sodium metal dissolved in 70 ml of absolute alcohol were refluxed for 10 h. Work-up of the reaction mixture followed by recrystallization from ethanol gave 4.3 g (63.4%) of crystals, m.p. 98–99°. By replacing diethyl acetamidomalonate (V, R = CH_3) with diethyl propinonamidomalonate (V, R = C_2H_5) the identical product was obtained in a yield of 28.4%.

Anal. Calcd. for $C_{13}H_{21}NO_5$: C, 57.55; H, 7.80; N, 5.16. Found: C, 57.70; H, 7.69; N, 5.12.

Infrared (CCl_4): 2.89 μ, 3.10 μ, and 3.20 μ (NH); 5.78 μ (CO, ester); 5.88 μ (CO, lactam). Nuclear magnetic resonance ($CDCl_3$): τ 9.14 (d) and τ 9.00 (d) ($CH(\mathbf{CH_3})_2$); τ 8.71 (t) ($COOCH_2\mathbf{CH_3}$); τ 8.18 (m) ($\mathbf{CH}(CH_3)_2$); τ 7.76, τ 7.68, τ 7.62, and τ 7.54 (C_3—$\mathbf{H_2}$); τ 7.08 (m) (C_4—**H**); τ 5.76 (q) and τ 5.73 (q) ($COO\mathbf{CH_2}CH_3$); τ 2.80 (s) (N**H**).

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The reaction of all-*cis* cyclopentanetetracarboxylic acid dianhydride with primary amines

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Although Alder and his co-workers (1) have thoroughly investigated the stereochemistry of the cyclopentanetetracarboxylic acids, the reaction of the all-*cis* dianhydride I with primary amines has not been reported. This note reports the reaction of I with different primary amines.

The *cis*-dianhydride gave primarily *cis*-diimides II. However, the isomeric *trans*-diimides III could also be isolated, as well as an imide-*trans*-diamide IV (Reaction Scheme 1).

The exact mechanism of imide formation has not been unequivocally demonstrated, but probably is as shown in Reaction Scheme 2 (2). The first step involves nucleophilic attack of the base on the carbonyl carbon to form the intermediate A, which quickly loses a proton to the basic medium to form B; this then picks up a proton from solution to form C, the amide-carboxylic acid.

Apparently, an imide may be formed in two ways: either by the elimination of water from the amide-acid (heating succinanilic acid just above the melting point for ½ h gives an 18% yield of *N*-phenylsuccinimide) (Reaction Scheme 3), or by the formation of a diamide, which easily loses an amine to give the imide (3) (steps 6–8; Reaction Scheme 4).

In this latter sequence, step 6 (internal nucleophilic attack of the amide nitrogen on the adjacent carbonyl) is of great significance. It seems logical that the less basic the amine, the slower the rate of the nucleophilic attack. However, in this work, no definite conclusion can be drawn concerning the basicity of the amine in relation to the final isolable products. This is due to the difficulty of isolation of the various products of the reaction. A significant reaction competing with step 6 is the base-catalyzed isomerization at carbon 2 (Reaction Scheme 5).

Carbon 2 is the logical place for the first inversion because of the steric crowding. Since, in structure E, the group at position 1 has a hydrogen on one side and an amide group on the other side, whereas the group at position 2 has amide and anhydride groups on either side, inversion at carbon 2 is the easiest way to decrease crowding and increase stability, and thus give rise to a structure like IV*a*. Alder (1) gave

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[1] Taken in part from the M.S. thesis of Rose Ann Blau, Loyola University, Chicago, Illinois, June 1966.

