-methoxyindole: N. Neuss, H. E. Boaz, and J. W. Forbes, *J. Am. Chem. Soc.*, **76**, 2463 (1954).

(9) Additional support for the structure Ib as well as for IIIb and IV was obtained by mass spectrometric analysis, which will be discussed in the full length paper on this synthesis.

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RECEIVED MAY 19, 1964

Electronic Effects of the Sulfonyl Group in Aromatic Systems. Relationships between Inductive and d-Orbital Resonance Contributions¹

Sir:

Recent reports² have discussed possible relationships between resonance and induction parameters of substituted benzenes. Although Taft³ proposed σ_R and σ_I as independent parameters which in general are not directly interrelated, McDaniel's correlations⁴ suggested that in benzoic acids a linear *meta-para* relationship may exist for families of substituents bonded to the ring through a common atom, e.g., SCH_3 , SH , $\text{SC}(\text{O})\text{CH}_3$, $\text{S}(\text{O})\text{CH}_3$, SO_2NH_2 , and SO_2CH_3 . The corresponding phenols, however, deviated substantially from linearity. Subsequently, Taft^{2a} demonstrated that better linearity is realized if comparison is restricted to series of more closely related substituents, e.g., *m*- and *p*- $\text{FC}_6\text{H}_4\text{SO}_2\text{X}$ (X is F, Cl, CH_3 , C_2H_5 , NH_2 , O^-). Significantly, $\text{S}(\text{O})\text{CH}_3$ and SF_5 did not qualify for the SO_2X line.

We now report that for acetic acids, benzoic acids, and phenols substituted with $\text{SO}_2\text{C}_6\text{H}_4\text{Y}^{1b,5,6}$ the parameters of SO_2X and relative influence of Y can be correlated for each series; other factors influencing the S–X bond remain virtually constant (*cf.* above). From the data (Table I)⁷ several significant relationships become apparent.

(1) (a) Supported by grants from the Petroleum Research Fund and Army Research Office (Durham); (b) preceding paper: C. Y. Meyers, *Gazz. chim. ital.*, **93**, 1206 (1963).

(2) (a) R. W. Taft, E. Price, I. R. Fox, I. C. Lewis, K. K. Andersen, and G. T. Davis, *J. Am. Chem. Soc.*, **85**, 3146 (1963); (b) L. A. Cohen and W. M. Jones, *ibid.*, **85**, 3397, 3402 (1963); (c) D. R. Eaton and W. A. Sheppard, *ibid.*, **85**, 1310 (1963); (d) O. Exner, *Tetrahedron Letters*, 815 (1963).

(3) R. W. Taft, *J. Phys. Chem.*, **64**, 1805 (1960).

(4) D. H. McDaniel, *J. Org. Chem.*, **26**, 4692 (1961).

(5) C. Y. Meyers, G. Moretti, and L. Maioli, *ibid.*, **27**, 625 (1962); B. Cremonini, Doctoral Dissertation, University of Bologna, 1962.

(6) C. Y. Meyers, G. Lombardini, and L. Bonoli, *J. Am. Chem. Soc.*, **84**, 4603 (1962).

(7) I-effects from *meta* and *para* positions were considered equivalent; by definition, R-effects reflect all influences of π -interaction between the substituent and the system into which it is introduced: *cf.* ref. 2b, 2d, 3, R. W. Taft and I. C. Lewis, *Tetrahedron*, **5**, 210 (1959), and M. J. S. Dewar and P. J. Grisdale, *J. Am. Chem. Soc.*, **84**, 3529 (1962), *et seq.*

