Photochemical Reaction of Inclusion Molecular Complexes of *N,N*-Dialkylpyruvamides with Desoxycholic Acid. Host-controlled Reaction of Guest Compounds in the Solid State

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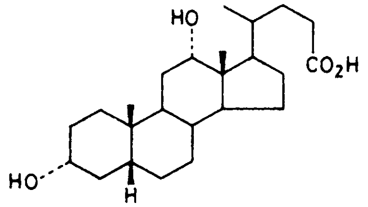
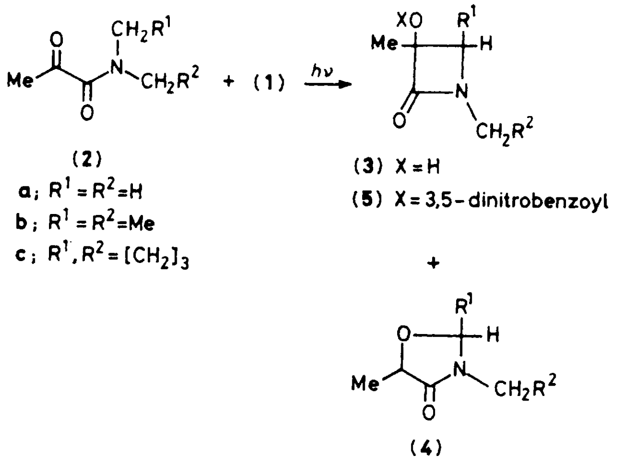
Solid state photolysis of inclusion molecular complexes of *N,N*-dialkylpyruvamides with desoxycholic acid gives the corresponding β-lactams which are not obtained in the corresponding photoreaction of the pyruvamides in solution.

The complexation of guest compounds with unimolecular hosts such as cyclodextrins in solution has received much attention. The host-controlled reactions of the guest compounds in these complexes have been studied extensively in relation to enzyme models.[1] There is, however, another type of host–guest complex which exists only in the solid state. These crystalline multimolecular inclusion complexes are known as clathrates, and they are sub-classified as (a) the true clathrate type, (b) the channel type, and (c) the layer type.[2] It is well known that desoxycholic acid (**1**) forms channel type inclusion complexes with a variety of organic substances.[3] In these complexes, the guest molecules are accommodated in continuous canals (channels) running through the crystals of (**1**).

Recently, Lahav *et al.* reported very interesting studies on the solid state photolysis of molecular complexes of (**1**) with ketones[4] and a peroxide.[5] In these reactions, the host compound (**1**) reacted with the excited guest compounds, and the desoxycholic acid derivatives were obtained as products. In relation to our previous study of *N,N*-dialkyl α-oxoamides in the crystalline state,[6] we now report on the solid state photolysis of inclusion complexes of *N,N*-dialkylpyruvamides (**2**) with (**1**). In this reaction, the host compound (**1**) does not react with the guest compounds but instead controls the reaction, and β-lactams (which are not obtained from the corresponding photolysis in solution) are formed as the main products. Furthermore, the β-lactams obtained are optically active.



(**1**)



(**2**)
a; $R^1 = R^2 = H$
b; $R^1 = R^2 = Me$
c; $R^1,R^2 = [CH_2]_3$

(**3**) X = H
(**5**) X = 3,5-dinitrobenzoyl

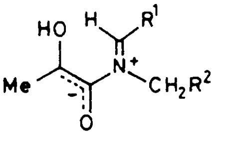
(**4**)

The inclusion complexes were prepared by crystallizing (**1**) using the pyruvamides (**2**) as solvents. The molar ratios of (**1**) to (**2**) were found to be *ca.* 4 : 1.† The photolyses were carried out in the presence of air at room temperature. The solid state photolysis of the complex of *N,N*-dimethylpyruvamide (**2a**) with (**1**) gave 1,3-dimethyl-3-hydroxyazetidin-2-one (**3a**) (42%) as a main product accompanied by a small amount of an oxazolidinone (**4a**) (*ca.* 10%). The β-lactam was converted into the crystalline 3,5-dinitrobenzoate (**5a**) since (**3a**) is a hygroscopic liquid. The structure of (**5a**) was determined by elemental analysis and spectral data. Photolysis of (**2a**) in benzene did not give (**3a**) but afforded (**4a**) instead in low yield (<10%).

Irradiation of the complex of *N,N*-diethylpyruvamide (**2b**) with (**1**) also yielded the corresponding β-lactam as the main product (74%) as a mixture of two stereoisomers (*ca.* 1 : 1) which were not completely separated. The separation was achieved after conversion into the 3,5-dinitrobenzoates, although the stereochemical structures of the two isomers have not yet been assigned. In the photolysis of (**2b**) in solution, the β-lactam is not obtained, and the main product is the oxazolidinone (**4b**).[7]

When the complex of (**2c**) was irradiated the β-lactam (**3c**) was obtained in 52% yield as a crystalline compound. The structure of (**3c**) was confirmed by direct comparison with an authentic sample.[8] It is known that (**3c**) is formed only in a low yield (5%) on irradiation of (**2c**) in benzene.[8]

Recently, we clarified that β-lactams (**3**) and oxazolidinones (**4**) are formed from pyruvamides *via* zwitterionic intermediates (**6**).[9] Inclusion of the pyruvamides in the crystals of (**1**) apparently enhances the formation of the β-lactams as described above. Similar results were obtained from the photolysis of some α-oxoamides in the crystalline state[6] where the yields of the β-lactams were much higher than those from the photolysis in solution. Although the reason why β-lactams are favoured in the solid state reactions is not clear at present, the restraints on the molecular motion of the zwitterionic intermediates (**6**) imposed by the crystal lattice [in the case of crystals of (**1**)] or by the host compound (in the case of the molecular complexes) are presumed to be responsible.[6] The present reaction provides the first example of host-controlled reactions of guest compounds in solid state photoreactions.



(**6**)

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† The ratios were calculated on the basis of the weights of the complexes and the amounts of the amides involved in them. The amides were determined by vapour phase chromatography after dissolving the complexes in methanol.

Table 1.

Product	$[\alpha]_D(CHCl_3)$	Enantiomeric excess[a] (%)
(5a)	+3.0°	*ca.* 15
(5b)	+5.5°	*ca.* 9
	+0.6°	<3
(3c)	−2.6°	*ca.* 15

[a] Measured by n.m.r. spectroscopy using a chiral shift reagent, $Eu(tfc)_3$ {tfc = tris[3-(trifluoromethylhydroxymethylene)-(−)-camphorato]}.

The products formed in the photolysis of the molecular complexes were found to be optically active although the enantiomeric excesses were not high (Table 1). The asymmetric induction is undoubtedly due to the chirality of the channels in the crystals of (**1**). Asymmetric synthesis using clathrates has not previously been reported except for the polymerisation of 1,3-dienes included in (**1**).[10]

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