with sodium hydride in a fashion described here, affording IIIb (85% yield) as colorless crystals m.p. 202°; λ_{max}^{EtOH} 255 mμ (4.02); λ_{max}^{KBr} (cm.$^{-1}$) 3419, 1736, 1720, (*anal.* found for $C_{20}H_{15}ON$: C, 84.3; H, 5.8; N, 4.86; mol. wt., 290 (ebullioscopic, benzene)[3]). IIIb showed no identity with a sample of 2,5-diketo-1,3,3,4,6,6-hexaphenylpiperazine (IV), m.p. 224°; λ_{max}^{EtOH} 250–255 mμ (4.10); λ_{max}^{KBr} (cm.$^{-1}$) 3226, 1727, 1689 (*anal.* found for $C_{40}H_{30}O_2N_2$: C, 84.4; H, 5.5), prepared as described.[5] IIIb readily dissolved in cold concd. sulphuric acid (scarlet-red coloration), giving on dilution with water an immediate precipitate of colorless α-anilino-α,α-diphenylacetic acid, m.p. 174–177° (reported[6] m.p. 174.5°); λ_{max}^{KBr} (cm.$^{-1}$) 3419, 3367, 1733 (*anal.* found for $C_{20}H_{17}O_2N$: N, 4.4).[7] The physical and chemical evidence presented here clearly suggest that the azacyclopropanone, in analogy with cyclopropenone system,[8] has presumably a remarkable resonance stabilization to set off its internal strain. The observed low reactivity of (III) toward nucleophilic reagents seems to be parallel to that of substituted 2-azetidinones (β-lactams) with alkalies.[9]

Acknowledgment.—H. L. is indebted to Abrahm and Herbert Sive Memorial Research Fellowship, Johannesburg, South Africa, for financial aid.

(5) H. Klinger and Nickell, *Ann.*, **390**, 367 (1912).

(6) W. Schlenk, J. A. Appenrodt, A. Michael and A. Thal, *Ber.*, **47**, 484 (1914).

(7) By contrast (IV) was sparingly soluble in concd. sulfuric acid (brown coloration), giving unchanged starting material upon dilution with water.

(8) R. Breslow, R. Haynie and J. Mirra, THIS JOURNAL, **81**, 247 (1959).

(9) S. A. Ballard and D. S. Melstrom in Elderfield's "Heterocyclic Compounds," Vol. I, John Wiley & Sons, Inc., New York, N. Y., 1950, pp. 107–110.

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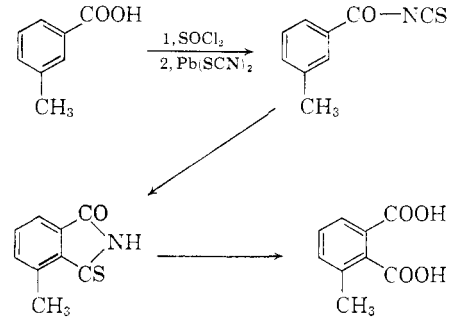
SPECIFIC *ortho*-CARBOXYLATION OF AROMATIC ACIDS AND ARALKYLAMINES: MONOTHIOIMIDES AND THIOLACTAMS

Sir:

We wish to report a simple reaction for converting benzoic acids to phthalic acids, arylacetic acids to homophthalic acids, and β-arylethylamines to *o*-carboxy-β-arylethylamines. The acids are converted through their chlorides by reaction with lead thiocyanate to acyl isothiocyanates,[1] which are cyclized to monothio-phthalimides or -homophthalimides by treatment with aluminum chloride in carbon disulfide for periods of several hours to several days. β-Arylethyl isothiocyanates, prepared from amines and carbon disulfide,[2] are similarly cyclized to thiolactams. Hydrolysis of the cyclized products then gives the acids corresponding to carboxylation of the starting materials. The cyclization of benzoyl isothiocyanates appears to require the presence of an activating *meta*-substituent, such as methyl; unsubstituted benzoyl isothiocyanate has up to now resisted cyclization, although β-naphthoyl isothiocyanate reacts successfully. Within this apparent limitation, the reaction provides a direct route for the synthesis of compounds heretofore available only with difficulty or not at all. The cyclization of benzoyl isothiocyanates appears to be selective when two *ortho*-positions are open, for *m*-toluyl isothiocyanate yielded only 3-methylphthalic acid, resulting from cyclization in the vicinal position.



Preliminary experiments indicate that the reaction also occurs with heterocyclic analogs, such as 3-thenoyl isothiocyanate, and with β,γ-unsaturated aliphatic acids such as cyclohexene-1-acetic acid. Examples of the closely related cyclization of β-arylethyl isocyanates have previously been reported,[3] although its utilization in an *ortho*-carboxylation procedure was not undertaken. Acyl isocyanates would presumably behave similarly, but we have not as yet investigated them, owing to the greater difficulties in preparing and handling them compared to the sulfur analogs.

