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NEW ROUTES TO CONDENSED POLYNUCLEAR COMPOUNDS-V

'TRANS CYCLISATION'

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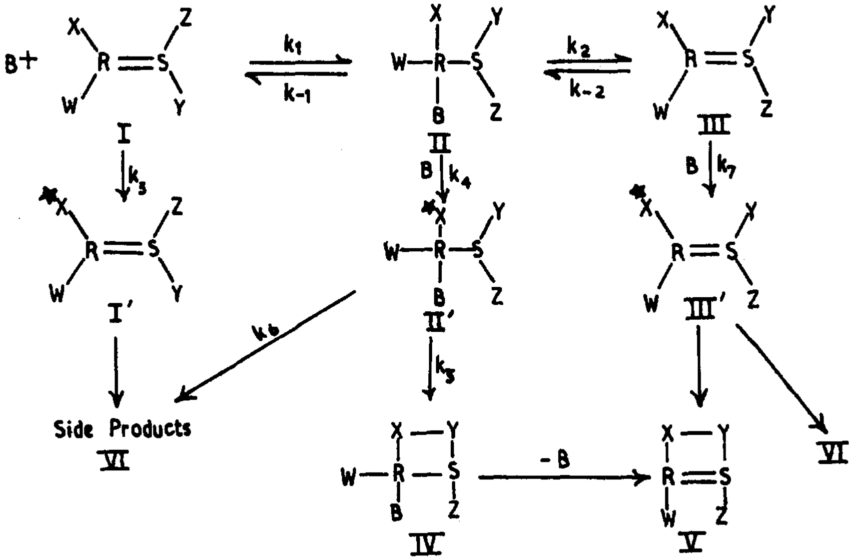
Union between two groups originally trans across a double bond if effected in a single operation may be termed a 'trans cyclisation'. As a mechanistic class, these multistep[2] reactions are of considerable interest because the obvious path of cyclisation through equilibration to the cis isomer cannot often operate satisfactorily. In most cases a reactive site[3] needs to be generated on one of the groups for its joining with the other, and this can lead to predominant side reactions specially if the original trans arrangement is strongly preferred over the cis. Simple analysis shows that for success here, besides other kinetic requirements, the rate of reactive intermediate formation from the cis isomer (k_7) has to be much larger than that from the trans isomer (k_3), which is unlikely for two similar steps[4]. Thus, even moderate yields may not be feasible in such 'trans cyclisations'.

This difficulty has been ingenously overcome in photocyclisations, say of o-halo- stilbenes, by building up a cis concentration in a radiation controlled equilibrium. A conceptually equivalent approach can be transient generation of an alternate sterically viable moiety which is relatively stable under the reaction conditions e.g. the cyclisation joining X and Y may proceed through adduct II with subsequent expulsion of the addendum as shown in Chart I[5].

We have attempted 'trans cyclisations' across C=N and C=C bonds

with a number of compounds of the type I (X = o or m-Cl-Ph), through their reaction with amide ions. The rationale of this approach is that on basis of (i) expected tendency of amide ions to add across such double bonds, (ii) their preclivity to generate aryne intermediates[6] and (iii) the reactivity of the latter towards groups with anionic activation[7], a reaction path I→II→II′→IV→V (Chart I) can be envisaged. An alternate reaction path through III could also be visualised, specially in cases where this isomer is not less stable than I; forced proximity between X* and Y conferring the necessary mutual reactivity.

Chart I



*reactive site generated on group X.

Treatment of Ia (X=o-Cl-Ph, or o-Br-Ph, R=C,S=N,Y=Ph)[8], Ib(Ia with X = m-Cl-Ph), Ic(Ia with W=CH$_3$), Id (X=o-Cl-Ph, R=S=C,Y=Ph,Z=COOH), Ie (X=m-Cl-Ph, R=S=C, Y=COOH, Z=Ph) and If (X=o-Cl-Ph, R=S=C,Y=Z=Ph) with excess potassium amide in liquid ammonia gave phenanthridine (quantitative), phenanthridine (70%), 6-methyl-phenanthridine (60%), 9-phenanthrene carboxylic acid (35%), 3-phenylcoumarin (50%) and 9-phenylphenanthrene (80%) respectively[9]. Additional examples of each of the above types with substituents on the rings were found to give essentially similar results.

The necessary kinetic condition does not obtain in reactions of Ig (X=o-Cl-Ph, R=S=C, Y=Ph, Z=H), Ih(X=o-Cl-Ph,R=S=N, Y=Ph) and Ii (X =o-Cl-Ph, R=S=C, Y=p-pyridyl,Z=H), In these cases little 'trans cyclisation' products could be isolated and the reaction mixtures were mainly complexes of materials arising from amination (VI). Identical mixtures resulted from reactions of Ig and its cis-isomer; trans-2-aminostilbene could infact be isolated in each case.

It should be pointed out that the reactions reported here, although operationally falling under the category of trans cyclisation, may or may not be following the same mechanistic path in detail[10]. In case of anils a fast and virtually irreversible formation of the intermediate anion II is indicated by the fact that the rate of loss of halide ions, under standard reaction conditions, from Ij (X=Ph,R=C,S=N,Y=o-Cl-Ph) is couple of orders of magnitude less than that from Ia. It is well known that generation of a negative charge on an atom attached to an aryl halide suppresses benzyne formation[11,12] Good yield of 2-chlorophenanthridine obtained in reaction of Ik (Ia with Y=p-Cl-Ph) also seems to be a consequence of this protective anion formation. That adduct anion of the type II can cyclise in this manner is clear from reaction of N-(o-chlorobenzyl) aniline[7] with amide ions in liquid ammonia, where 5,6-dihydrophenanthridine is obtained almost quantatively. Involvement of 'free aryne' intermediates in cyclisation of anils can also be inferred as both ortho (Ia)and meta (Ib) compounds afford phenanthridine. In contrast reaction of o-chlorophenyl cinnamic acids (Id and its cis isomer[13]) leads to phenanthrene-9-carboxylic acid while that of meta choloro acid Ie affords 3-phenylcoumarin, and what is even more intriguing one to almost exclusion of the other[10].

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3. J.E.Leffler, "The reactive intermediates of organic chemistry", Interscience Publishers Inc.New York (1956). Here due to the tendency of reactive intermediates for fast reactions with the surroundings their formation,treated as one step, may be considdred irreversible. In the event of substantial reversion or non-intermediacy of reactive species, good cyclisation yields can result but these conditions rarely obtain in practice.
4. Except in special cases like intramolecular reactive intermediate formation.
5. Here the necessary conditions (i) $k_1 > k_3$, (ii) $k_1k_4 > k_3k_{-1}$ (iii) $k_5 > k_6$ for good yield can be met even without k_4 being larger than k_3. Intercomversions of I$'$and II$'$are not considered since by definition reactions at the reactive site should be faster.
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8. Unless otherwise mentioned W=H, Z=nitrogen lone pair and B=NH$_2$. In II, II, IV, S carries a unit negative charge.
9. Structures of these products were confirmed by comparison with authentic samples. Only in Ia, Ib,Ic and Ie trans X-Y arrangement is preferred thermodynamically.
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