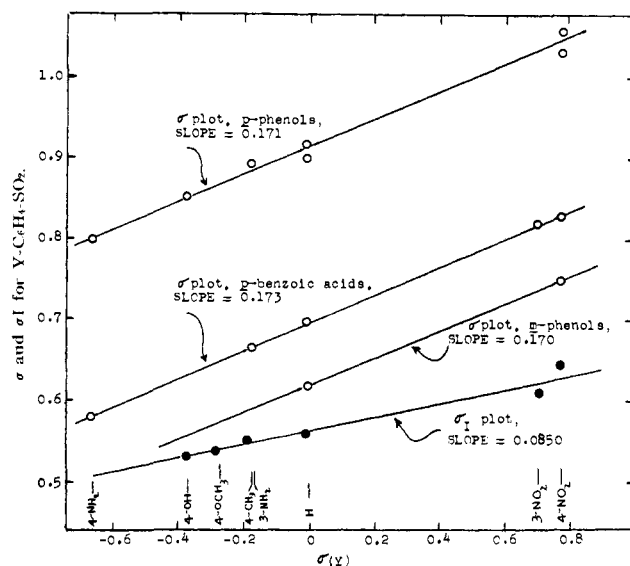


Fig. 1.—Correlations of $\sigma(\text{Y})$ with σ_I and σ for $\text{YC}_6\text{H}_4\text{SO}_2$.

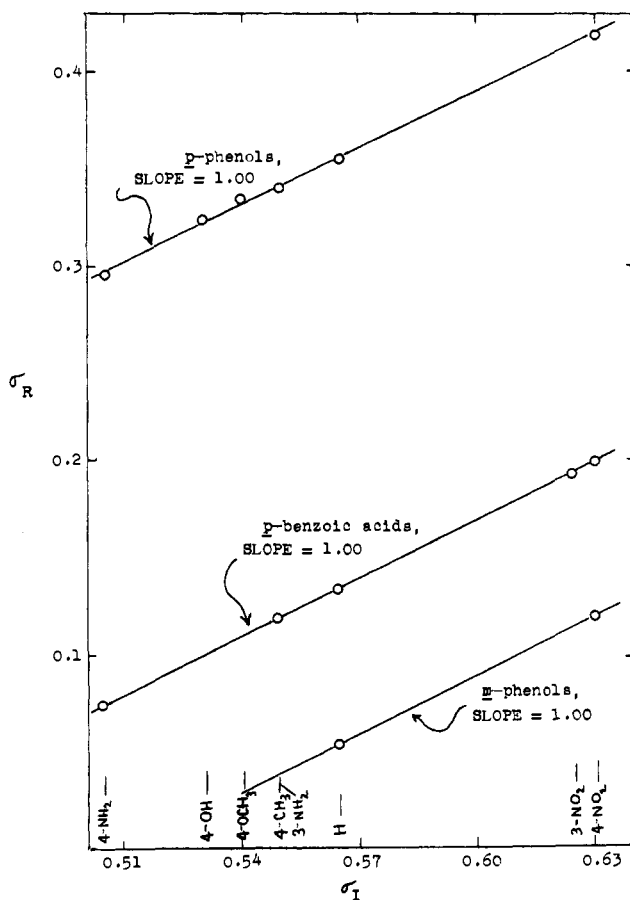


Fig. 2.—Correlations of σ_R with σ_I for $\text{YC}_6\text{H}_4\text{SO}_2$ (Y substituents as indicated).

The linear relationships between $\sigma(\text{Y})$ ⁸ and, respectively, σ_I and σ for $\text{YC}_6\text{H}_4\text{SO}_2$ in each series are shown in Fig. 1. The slopes indicate that σ increases at the same rate for *p*-benzoic acids and *m*- and *p*-phenols, and σ increases *twice* as fast as σ_I . From this and the relationship $\sigma = \sigma_R + \sigma_I$ it follows that *in each of the series R- and I-effects increase at the same rate* (Fig. 2). Expressions derived from these relationships may be

(8) Hammett substituent constants (ionization of benzoic acids): J. Hine, "Physical Organic Chemistry," 2nd Ed., McGraw-Hill Book Co., Inc., New York, N. Y., 1962, p. 87.