The intermediate monothioimides, which can be isolated in moderate yields, constitute a class of compound of which only one example (monothiophthalimide[4]) has heretofore been reported, and to which no preparatively satisfactory general route has been available. All the monothiophthalimides we have prepared are red substances, while the monothiohomophthalimides are yellow (thioamides are usually colorless or straw-colored). Lithium aluminum hydride reduces both thioimides and thiolactams with removal of sulfur, giving tetrahydroisoquinolines. The potentialities for the synthesis of these and other classes of heterocyclic compounds from the thioimide intermediates are obvious.

Treatment of *m*-toluyl chloride with lead thiocyanate gave *m*-toluyl isothiocyanate, a colorless, unstable liquid, b.p. 78°(0.85 mm.) (N-*m*-toluyl-N′-phenylthiourea, m.p. 113°). (Since acyl isothiocyanates are in most cases unstable to short-term storage, most of those prepared in this work have been converted by reaction with aniline to N-acyl-N′-phenylthioureas for analysis and characterization).[5] Refluxing a mixture of *m*-toluyl

(1) A. E. Dixon and J. Taylor, *J. Chem. Soc.*, **93**, 684 (1908).

(2) W. R. Vaughan, M. V. Anderson, H. S. Blanchard and D. I. McCane, *J. Org. Chem.*, **20**, 819 (1955); M. L. Moore and F. S. Crossley, *Org. Syntheses*, Coll. Vol. III, 599 (1955).

(3) L. M. Mohunta and J. N. Ray, *J. Chem. Soc.*, 1263 (1934); R. H. F. Manske and R. Robinson, *ibid.*, 240 (1927).

(4) J. C. Porter, R. Robinson and M. Wyler, *ibid* 620 (1941); H. D. K. Drew and D. B. Kelly, *ibid.*, 625 (1941).

(5) Satisfactory analyses have been obtained for all new compounds reported here, with the noted exception of some of the less stable acyl isothiocyanates, all of which, however, showed infrared absorption at 1960 cm.$^{-1}$.

isothiocyanate and 2.2 equivalents of aluminum chloride with *ca.* ten parts of carbon disulfide for four days gave a 45% yield of 2a-thio-3-methylphthalimide, m.p. 192°. Alkaline hydrolysis gave 80% of 3-methylphthalic acid, m.p. 157–158° (lit.[6] 157°), and sublimation gave 62% of 3-methylphthalic anhydride, m.p. 117–118° (lit.[7] 117–118°); 3-methylphthalimide, m.p. 188–189° (lit.[8] 189–190°). Treating 3,5-dimethylbenzoyl chloride with lead thiocyanate gave 63% of the isothiocyanate, b.p. 99°(1.5 mm.). Treatment with aluminum chloride gave 65% of 3,5-dimethyl-2a-thiophthalimide, m.p. 209–210°; hydrolysis gave 3,5-dimethylphthalic acid, m.p. 185° dec. (lit.[9] 185–186° dec.) (neutr. equiv., calcd. 97; found, 97 ± 1). Phenylacetyl chloride gave 72% of isothiocyanate, b.p. 86° (0.5 mm.); N-phenylacetyl-N′-phenylthiourea, m.p. 107–108°. Cyclization gave 2a-thiohomophthalimide (52%), m.p. 221–222°, hydrolysis of which gave homophthalic acid, m.p. 178° (lit.[10] 181°)(neutr. equiv. calcd., 90, found, 91), and reduction with excess lithium aluminum hydride gave tetrahydroisoquinoline, 47% as its picrate, m.p. 196° (lit.[11] 195–196°). β-Naphthoyl chloride gave 44% of isothiocyanate, m.p. 74°; N-β-naphthoyl-N′-phenylthiourea, m.p. 148–149°. Cyclization gave 25% of 1a-thio-1,2-naphthalimide, m.p. 248–249°, which was hydrolyzed to naphthalene-1,2-dicarboxylic acid, m.p. 175° dec. (lit.[12] 175° dec.). β-Phenylethyl isothiocyanate[13] gave 40% of 1-thiodihydroisocarbostyril, m.p. 98–99°, which was hydrolyzed to *o*-(2-aminoethyl)-benzoic acid hydrochloride, m.p. 197–198° (lit.[14] 199–200°), and reduced by lithium aluminum hydride to tetrahydroisoquinoline, picrate m.p. 196°. α-Naphthylacetyl chloride gave 72% of isothiocyanate (N-α-naphthylacetyl-N′-phenylthiourea, m.p. 125°), which was cyclized in 41% yield to 8a-thio-1-homonaphthalimide, m.p. 254–255°. Hydrolysis gave homonaphthalic acid, m.p. 214–215° (lit.[15] 213–214°).