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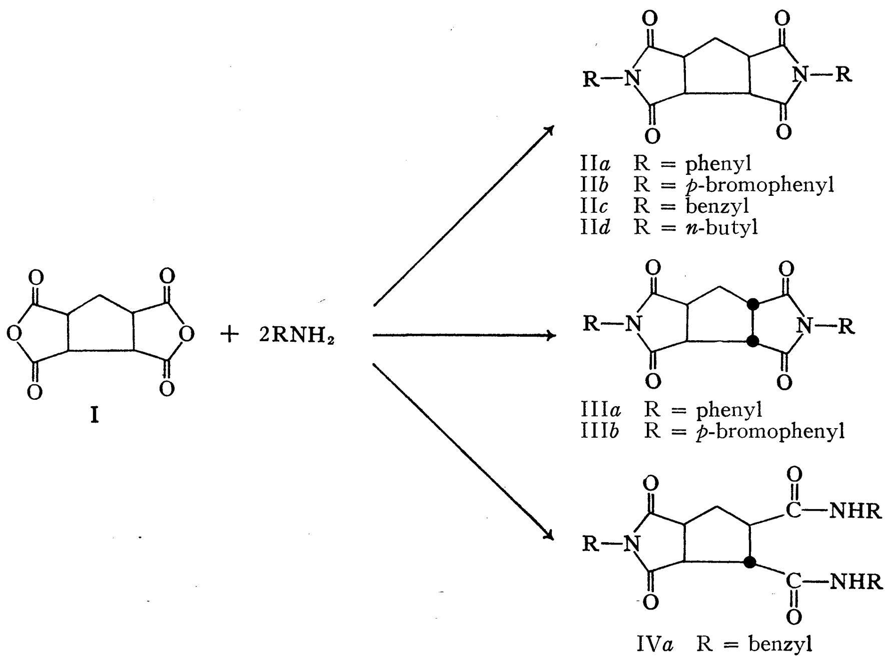
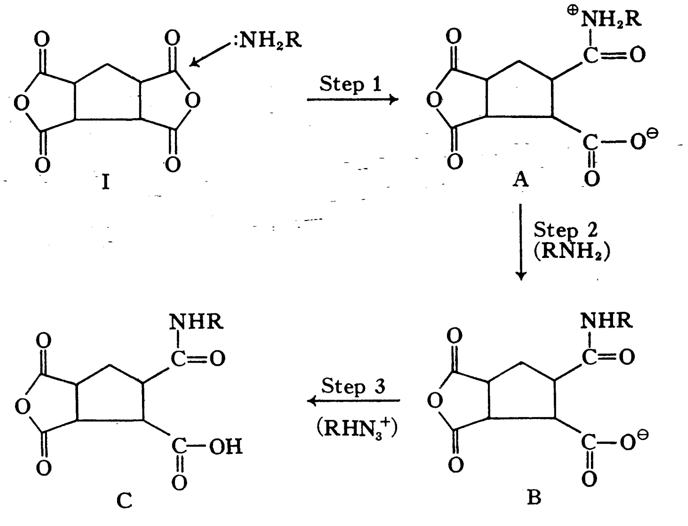
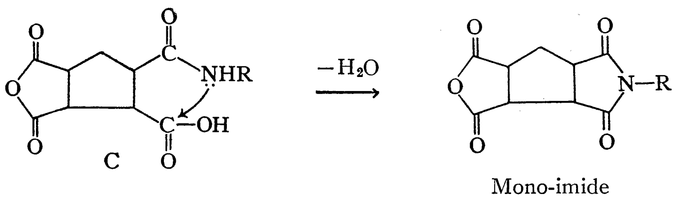


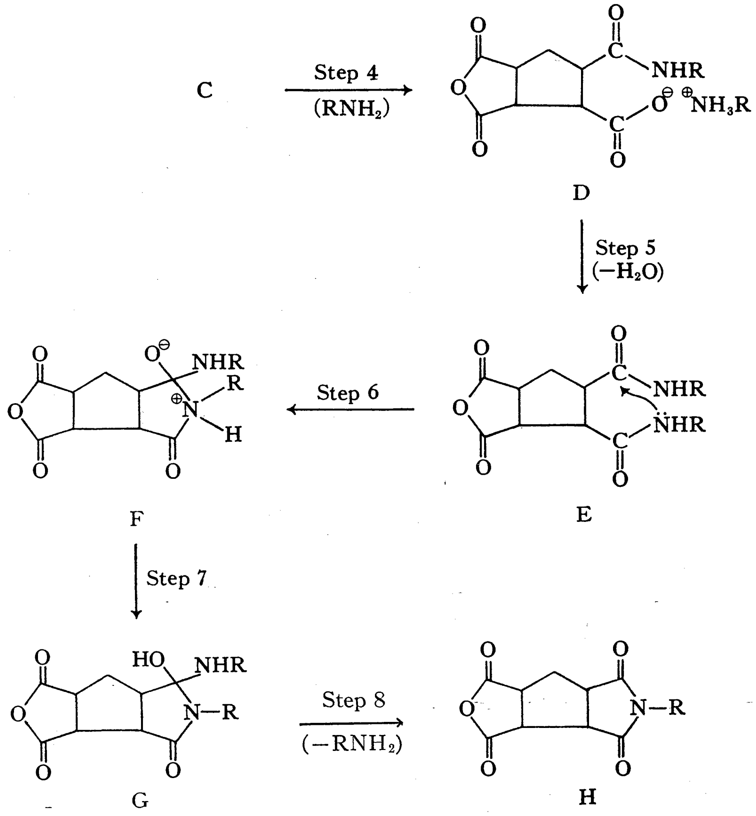
REACTION SCHEME 1.



