Table I. *N*-Phenyliodonio Amide Tosylates from Amides and MTIB in Acetonitrile[a]

$RCONH\overset{+}{I}Ph$, $\bar{O}Ts$,[b] R =	yield,[c] %
CH_3	66
$(CH_3)_2CH$	68
$(CH_3)_3C$	80
$CH_3(CH_2)_4$	89
Ph	90

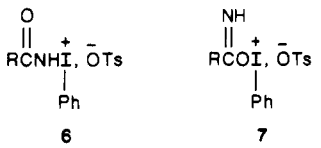
[a] Reactions were conducted on ca. a 5-mmol scale in MeCN (13 mL) by the procedure described for the reaction of α-phenylacetamide with MTIB. [b] Satisfactory analytical data (±0.40%) for C, H, I were finally obtained for all compounds, sometimes only after a second analysis of the same sample. [c] Rounded off to the nearest percent and based on the limiting reagent.

Table II. Hydrolysis of *N*-Phenyliodonio Amide Tosylates to Alkylammonium Tosylates in Acetonitrile

$RCONH\overset{+}{I}Ph$, $\bar{O}Ts$					$R\overset{+}{N}H_3$, $\bar{O}Ts$[c]
R	mmol	H_2O,[a] mmol	MeCN vol, mL	time,[b] h	yield, %[d]
CH_3	2.31	2.3	15	1	83
$(CH_3)_2CH$	2.17	2.2	13	0.5	64[e]
$(CH_3)_3C$	2.10	2.2	15	0.5	81
$CH_3(CH_2)_4$	2.04	2.2	10	0.5	75[f]

[a] Based on volume of H_2O in μL. [b] Reaction mixtures were heated to reflux and maintained under reflux for the specified periods of time. [c] The products separated from the solvent when the reaction mixtures were kept at room temperatues (R = *t*-Bu, *n*-C_5H_{11}) or in a refrigerator freezer (R = Me, *i*-Pr). [d] Based on unrecrystallized products and rounded off to nearest percent: R (mp, uncorrected); Me (145.5–147 °C), *i*-Pr (121.5–127 °C), *t*-Bu (220.5–222 °C), *n*-C_5H_{11} (88–104 °C). [e] A second fraction (mp 120–125 °C, uncorrected) was obtained from the concentrated filtrate by treatment of the residual material with Et_2O; combined yield, 90%. [f] Recrystallization of 0.20 g of the crude product from MeCN returned 0.16 g, mp 118–119.5 °C (uncorrected).

question. Although the foregoing results are consistent with the *N*-phenyliodonio amide structure **6** for the products derived from carboxamides and MTIB, they are not sufficient to rule out the isomeric *O*-phenyliodonio imidate structure **7**. In addition to sharing the same



6 **7**

elemental composition, the *O*-iodonio imidates should exhibit C=N stretching absorption in the same infrared region as the C=O band of **6**[11] and might be expected to rearrange to *N*-iodonio amides and hence to isocyanates in solution.[12] This structural ambiguity was resolved by the preparation and FT-IR analysis (Nujol)[13] of the phenyliodonio derivatives of ^{15}N- and ^{18}O-labeled acetamides.[14] If structure **6** (R = Me) is correct, the absorption band at 1681 cm^{-1} in the IR spectrum of the unlabeled iodonio amide should appear at about the same frequency in the spectrum of **6**-^{15}N but at a substantially lower frequency in the spectrum of **6**-^{18}O. If structure **7** is correct, the opposite would be true. The experimental data confirm the *N*-phenyliodonio amide tosylate assignment. Thus, the absorption band in question appears at 1681 cm^{-1} in the spectrum of the ^{15}N-isotopomer and at 1654 cm^{-1} (and a bit broadened) in the spectrum of the ^{18}O-isotopomer.

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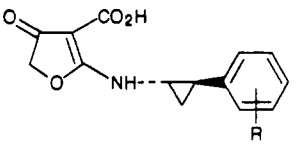
(11) Colthup, N. B.; Daley, L. H.; Wiberly, S. E. *Introduction to Infrared and Raman Spectroscopy*, 2nd ed.; Academic Press: New York, 1975; Chapter 11, p 325.
(12) By analogy to the Chapman rearrangement; see: Schulenberg, J. W.; Archer, S. In *Organic Reactions*; Wiley: New York, 1965; Vol. 14, Chapter 1.
(13) The FT-IR spectra (Nujol mulls) were recorded on a Beckman FT-2100 infrared spectrophotometer by Mr. Ketan Shah. The IR experiment with labeled compounds was suggested by Dr. G. Edwin Wilson, Jr.
(14) These compounds were prepared from [^{15}N]acetamide (99 atom %, Cambridge Isotope Laboratories) and [^{18}O]acetic acid (88.2 atom %, MSD Isotopes).

