

行政院國家科學委員會專題研究計畫 成果報告

酸催化亞胺與醯胺之光化學反應

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New Photochemical reactions of Benzyldeneaniline with Amides Assisted by protic Acid

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中文摘要

一系列之亞胺化合物(1-7)從苯甲醛與苯胺之縮合反應而得。亞胺化合物(1-7)在質子酸的催化作用下可與醯胺進行光化學反應得到加成產物(8-14)其產率從 70% 至 85% 之間，此新型之光化學反應之反應機構是從激發態之電子轉移反應而得到醯胺之陽離子自由基與亞胺之自由基結合而來。

關鍵詞：亞胺、醯胺、光化學、酸催化。

Abstract

A series of benzyldeneaniline derivatives 1-7 were prepared by condensation of benzaldehyde with aniline. The benzyldeneanilines reacted photochemically with amides such as *N,N*-dimethylacetamides in the presence of a protic acid to afford various of *N*-(2-aryl-2-phenylamino-ethyl)-*N*-methylacetamides (8-14) in high (70-85%) yields.

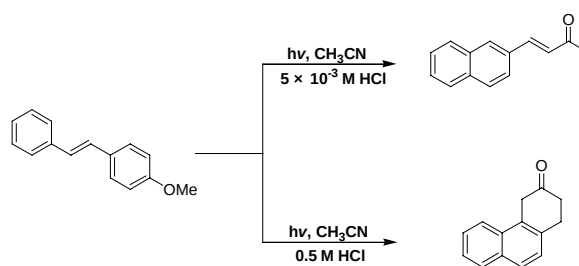
Results

The importance of acid catalysis in various photochemical transformations has been recognized recently¹⁻¹⁰.

We have also disclosed an acid catalyzed hydrolysis of a dihydrophenanthrene intermediate from a photorearrangement of stilbene¹¹. The reaction pathways can be tuned with the assistance of protic acid¹² (Scheme 1).

Keywords: imine, amide, photochemistry, electron transfer, addition.

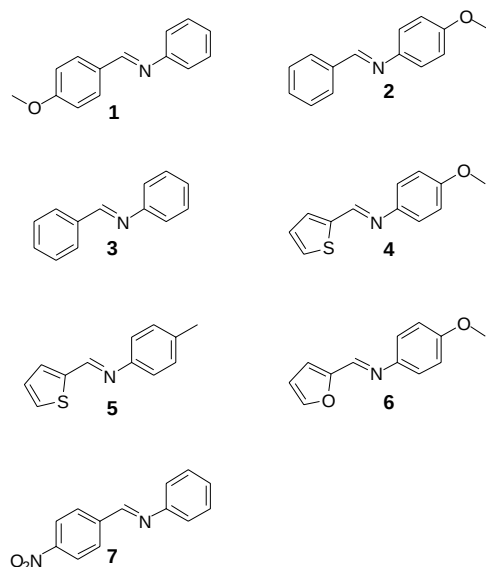
Scheme 1



There is quite a few studies on the photochemical reactions on the benzyldeneaniline derivatives¹³⁻¹⁷. The reactions include oxidative photocyclization¹³, photoreduction¹⁴, photoalkylation¹⁵ and alkylation of iminium cations¹⁶⁻¹⁷. In this report, we have prepared a series of

benzylideneaniline derivatives **1-7** (scheme 2) by condensation of various aldehydes with anilines.

scheme 2



We would like to report a new type of photochemical reactions between compounds **1-7** with *N,N*-dimethylacetamide. When a 6 mM solution of benzylideneaniline (**3**) in anhydrous *N,N*-dimethylacetamide solution how much containing saturated HCl is degassed with argon for 15 minutes and is irradiated for four hours using 350 nm light (Rayonet photolysis apparatus). Then the reaction mixture is neutralized with sodium hydroxide. The product is extracted with ethyl acetate and the solvent is removed to afford *N*-methyl-*N*-(2-phenylamino-ethyl)-acetamide (**10**) in 81% yield. The structure is identified with the ^1H -NMR (300 MHz, TMS, CDCl_3) δ 7.41(d, $J=7$ Hz, 2H), 7.34(t, $J=7.8$ Hz, 2H), 7.26(m, 1H), 7.05(t, $J=7.6$ Hz, 2H), 6.59(t, $J=7.16$ Hz, 1H), 6.46(d, $J=8.6$ Hz, 2H), 4.54(dd, $J=9.6, 3.3$ Hz, 1H), 4.25(dd, $J=14, 9.7$ Hz, 1H), 3.10(dd, $J=14, 3.4$ Hz,

1H), 2.9(s, 3H), 2.10(s, 3H); ^{13}C -NMR(100 MHz, CDCl_3) δ 172.63, 147.05, 141.13, 128.89, 128.70, 127.40, 126.44, 116.91, 113.03, 58.51, 55.02, 37.38, 22.02; FAB m/z (relative intensity)269.21(45), 268.1(M^+ , 25), 182.1(100), 154(50), 136.0(40).

