Tetrahedron Vol 33, pp 3155 to 3157 Pergamon Press 1977 Printed in Great Britain

MOLECULAR REARRANGEMENTS—XII

PYROLYSIS OF α-PHENYLACETANILIDE

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(*Received in UK* 9 *March* 1977; *Accepted for publication* 3 *June* 1977)

Abstract—Pyrolysis of α-phenylacetanilide resulted in migration of the benzyl group to the *o*- and *p*-positions of the aniline nucleus and formation of CO, NH_3, toluene, benzaldehyde, dibenzyl, *trans*-stilbene, aniline, 9-phenylacridine and 2,3-diphenyl-indole. With *o*-toluidine as a solvent, the previous products were accompanied by 2,3-diphenyl-7-methylindole and 4-amino-3-methyl diphenylmethane. With isoquinoline, 1-benzyl isoquinoline and 1,1'-bi-isoquinolyl were also obtained.

It is concluded that the pyrolysis of phenylacetanilide depends on the homolytic fission of the amide C–N bond into anilino and phenylacetyl free radicals followed by the interaction of the primary and secondary formed radicals with the rearrangement products and solvent nuclei.

The migration of acetyl, propionyl and benzoyl groups were observed[1] when N,N-diacylanilines were heated with $ZnCl_2$ or HCl gas. The migrating group enters *o*- or preferably *p*-position forming *o*- or *p*-aminoketones.[2,3] The process was assumed to involve electrophilic substitution by acylium ions[4] generated from catalyst-anilide complex.

The first observed non-catalysed rearrangement of N-acylanilines occurred when strongly heated, and traces of *o*- and *p*-aminoacetophenones were identified.[5]

A somewhat similar reaction is the photochemical rearrangement of anilides,[6] where the acyl-N bond undergoes rupture and the products are the *o*- and *p*-aminophenyl alkyl ketones. The rearrangements are probably intramolecular,[6] although partial transfer of the acyl group from acetanilide to a foreign molecule was also detected.[7]

Recently,[8] photolysis of benzanilide in ethanol was observed to produce the amino ketones and other products, suggesting a free radical intermolecular mechanism.

The present work describes the behaviour of α-phenylacetanilide on thermolysis in absence of promoters, either alone or in presence of aromatic solvents where their ring substitution was also observed.

Heating phenylacetanilide under reflux for 7 days leads to its pyrolysis into benzaldehyde, toluene, dibenzyl, *trans*-stilbene, aniline, *o*- and *p*-aminodiphenylmethane accompanied by evolution of carbon monoxide.

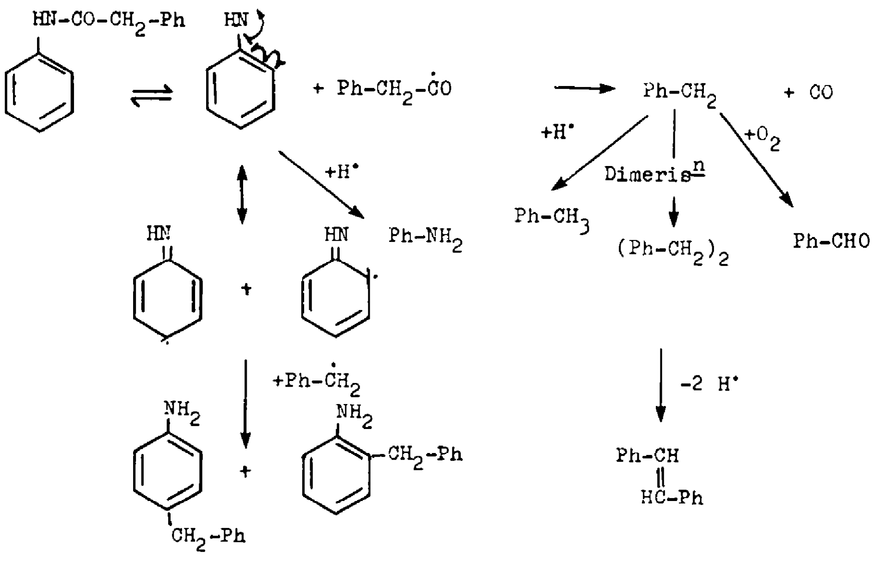
Heating in a sealed tube in nitrogen atmosphere gave the same products together with ammonia, 9-phenylacridine and 2,3-diphenylindole.

With *p*-toluidine as a solvent, the pyrolysis products were separated together with 2,3-diphenyl-7-methylindole and 4-amino-3-methyl diphenylmethane.

With isoquinoline, 1-benzyl isoquinoline and 1,1'-bi-isoquinolyl were obtained together with the normal pyrolytic products.

Formation of such products strongly suggests that pyrolysis of the anilide proceeds through the homolysis of the amide (C–N) linkage into anilino and phenylacetyl free radicals. The latter undergoes decarbonylation rather than dimerisation[9] forming carbon monoxide and the most stable benzyl radical. The anilino and benzyl radicals subsequently contribute[10] to the formation of the identified products.

The benzyl radical abstracts H forming toluene, suffers atmospheric oxidation to benzaldehyde,[11] dimerises into dibenzyl[10] or couples with the mesomeric anilino free radicals forming *o*-aminodiphenylmethane and its *p*-isomer as represented by Scheme 1.



Scheme 1.

9-Phenylacridine is reasonably assumed to be formed from 2-aminodiphenylmethane as shown in Scheme 2.