A Novel 3(2*H*)-Furanone-2(5*H*)-Furanone Rearrangement

Summary: A novel 3(2*H*)-furanone-2(5*H*)-furanone rearrangement that led to the facile preparation of a new class of γ-lactone amides **6** and **8** is reported herein.

Sir: Recently,[1,2] the synthesis of a number of 2-[*N*-(*trans*-2-phenylcyclopropyl)amino]-4,5-dihydro-4-oxo-3-furancarboxylic acids (**1**) was reported. In the present



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communication we wish to report a further extension of this work, namely, a novel 3(2*H*)-furanone-2(5*H*)-furanone rearrangement which was accomplished by treating 2-[*N*-(*trans*-2-phenylcyclopropyl)amino]-4,5-dihydro-4-oxo-3-furancarboxylic acid (**2**) with 1 equiv of *N*,*N*-bis(2-oxo-3-oxazolidinyl)phosphorodiamidic chloride (BOP-Cl) (**3**)[3] and an appropriately substituted aromatic amine **5** (1 equiv), in the presence of triethylamine.[4] The rearrangement resulted in the facile synthesis of a new class of 2(5*H*)-furanone amides **6** (Scheme I). The mechanism of the rearrangement appears to be complex. It is assumed[3] to involve an activation of the carboxyl group of acid **2** by BOP-Cl via an initial nucleophilic attack on the phosphorus atom by the carboxylate anion to give the intermediate adduct **4**. The latter then rearranges to form, in the presence of aromatic amine **5**, the 2(5*H*)-furanone amide derivative **6**.

In addition to the γ-lactone amides **6**, a number of 4-(*N*-phenylamino)-2,5-dihydro-2-oxo-3-furancarboxamide derivatives **8** were obtained by a similar 3(2*H*)-furanone-2(5*H*)-furanone rearrangement of 2-(*N*-phenylamino)-4,5-dihydro-4-oxo-3-furancarboxylic acids **7** (Scheme II).

(1) Georgiev, V. St.; Mack, R. A.; Kinsolving, C. R. U.S. Patent 4614810, 1986.
(2) Georgiev, V. St.; Mack, R. A.; Kinsolving, C. R. *Heterocycles* **1986**, *24*, 3195.
(3) Diago-Meseguer, J.; Palomo-Coll, A. L.; Fernández-Lizarbe, J. R.; Zugaza-Bilbao, A. *Synthesis* **1980**, 547.
(4) The rearrangement was carried out in methylene dichloride solution at 0–10 °C (stirring for 15–45 min) then at ambient temperature (stirring for 2–2.5 h). Following its completion, the reaction mixture was poured into ice–water, acidified with 2 N hydrochloric acid, and worked up.

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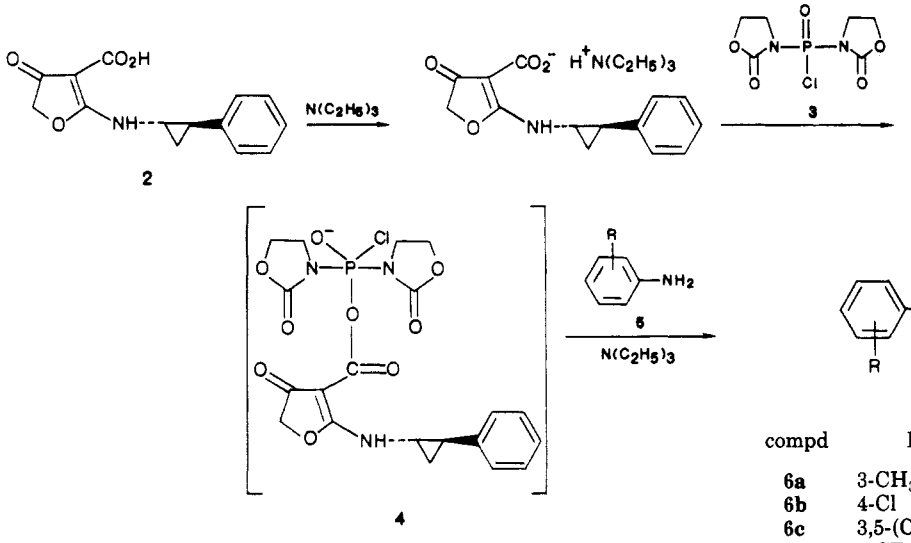
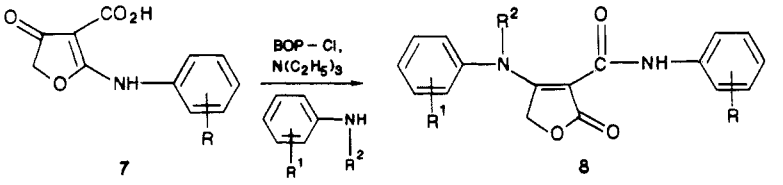
Scheme I



compd	R	mp, °C (solv)	yields, %
6a	3-CH_3	136–137 (ethanol)	74
6b	4-Cl	107–109 (2-propanol)	63
6c	3,5-$(OCH_3)_2$	153–154 (ethanol)	50
6d	3-CF_3	131–133 (ethanol)	54
6e	3-NO_2	188–190 (ethyl acetate)	58

