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[A0011]

A New Photochemical Route to Cyclopropanes and Bicyclo[n,1,0]alkanes

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Introduction

Up to now only few examples of cyclopropane syntheses by *NORRISH-YANG*-reaction are known. In most of these cases an initial PET to the excited carbonyl group was proven or seems very likely basing on the modern state of knowledge. [1,2] In the following we would like to present a new method to prepare highly functionalized cyclopropanes.

It is well known by the chemistry of monoradicals that radical centres are excellent neighbouring groups for the nucleophilic substitution. [3,4] The -hydroxy radicals **1** occupy a special position. If X is a suited leaving group the elimination of the acid HX occurs without formation of any ionic intermediates and with rate constants $k > 10^9\ s^{-1}$. [5,6] It is noteworthy, in the formed enolate radical **2** the highest spin density is now mainly localized at the adjacent carbon atom.

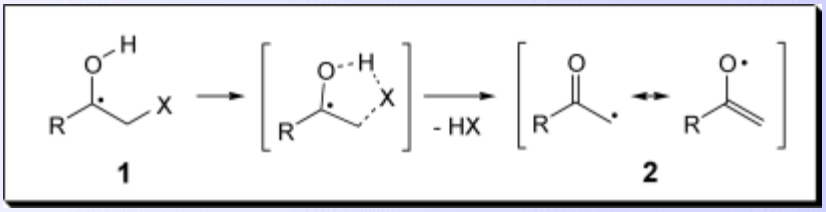


Fig. 1

Bearing in mind that the lifetimes of triplet biradicals generated by the *NORRISH-YANG*-reaction are usually

30-100 ns it should be possible that the elimination **12** goes faster than the well-known *NORRISH-YANG*-processes (cyclization, fragmentation, H-backtransfer). In this way [1,n]-biradicals would be converted into [1,n-1]-biradicals. We have called this process 'spin centre shift'.

Photochemical behaviour of 2-mesyloxy- and 2-nitrooxy-alkylphenylketones

We investigated the photochemical behaviour of various -mesyloxy (**3a** - **3e**, **3h**, **3i**) and -nitrooxy ketones (**3f**, **3g**) respectively. (table 1) [7] Both are easily accessible by a variety of synthetic methods. Upon irradiation of these ketones **3** the oxygen atom of the excited carbonyl group abstracts a hydrogen atom from the -position of the side chain giving the triplet-1,4-biradicals **4**. (fig. 2) They now undergo a very rapid elimination of methane sulfonic acid and nitric acid respectively and the 1,3-biradicals **5** are formed, which subsequently cyclize to benzoyl cylopropanes **6** after ISC.