(6) F. Mayer and O. Stark, *Ber.*, **64**, 2006 (1931).
(7) F. Mayer and H. Günthe., *ibid.*, **63**, 1459 (1930).
(8) S. Gabriel and A. Thieme, *ibid.*, **52**, 1083 (1919).
(9) W. H. Perkin and R. A. B. Tapley, *J. Chem. Soc.*, **125**, 2436 (1924).
(10) W. Davies and H. G. Poole, *ibid.*, 1616 (1928).
(11) E. F. Bradbrook and R. P. Linstead, *ibid.*, 1739 (1936).
(12) J. von Braun and H. Deutsch, *Ber.*, **45**, 2188 (1912).
(13) E. Bamberger and W. Dieckmann, *ibid.*, **26**, 1217 (1893).
(14) A. Pictet and T. Spengler, *ibid.*, **44**, 2034 (1911).
(15) H. G. Rule and H. M. Turner, *J. Chem. Soc.*, 317 (1935).

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BOOK REVIEWS

The Alkaloids, Chemistry and Physiology. Volume VI. Supplement to Volumes I and II. Edited by R. H. F. MANSKE, Dominion Rubber Research Laboratory, Guelph, Ontario. Academic Press Inc., 111 Fifth Avenue, New York 3, N. Y. 1960. xii + 442 pp. 16 × 23.5 cm. Price, $14.00.

The appearance of this supplement is a very welcome addition to the alkaloid literature. It is not strictly a supplement to Vols. I and II since there is no further treatment of the indole, acridine or *Erythrina* alkaloids which were reviewed in Vol. II. The publishers have been extremely tardy in bringing this book to the public. Many of the chapters were written in 1957 and I would like to add my small voice to that of Carl Djerassi (*cf.* THIS JOURNAL, **81**, 6092 (1959)) and protest at this inexcusable delay in publishing. In this review I will attempt to bring the prospective buyer up to date and mention recent important developments.

Chapter 1. Alkaloids in the plant, by K. Mothes: Having read this chapter one comes to the conclusion that the only thing which is common to all alkaloids is the presence of nitrogen in their structures. The large number of references attest considerable activity in this field and rapid progress is being made in elucidating the biosynthesis, metabolism and translocation of alkaloids in plants, especially by utilizing tracers (*cf.* also *Symposium Soc. Expt. Biol.* No. 13, 258 (1959)). The structure of echinulin, p. 3, has been modified (*Tetrahedron Letters*, No. 16, 1 (1959)).

Chapter 2. The pyrrolidine alkaloids, by L. Marion: This is a short chapter indicating that there has been little activity in this field in the last ten years. *In vivo* studies on stachydrine indicate that the elucidation of the biogenesis of even a simple alkaloid can involve considerable effort (*Can. J. Chem.*, **37**, 1197 (1959); **38**, 396 (1960)). Repetition of Hess's hygrine synthesis led to a tetrahydrooxazine (*Coll. Czech. Chem. Comm.*, **24**, 2433 (1959)). Betonicine has been isolated from *Achillea millefolium* (*Monatsh.*, **90**, 396 (1959)).

Chapter 3. Senecio alkaloids, by N. J. Leonard: This is an excellent review of the pyrrolizidine alkaloids and the author has been able to mention work published in 1958 (!) in an addendum. Since then viridifloric acid has been shown to be the (−)-*erythro* isomer (*Austral. J. Chem.*, **12**, 694 (1959)). The amide of heliotrinic acid has been synthesized (*ibid.*, **12**, 706 (1959)) and has the *threo* configuration. Mikanecic acid is an artifact produced by the dehydration and dimerization of sarracenic acid (*Chemistry & Industry*, 366 (1959)). The structure of seneciphyllic acid has been modified (*ibid.*, 21 (1959)). The correct structures of jaconecic acid, jaconine, jacobine and related compounds have finally been elucidated (*Austral. J. Chem.*, **12**, 247 (1959); THIS JOURNAL, **81**, 5201 (1959)). The absolute configuration at C-8 in retronecine has been determined (*ibid.*, **81**, 5803 (1959)). It is interesting to learn that 1-methylenepyrrolizidine is the major alkaloid in a *Crotalaria* sps. (*Austral. J. Chem.*, **12**, 255 (1959)). The Robinson-Schöpf scheme for the biosynthesis of the pyrrolizidine nucleus has been realized in the laboratory (*Chem. zvesti.*, **13**, 163 (1959); THIS JOURNAL, **82**, 503 (1960)).

Chapter 4. The pyridine alkaloids, by L. Marion: The pelletierine myth seems to be finally buried and a re-examination of the rearrangement of isopelletierine oxime (*ibid.*, **81**, 4664 (1959)) has added nails to the coffin. Isopelletierine has been isolated from *Duboisia* sps. (*J. Chem. Soc.*, 3967 (1957); *Austral. J. Chem.*, **11**, 82 (1958)). The efficiency of modern methods for the separation of alkaloids has been demonstrated in a study of the bases of