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CYCLOADDITION REACTION OF CYCLOBUTENE WITH AROYLAZIRIDINES1)

———DIPOLE-DIPOLE INTERACTION MECHANISM IN 1,3-DIPOLAR CYCLOADDITION

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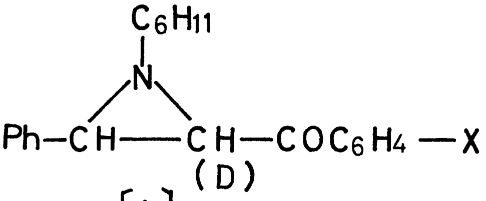
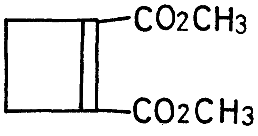
1,3-Dipolar reaction of a variety of aroylaziridines with dimethyl 1-cyclobutene-1,2-dicarboxylate resulted in the exclusive formation of one isomer of the isomeric adducts. Based upon the stoichiometry, the dipole-dipole interaction mechanism was suggested first in the 1,3-dipolar cycloaddition, which is not inconsistent with the stereochemical results hitherto reported.

Recently, several cyclobutenes have been found to be effective dienophiles,2) while little is known on the dipolarophilic properties of cyclobutenes. We report here our results on the cycloaddition of aroylaziridines [1] with dimethyl 1-cyclobutene-1,2-dicarboxylate [2].

Refluxing of 2-benzoyl-1-cyclohexyl-3-phenylaziridine [1; X=H] with an equimolar amount of the cyclobutene [2] in dry benzene for 7 hrs under N_2 afforded, after

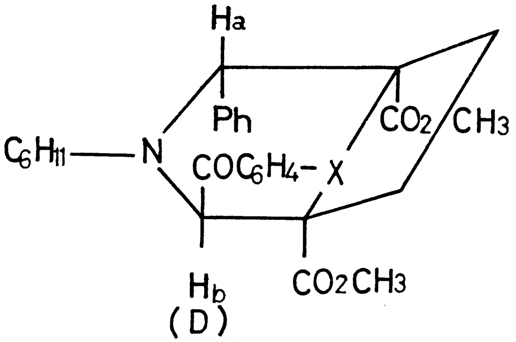


[1]

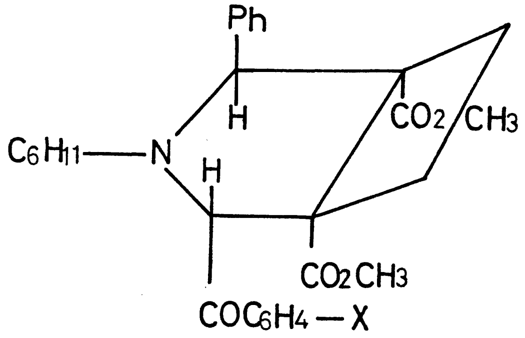


[2]

chromatographic purification, only one [3; X=H] of the two possible isomers[3] in 59 % yield. Similarly, smooth cycloadditions of *p*-substituted aroylaziridines [1] to [2] gave the adducts [3] in good yields, physical and spectral data of which are summarized in a Table. Reaction of [2] with the stereochemically pure samples of *cis*- and *trans*-2-aroylaziridines gave the same adducts in approximately the same yields, and when [2] was treated with the deuterated aziridine (63 % labeled at 2-position), the pmr spectrum of the adduct showed a singlet, intensity of which was 0.6H, at δ= 6.00, which allowed an unambiguous assignment of H_b. The assignment



[3]