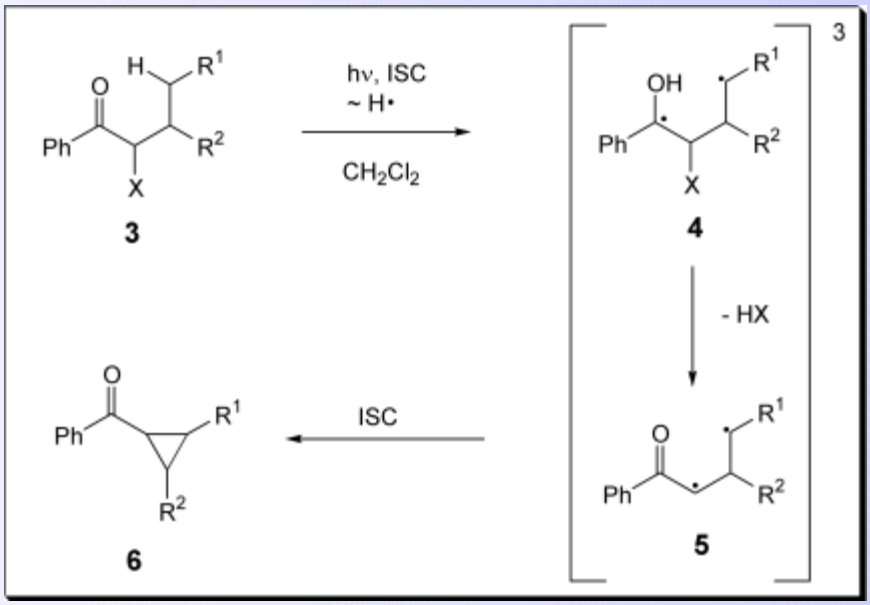


Fig. 2

Irradiation of these ketones **3** was performed in methylene chloride or methanol as solvent. With respect to the yield and the irradiation time methylene chloride is usually more suited than methanol. Upon irradiation in methylene chloride it is necessary to add a weak base (N-methylimidazole) to capture the strong acid (MsOH, HNO_3), which is liberated during the photoreaction.

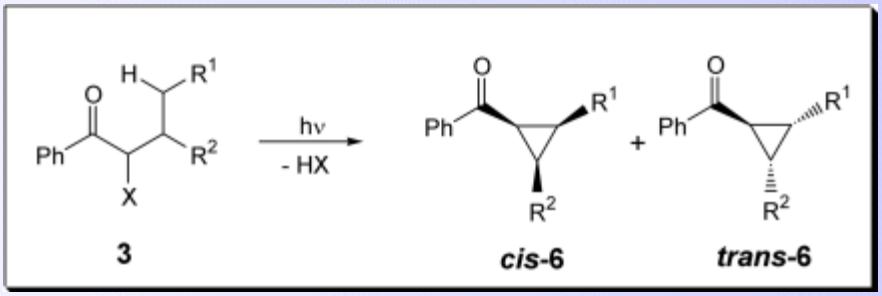


Table 1

R^1	**R^2**	**X**	**3**	**6**	**solvent**	**yield [%]**	**cis [%]**	**trans [%]**	**byproducts**
H	H	OMs	**a**	**a**	CH_2Cl_2	87	-	-	-

Me	H	OMs	**b**	**b**	CH_2Cl_2	63	-	100	**7** (16%)
H	Me	OMs	**c**	**b**	CH_2Cl_2	90	-	100	-
Ph	H	OMs	**d**	**c**	CH_2Cl_2	78	60-65	35-40	-
Ph	H	OMs	**d**	**c**	MeOH	30	60-65	35-40	-
H	Ph	OMs	**e**	**c**	CH_2Cl_2	44	60-65	35-40	-
H	Ph	OMs	**e**	**c**	MeOH	12	60-65	35-40	-
CO_2Me	H	ONO_2	**f**	**d**	CH_2Cl_2	15-45[a)]	-	100	**8**
CO_2Me	H	ONO_2	**f**	**d**	MeOH	31	-	100	-
H	CO_2Me	ONO_2	**g**	**d**	CH_2Cl_2	55	-	100	-
H	CO_2Me	OMs	**h**	**d**	CH_2Cl_2	59	-	100	-
OBn	H	OMs	**i**	**e**	CH_2Cl_2	46	-	100	-

a) The addition of base lead to a thermal side reaction to 4,5-dioxo-5-phenyl-pentanoic acid methyl ester **8**. This side reaction reduced the yield of cyclization product depending on the reaction conditions.

By means of this method we prepared alkyl, aryl, alkoxy and carboxy cyclopropanes (table 1). In most cases the yields are high (up to 90%) and the cyclization occurs, depending on the substituent pattern, often fully diastereoselective (trans selective).

In contrast to the "classical" *NORRISH-YANG*-reaction the photoactive benzoyl group is preserved. In some cases a photochemical consecutive reaction appears. Upon irradiation of the ketone **3b** (R^1 = Me) the partial formed cis isomer (***cis*-6b**) reacted within the meaning of a *NORRISH-TYP-II*-cleavage to the ,-unsaturated ketone **7**. (fig. 3) [8]