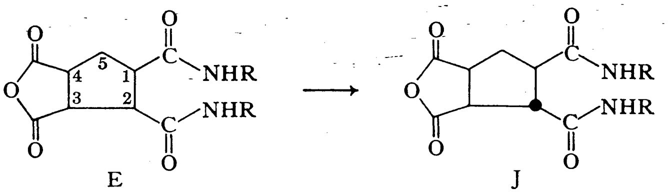
REACTION SCHEME 2.



REACTION SCHEME 3.



REACTION SCHEME 4.



REACTION SCHEME 5.

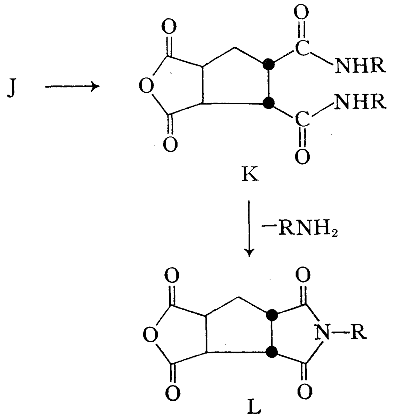
several different examples of this type of inversion of the tetracids and esters under a variety of acidic and basic conditions. The amides in IV were indeed *trans*, for heating with acetic anhydride or acetyl chloride or concentrated hydrochloric acid all failed, and the starting compound was obtained.

Once IV is formed, continued refluxing under basic conditions caused inversion at carbon 1 to form compound K, which readily could form an imide (compound L) (Reaction Scheme 6).

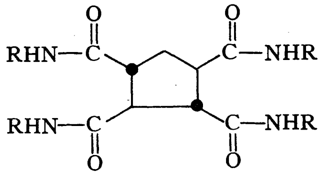
Either concurrent with or subsequent to the inversion(s), the amine starts the attack on the other anhydride group and, by duplicating the steps shown above, eventually leads to compounds of the type II, III, or IV.

It is rather interesting that the *trans,-trans,trans*-tetraamide (M) was sought but could not be isolated.

II*a* and III*a* (and II*b* and III*b*) had identical analyses and quite similar infrared spectra, but the melting points were quite different and the nuclear magnetic reso-



Reaction Scheme 6.



M

nance spectra of the *trans*-diimides III showed absorptions at 3.52 δ (III*a*) (formic acid) and 3.27 δ (III*b*) (acetone-d_6), and that of the *cis*-diimides II showed absorptions at 3.40 δ (II*a*) (formic acid) and 3.17 δ (II*b*) (acetone-d_6), indicating a definite shift of approximately 8 c.p.s. downfield in the absorption of the methine protons.

Five-membered cyclic imides have an absorption in the carbonyl region of approximately 1 770 and 1 700 cm^{-1}, and six-membered cyclic imides absorb at 1 710 and 1 700 cm^{-1} (4). If two different types of carbonyl groups were present in the same molecule (i.e. five and six membered ring imides), then the carbonyl bands should be split. Since this did not occur and since the absorptions occurred at 1 770 and 1 700 cm^{-1}, the imides have five-membered rings.

It is interesting that for compound IV*a*, which does have two different kinds of carbonyl groups (imide and amide), there were definite bands at 1 765, 1 710, and 1 670 cm^{-1} (Fig. 1) (all in 5% solution in chloroform).

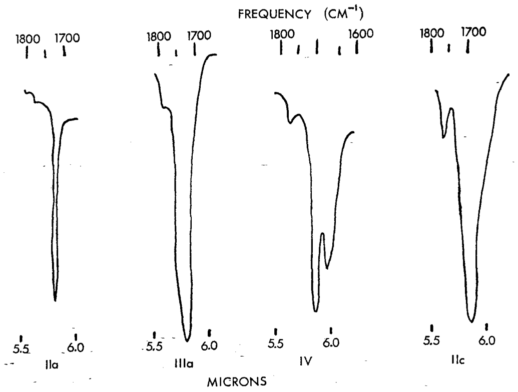


Fig. 1.

