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SYNTHESES OF BICYCLOCAPROLACTAM SYSTEMS BY THE PHOTO-RING-EXPANSION OF N-SUBSTITUTED SUCCINIMIDES[1]

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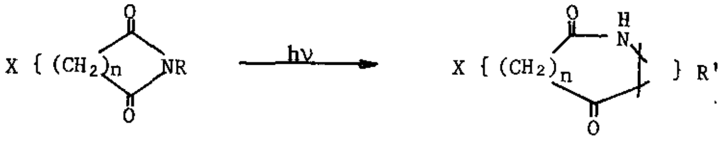
Synthetic application of the photo-ring-expansion was studied with bicyclo N-substituted succinimides and a variety of bicyclocaprolactams were photochemically synthesized with retention of their endo and exo configurations.

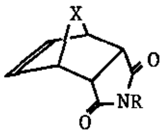
We have recently found that alicyclic imides **1** such as N-substituted succinimides and glutarimides undergo photocyclization, to afford keto lactam **2**, with ring-expansion by the two carbon unit derived from the side chain as shown in Scheme I.[2] By utilizing this novel ring-expansion reaction, syntheses of variety of seven- and eight-membered lactam derivatives are reported.[3] As an extension of the application of this reaction in heterocyclic chemistry, we now wish to describe photochemical synthesis of caprolactams containing bicyclo ring systems.

Scheme I



1 (n=2,3) 2 (n=2,3)

The bicyclo-succinimides used in this study were prepared as follows: The *endo*-bicyclo[2,2,1]-5-hepten-2,3-dicarboxylic imides 3 (X=CH_2)[4] were prepared by condensation of the appropriate amine and the *endo* anhydride, or alkylation of the *endo* imide 3a, and the N-substituted imides 3 (X=CH_2) thus obtained were hydrogenated to the bicyclic imides 5b-e. The N-substituted *exo* imide 8a was prepared by ethylation of the *exo* imide which was obtained by



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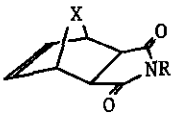

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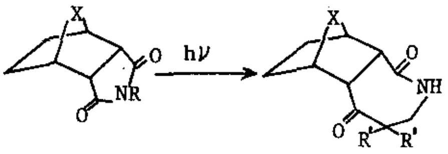

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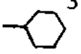
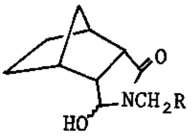
a X=CH_2, R=H
b X=O, R=H

	X	R		X	R'
a	CH_2	H			
b	CH_2	CH_2CH_3	b	CH_2	H
c	CH_2	$CH_2CH(CH_3)_2$	c	CH_2	CH_3
d	CH_2	CH_2– 	d	CH_2	R'-R'= $-(CH_2)_5-$
e	CH_2	CH_2– 	e	CH_2	R'-R'= $-O(CH_2)_3-$
f	O	H			
g	O	CH_2CH_3	g	O	H

hydrogenation of 4a.[4] In a similar manner, the *endo* oxo imide 5g was prepared by ethylation of 5f which was obtained from 3b, whereas the *exo* oxo imide 8b was prepared from 8d obtained by reduction of 4b.[5]



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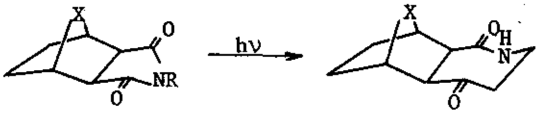

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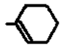
a R= $-\overset{CH_3}{\overset{|}{C}}=CH_2$

b R= 

	X	R
a	CH_2	C_2H_5
b	O	C_2H_5
c	CH_2	H
d	O	H

a X= CH_2

b X= O

A solution of the substituted imide 5 in acetonitrile (10 mM) was irradiated with a 60 W low-pressure mercury lamp for 40 min, and the results are tabulated in Table I. Major photo-products were purified by column chromatography (silica gel) and identified by their spectra and elemental analyses.[6]

In all cases the expected bicyclo keto lactams having two additional carbons in their ring were readily obtained in moderate isolated yields, accompanied by some amount of the N-unsubstituted imide, the product of the Norrish type II elimination in accord with the general rule (Scheme I).

Again, the principal feature of the Norrish type II processes of the

Table I Photo-products from the Cyclic Imides 5,8,10

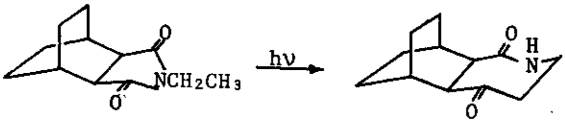
Imide	Product	Yield[a)] (%)	mp°C	Elimination Product (%)	Recovered (%)
5b	6b	63	162-4(dec.)	9	4
c	c	34[b)]	180-3(dec.)	4	28
d	d	26[c)]	184-6(dec.)	-	6
e	e	{36[d)] 29	214-6(dec.) 219-21(dec.)	13	3
g	g	66	212-4(dec.)	12	4
8a	9a	59	207-9(dec.)	10	19
b	b	73	247-50(dec.)	12	5
10	11	46	171-3(dec.)	-	-

a) Recovered imides were not calculated.

b) accompanied by 7a (26 %).

c) accompanied by 7b (30 %).

d) The diastereoisomers were separated by column chromatography (silica gel).



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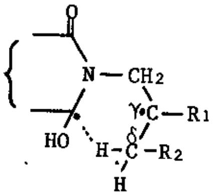

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bicyclic imides is not the elimination but rather the cyclization in favor *of the keto lactam synthesis*. In the case of 5c and 5d the amido alcohols 7a, b with a γ-unsaturated bond were isolated in some significant amount. The formation of 7 may be rationalized by considering a δ-hydrogen transfer of the intermediate biradical 12, a similar mechanism suggested in our previous paper,[7] to be involved in the general pattern of the photolysis of N-substituted phthalimides. It is worth noting that the initial endo and exo configurations of the starting substrates 5, 8 were retained in the ring-expanded photo-products without interruption by other side reactions such as α-cleavage. Irradiation of the simple models such as 5a and 8d resulted in recovering the starting compounds without changing the configuration confirming the above observation. Further synthetic application of this photoreaction will be reported elsewhere.

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REFERENCES

1 a) Photochemistry of the Imide System. VI. b) For Part IV see Y. Kanaoka, Acc. Chem. Res., 1978, 11, in press. c) For Part V see K. Murayama, Y. Kubo, M. Machida, K. Oda, Y. Kanaoka and K. Fukuyama, J. Org. Chem., 1978, 43, 2303. d) Photoinduced Reactions. XXXVI. For Part XXXIV and XXXV see ref. 1b) and 1c), respectively.

2 Y. Kanaoka and Y. Hatanaka, J. Org. Chem., 1976, 41, 400.

3 Y. Kanaoka, H. Okajima and Y. Hatanaka, Heterocycles, 1977, 8, 339.

4 C. F. Culberson and P. Wilder, Jr., J. Org. Chem., 1960, 25, 1358.

5 H. Kwart and I. Burchuk, J. Am. Chem. Soc., 1952, **74**, 3094.

6 All new compounds gave satisfactory elemental analyses and their structures were supported by spectral (uv, ir, nmr, mass) data.

7 Y. Kanaoka, Y. Migita, K. Koyama, Y. Sato, K. Nakai and T. Mizoguchi, Tetrahedron Letters, 1973, 1193.

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