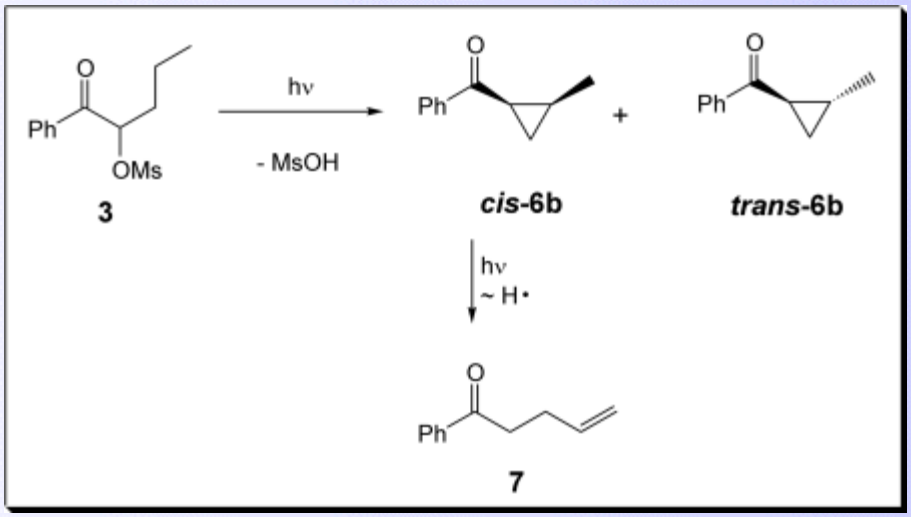


Fig. 3

The cyclization product **6c** also proved to be photoactive. Separate irradiation of the diastereomeres ***cis*-6c** and ***trans*-6c** resulted in partial conversion to the respective other diastereomere. A solution of **6c** in methylene chloride reached an apparent photostationary state (cis : trans = 1.7, determined by ^{1}H-NMR spectroscopy in CD_2Cl_2). (fig. 4) [9]

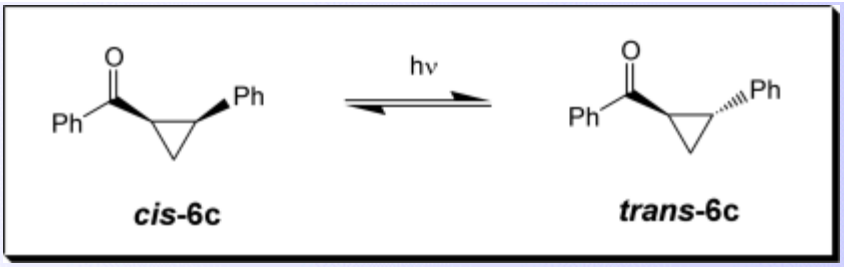


Fig. 4

Preparation of 2,3-disubstituted benzoyl cyclopropanes could also be effected by this method. Irradiation of the ketone **3j** resulted in a fully diastereoselective formation of the cyclization product ***trans,trans*-6f**. (fig. 5)