TABLE I

Compound	Melting point (°C)	Formula	Analyses (%) Calculated	Analyses (%) Found	Infrared carbonyl bands (cm^{-1})	Yield (%)
II*a*	103	$C_{21}H_{14}N_2O_4$	C, 69.99 H, 4.48 N, 7.78	C, 70.17 H, 4.80 N, 8.06	1 760, 1 700	33
II*b*	149	$C_{21}H_{14}Br_2N_2O_4$	N, 5.41	N, 5.18	1 770, 1 700	8
II*c*	155	$C_{23}H_{20}N_2O_4$	C, 71.12 H, 5.19 N, 7.21	C, 71.40 H, 5.36 N, 7.21	1 765, 1 710	20
II*d*	108	$C_{17}H_{24}N_2O_4$	C, 63.73 H, 7.55 N, 8.75	C, 63.81 H, 7.64 N, 8.78	1 760, 1 700	25
III*a*	195	$C_{21}H_{14}N_2O_4$	C, 69.99 H, 4.48 N, 7.78	C, 70.08 H, 4.71 N, 8.09	1 770, 1 710	7
III*b*	216	$C_{21}H_{14}Br_2N_2O_4$	N, 5.41	N, 5.05	1 770, 1 700	10
IV*a*	205	$C_{30}H_{29}N_3O_4$	C, 72.71 H, 5.90 N, 8.48	C, 72.30 H, 5.58 N, 8.53	1 765, 1 710 1 670	28

EXPERIMENTAL

All melting points were determined on a Fisher–Johns melting point apparatus and are uncorrected for steam exposure. Analyses were performed by Micro-Tech Laboratories, Skokie, Illinois. Infrared spectra were determined on a Perkin–Elmer model 21 apparatus, by the KBr technique as well as in chloroform, with no significant differences. Nuclear magnetic resonance spectra were determined on a Varian A-60A instrument, with tetramethylsilane as an internal standard.

Typical Experiment

A 2 to 1 *M* ratio mixture of amine to anhydride was heated until reflux temperature was achieved. This temperature was maintained until the reaction mixture stopped refluxing (*n*-butylamine, $pK_b = 3.40$, took 1 h; benzylamine, $pK_b = 4.70$, took 1 h; aniline, pK_b 9.32, took $1\frac{1}{2}$ h; and *p*-bromoaniline, pK_b 10.00, took $1\frac{1}{2}$ h). The mixture was then cooled to room temperature and triturated with boiling alcohol. The alcohol solution was then cooled and the products were separated by fractional crystallization. In the case of *n*-butylamine, only one product could be isolated. With the other three amines, it was possible to isolate two products in each case, by fractional crystallization. The common crystallization solvents were 95% ethanol or methanol–water mixtures.

Succinanilic acid (m.p. 146°), when heated to 155° for $\frac{1}{2}$ h, gave an 18% yield of *N*-phenylsuccinimide (m.p. 153°). *N,N′-Diphenylsuccinamide* (m.p. 223°), when refluxed with concentrated hydrochloric acid, gave an 18% yield of *N*-phenylsuccinimide (m.p. 153°).

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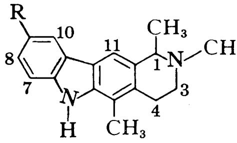
Alkaloids of *Aspidosperma vargasii* A. DC.

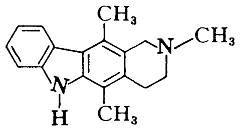
R. H. BURNELL AND DEANNA DELLA CASA

The bark of the large, coastal Venezuelan tree *A. vargasii* A. DC. (1) is rich in alkaloids, and a simple extraction procedure gives crystalline materials in high yields. All the bases isolated to date are of the carbazole or pyridocarbazole type and, as previous workers have reported (2), difficulties are encountered in preparing pure samples of these alkaloids.

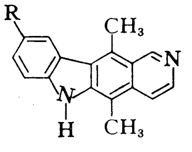
Both (±)-guatambuine (I) (3) and *N*-methyltetrahydroellipticine (II) (2) were obtained, but the physical properties of the



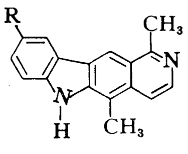
I R = H
V R = CH₃O



II



III R = CH₃O
IV R = H



VI R = H
VII R = CH₃O