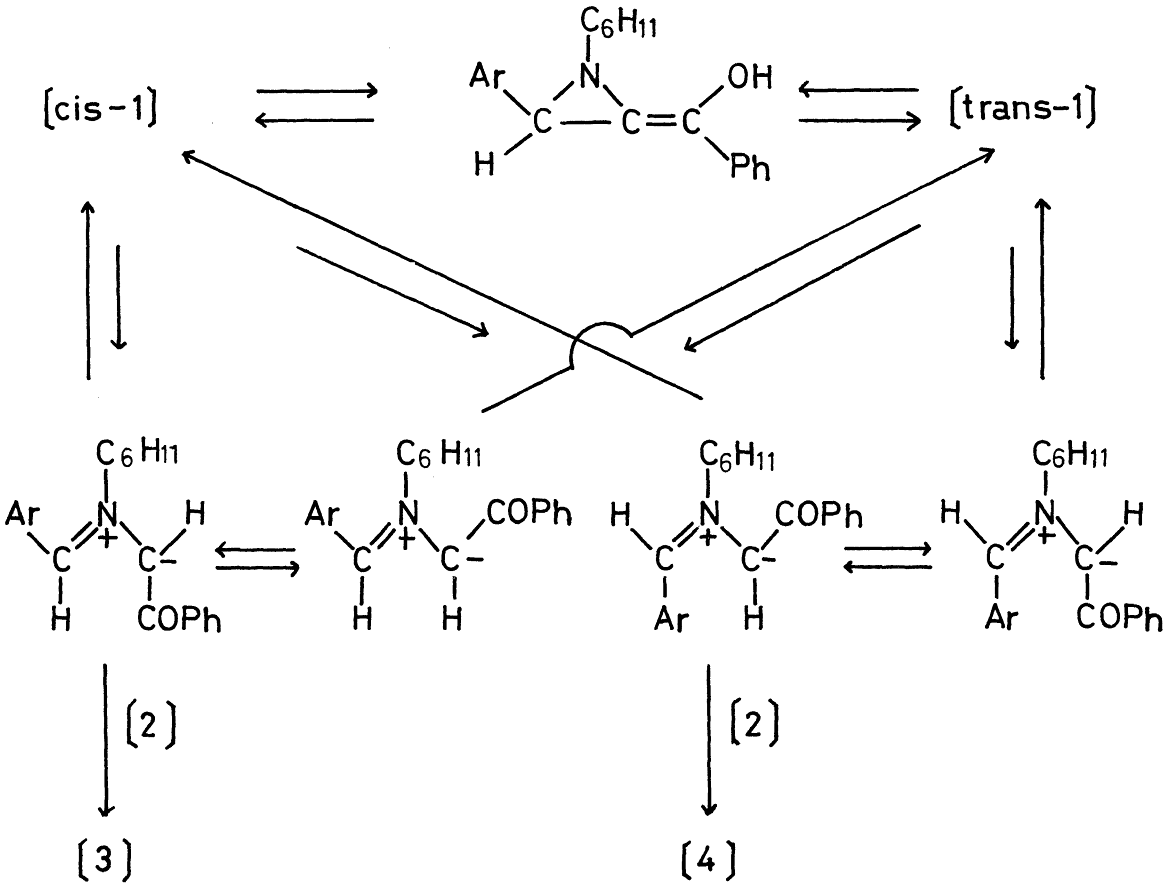


[4]

Table. Physical and Spectroscopic Properties of Pyrrolidines[6]

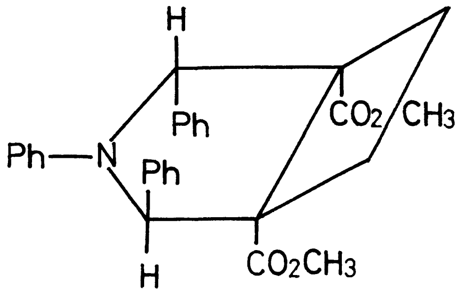
X[3]	mp (°C)	Yield(%)	ir(cm^{-1}) (C=O)	pmr($\delta_{CDCl_3}^{TMS}$)*				
				H_b	H_a	ester	CH_3	CH_3 or CH_3O
p-CH_3O	123.5-124.5	66	1730 1675	5.92	4.57	3.63	3.11	3.80
p-CH_3	134 - 135	80	1730 1679	5.93	4.59	3.64	3.14	2.40
H	150 - 151	59	1735 1684	6.00	4.62	3.61	3.13	———
p-Cl	136.5-137.5	60	1720 1679	5.90	4.51	3.62	3.09	———
p-NO_2	142 - 143	31	1721 1690	6.08	4.63	3.65	3.15	———

*) All adducts showed pmr signals in the appropriate region due to aromatic, cyclohexyl and cyclobutyl ring protons with the corresponding intensities.