Scheme II



compd	R	compd	R	R^1	R^2	mp °C (solv)	yields, %
7a	H	**8a**	H	4-Cl	H	209–210 (toluene)	46
7b	H	**8b**	H	4-CH_3	H	181–183 (ethanol)	55
7c	H	**8c**	H	H	CH_3	156–158 (ethanol)	67
7d	H	**8d**	H	H	H	175–176 (ethanol)	78
7e	3-NO_2	**8e**	3-NO_2	H	H	194–195 (tetrahydrofuran)	71
7f	2-OCH_3	**8f**	2-OCH_3	3-CF_3	H	170–172 (ethanol)	61
7g	3-CF_3	**8g**	3-CF_3	2-$(CH_3)_2CH$	H	108 (ethanol)	32
7h	3-CH_3	**8h**	3-CH_3	3-NO_2	H	190–191 (ethanol)	42
7i	4-Br	**8i**	4-Br	4-OCH_3	H	200 (ethanol)	45

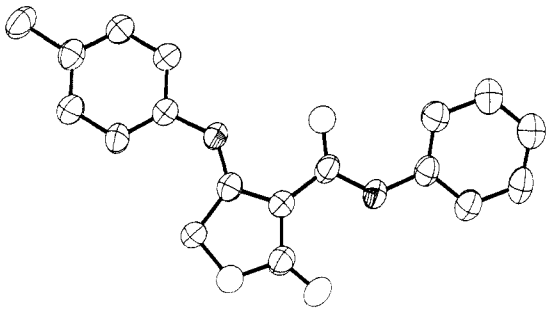


Figure 1.

When diphenylphosphinic chloride[5-7] was used in place of BOP-Cl as the activating reagent for the carboxyl group, the 3(2*H*)-furanone–2(5*H*)-furanone rearrangement of acids 7 proceeded smoothly to furnish the corresponding amide derivatives 8.[8] The structure of compounds 8 was determined by X-ray crystallography and a thermal-ellipsoid plot of **8b** is depicted in Figure 1.[9] When tested for biological activity, both 2(5*H*)-furanone amides **6** and **8** showed a moderate to potent antiallergic activity in the dermal vascular permeability and active anaphylaxis assays in rats.

Registry No. **2**, 103921-14-8; **3**, 68641-49-6; **5a**, 108-44-1; **5b**, 106-47-8; **5c**, 10272-07-8; **5d**, 98-16-8; **5e**, 99-09-2; **6a**, 106212-49-1; **6b**, 106212-50-4; **6c**, 106212-51-5; **6**, 106212-52-6; **6e**, 106212-53-7; **7a**, 58337-23-8; **7e**, 106212-54-8; **7f**, 106212-55-9; **7a**, 106212-56-0; **7h**, 106212-57-1; **7i**, 106212-58-2; **8a**, 106212-59-3; **8b**, 106212-60-6; **8c**, 106230-70-0; **8d**, 106212-61-7; **8e**, 106212-62-8; **8f**, 106212-63-9; **8g**, 106212-64-0; **8h**, 106212-65-1; **8i**, 106212-66-2; 4-$H_3CC_6H_4NH_2$, 106-49-0; $C_6H_5NHCH_3$, 100-61-8; $C_6H_5NH_2$, 62-53-3; 2-$(CH_3)_2CHC_6H_4NH_2$, 643-28-7; 4-$H_3COC_6H_4NH_2$, 104-94-9.

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(8) The infrared spectra (KBr discs) of compounds **6** and **8** displayed bands for lactone carbonyl at 1710–1739 cm^{-1} and amide group at 1645–1635 cm^{-1}. The ^1H nuclear magnetic resonance spectra of compounds **6** and **8** were determined in $CDCl_3$ or Me_2SO-d_6 solutions and contained signals for a lactone ring methylene group at 4.92–5.25 ppm, an amide hydrogen at 7.63–8.30 ppm, and a secondary amine hydrogen at 10.67–11.17 ppm.

(9) The X-ray crystallography data for compound **8b** will be reported elsewhere.

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