The yields for the new type of photochemical reactions of a series of substituted benzylideneaniline (**1-7**) with *N,N*-dimethylacetamide are list in table 1. When there is electron-donating methoxy substituent in the benzylidene moiety that the yields is enhanced (for **1**, 85%).For the electron withdrawing derivative (**7**) the yield become zero. Thus this photoreaction is very sensitive to the para-substituent at the bezylidene moiety. The photoreaction is less sensitive to the substituents at the aniline site (for compounds **2**, **4** and **5**).

Table 1.

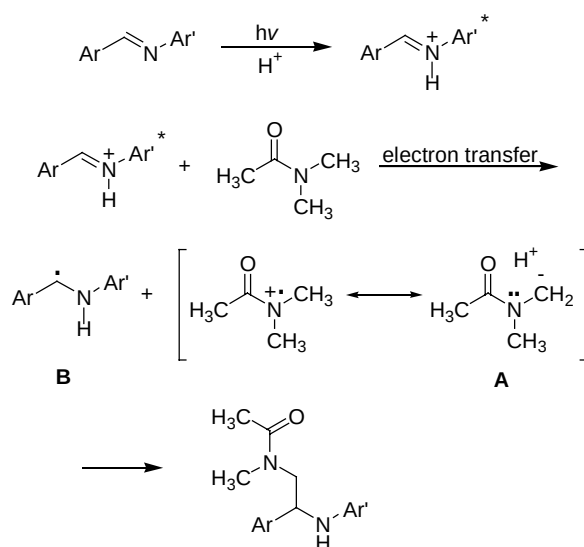
reactant	time(hr)	yields	products
	4	85%	
	4	84%	
	4	81%	
	8	76%	
	8	75%	
	8	71%	
	32	70% ¹	
	8	0%	No reaction

1: $6 \times 10^{-3}\text{M}$ in 15ml solvent (1.5ml and 13.5ml CH_3CN , HCl anhydrous)

If the phenyl ring of the benzylidene moiety is replaced by thiophene or furan, the photoreaction still proceed well (compounds **4**, **5** and **6**) with reasonable yields. If the *N,N*-dimethylacetamide is replaced by *N*-methyl-azepan-2-one (1.5 mL in 13.5 mL acetonitrile), the photoreaction with compound **1** afford 1-[2-(4-methoxy-phenyl)-2-phenylamino-ethyl-azepan-2-one **14** in 70% yield. Thus there is regioselective preference for the photoreaction at the *N*-methyl group rather than the secondary *N*-substituted alkyl group. This phenomena is pretty much the same as the observed regioselectivity for the photochemical addition reactions between trans-stilbene and *N,N*-diisopropyl- methylamine¹⁸.

As for the mechanism for this new type of photochemical addition of amide to imine which is catalyzed by protic acid is quite similar to Mariano's photochemical reactions involving iminium salt. For our photoreactions both the protic acid, and photons are essential. The reaction fails to proceed in the absence of both protic acid and photons. It is reasonable to propose that the mechanism is through electron transfer from the amides to the protonated imine excited state and results in the formation of amide radical cation and α -aminyl-benzyl radical (Scheme 3). The amide radical cations prepared by radiolysis is known to generate *N*-alkyl radical¹⁹ (**A** in Scheme 3).

Scheme 3



The recombination of the α -aminyl-benzyl radical (**B**) and *N*-methyl radical (**A**) afford the final product and one proton is also generated. The free energy difference (ΔG) calculated from the oxidation potential of the amide and reduction potential for the protonated imine (excited state) is quite negative (Rehm-Weller equation²⁰). Thus supports the involvement of the amide radical cation and α -aminyl-benzyl radical in the reaction mechanism.

Compound with strong electron withdrawing substituent at the benzylidene part (**7**) failed to afford any product is due to the decreased basicity of the imine or unstability of the protonated imine.

In summary, we have presented a new type of photochemical reaction between a series of benzylideneaniline compound and *N,N*-dimethylacetamide in the presence of catalytic protic acid. The yields of this addition product is quite satisfactory. The

mechanism is believed to involve amide radical cation and imine radical through photoexcited electron transfer. The reaction is in general applicable to other amides as well.

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