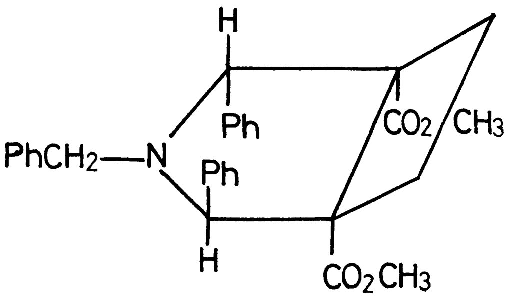


Scheme

of the geometry is based upon the pmr data(Table) and the well documented principle[7,8] that a ring proton or ester methyl protons are shielded by *cis-vic*-phenyl ring, and thus another possible structure [4] was excluded by comparison of the chemical shifts of ester methyl protons with those of the adducts [5] and [6] which were obtained by the thermal conrotatory ring opening and subsequent stereospecific cycloaddition[8] of *cis*-1,2,3-triphenylaziridine and *N*-benzyl-*cis*-2,3-diphenylaziridine with [2] in refluxing toluene; [5][6]: mp 174.5-176°C(52 % yield), pmr($\delta^{TMS}_{CDCl_3}$): 6.3-7.5(15H, m), 6.10(1H, s), 5.37(1H, s), 3.80(3H, s), 3.18 (3H, s), 1.5-2.8(4H, m), ir(KBr): 1725 cm^{-1}, [6][6]; mp 149-150°C(74 % yield), pmr($\delta^{TMS}_{CDCl_3}$): 7.0-7.7(15H, m), 5.28(1H, s), 4.30(1H, s), 3.89(3H, s), 3.16(3H, s), 2.86, 3.80(2H, ABq, J=15Hz), 1.9-2.8(4H, m), ir(KBr): 1710, 1725 cm^{-1}. The chemical shifts of ester methyl protons located at *cis-vic*-position to phenyl group are in good agreement. Furthermore, the chemical shifts of H_a, H_b and another ester methyl protons have reasonable values in comparison with those of the reported pyrro-



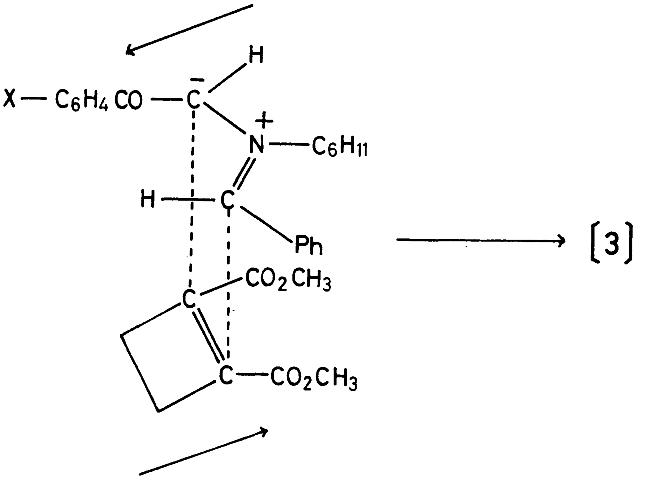
[5]



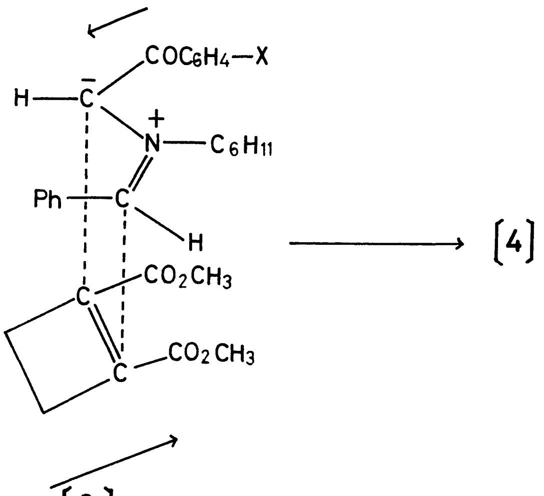
[6]

lidines.[9]