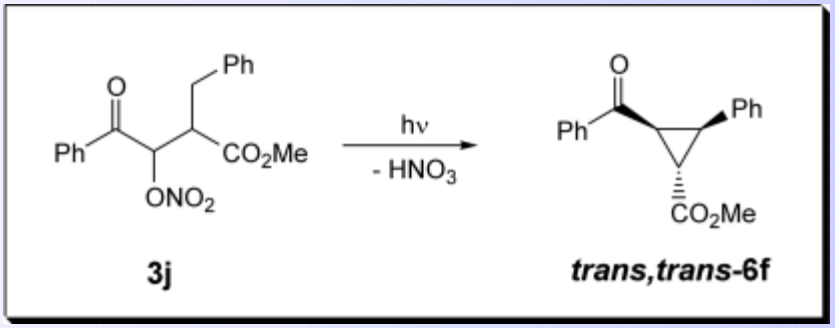
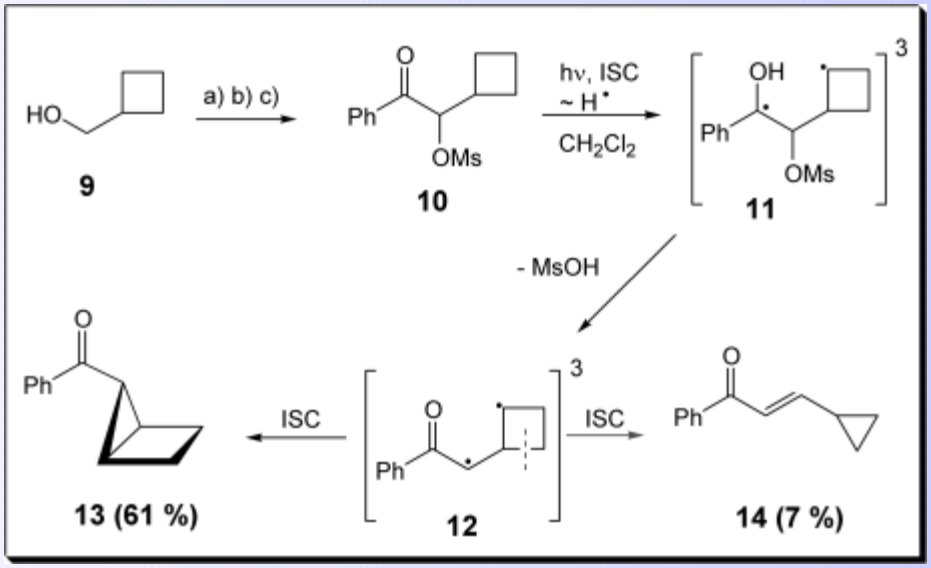
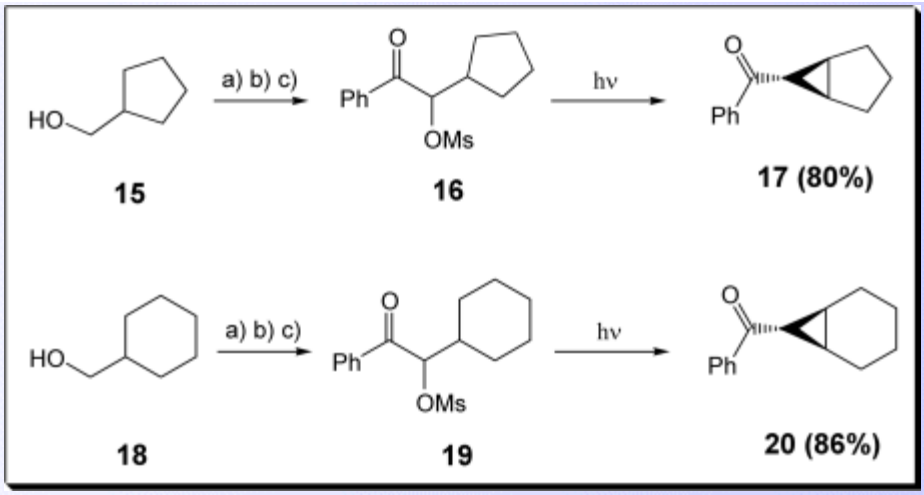


Fig. 5

Synthesis of bicyclo[n..1.0]alkanes

Starting with the commercially available cycloalkane methanoles (**9**, **15**, **18**) our method turns out to be particularly efficient to prepare bicyclo[n.1.0]alkanes (**13**: n = 4, **17**: n = 5, **20**: n = 6) in only few steps. (fig. 6). The photocyclization of the higher homologues (n = 5, 6) went entirely selective and in high yields (**17** = 80 %, **20** = 86 %), while in the case of photoreactand **10** (n = 4) formation of the non-bicyclic byproduct **14** (7 %) was observed.





method	**9 → 10**	**15 → 16**	**18 → 19**
a) PCC	88 %	76 %	91 %
b) PhC(OTMS)(CN)Li	73 %	75 %	79 %
c) Ms_2O/Py	57 %	61 %	67 %

Fig. 6

Summary

In summary, we have developed a new straightforward method to prepare highly functionalized cyclopropanes and bicyclo[n.1.0]alkanes. The basic principle is a spin centre shift, which proceeds during the elimination of a strong acid from the initially formed 1,4-hydroxybiradicals. The result is a decrease of the distance between the two radical centres and a 1,3-biradical is obtained. At present we are investigating further synthetic applications and we will report upon the results soon.

Acknowledgement

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