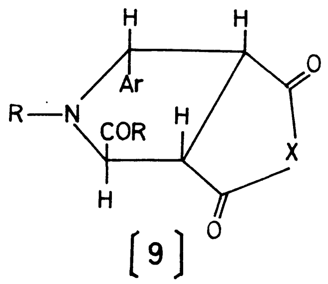
Although numerous interpretations of the stereochemistry of Diels-Alder reaction have been made in terms of secondary orbital interaction, dispersion force, steric repulsion, dipole-dipole interaction, charge transfer interaction and inductive force, no systematic study has been done in the related (4+2)π 1,3-dipolar cycloaddition. The high stereoselectivity observed here would suggest the overwhelming operation of dipole-dipole interaction in the transition state which may be approximated[10] by the orientation complex[7]; the interaction of the apparently more dipolar azomethine ylide with [2] will afford [3], while the less dipolar azomethine ylide would



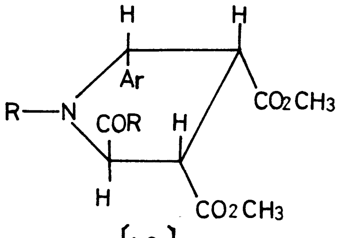
[7]



[8]



[9]



[10]

give the adduct [4], which could not be detected in the present case. The dipole-dipole interaction mechanism proposed here[11] is consistent with the reported experimental results that the adducts [9] and [10] were exclusively or predominantly formed.[9] Moreover, when a highly electron-withdrawing substituent such as nitro group is introduced to 3-phenyl ring of the aziridine, the geometrical relationship in [9] of the predominantly formed adducts is reversed,[12] which could be considered as an additional support for the dipole-dipole interaction mechanism. Attempts to obtain some kinetic evidences are underway in our laboratories.

REFERENCES AND NOTES

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3) We have confirmed that *cis*- and *trans*-2-aroylaziridines cycloadd even with powerful dipolarophiles via *trans*-azomethine ylide (see Scheme).[4,5]
The lower yield of [3; X= *p*-NO_2] may be due to the relative unstability of the corresponding aziridine. The pmr monitoring of the reaction did not indicate any presence of the isomer [4].

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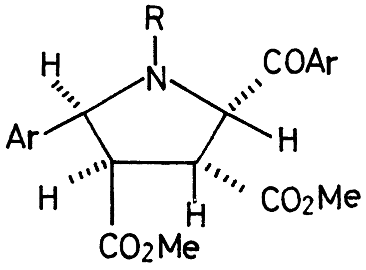
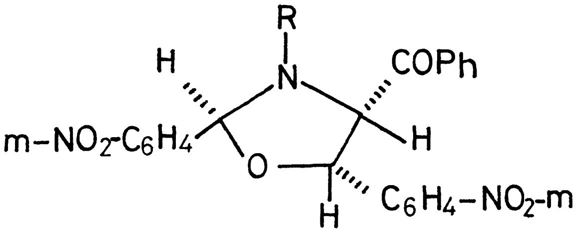
11) The local interaction of the substituent groups in the complex[7], i.e. the attractive π-overlap interaction of the ester and phenyl groups might also operate,

with the assistence of which the global dipole-dipole interaction favors the arrangement [7] over [8].

In the present case, the repulsive or steric interaction of the benzoyl group with a polar group such as an ester or a *m*-nitrophenyl group in [8] would not be so important as the π-overlap interaction of the ester and phenyl groups in [7] because the exclusive or predominant formation of the adducts [11] and [12] was observed.[9,12]



[11]



[12]

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