2,3-Diphenylindole is suggested to be formed through the addition of the anilino free radical on the olefinic double bond of stilbene,[12] followed by cyclisation and dehydrogenation as in Scheme 3.

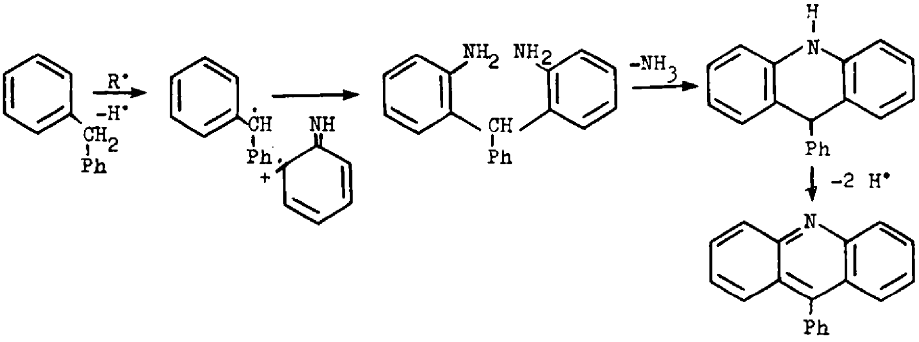
Formation of 2,3-diphenyl-7-methylindole on pyrolysis of the anilide in *o*-toluidine as a solvent can be reasonably suggested to take place through the intermediate formation of *o*-toluidino radical as observed previously[13] which adds to stilbene resulting in the final product (route c). On the other hand, formation of 4-amino-3-methyl-diphenylmethane in the same solvent is suggested to go partially through coupling of *o*-toluidino radical with benzyl radical (route *b*)in parallel with the expected direct benzylation of *o*-toluidine molecule (route a) Scheme 4.

The formation of 1-benzylisoquinoline and 1,1'-bi-isoquinolyl infers a free radical mechanism as indicated in previous work.[10]

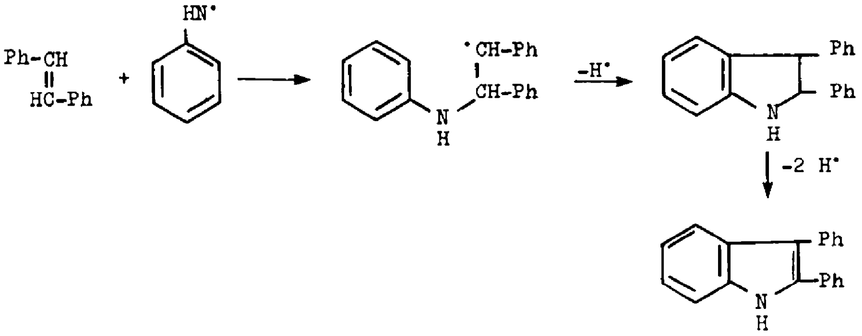
It is concluded that phenylacetanilide follows the same pyrolytic pathway as that suggested for alkyl-aryl ethers and alkyl-arylamines.[10]

EXPERIMENTAL

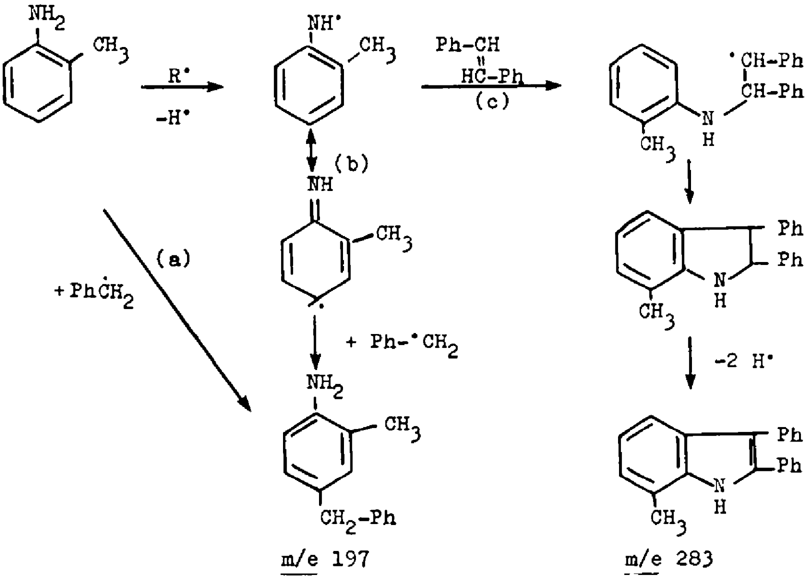
All m.ps recorded are uncorrected. The purity of the starting materials and the nature of the products was ascertained by tlc on silica gel (100–150 mesh) using butanol:water mixture (for



Scheme 2.



Scheme 3.



Scheme 4.

Table 1. Products of pyrolysis of α-phenylacetanilide

Experiment No.		1	2†	3†	4†
Solvent				*o*-Toluidine[a]	Isoquinoline[b]
Temperature		Reflux (280°)	310–315°	310–315°	310–315°
Amount of anilide used and consumed in g	B.P. (°C/Torr)	20–15	20–20	20–20	20–20
Products in g (%)					
Carbon monoxide		Evolved	Evolved	Evolved	Evolved
Ammonia[c]	—	—	Evolved	Evolved	Evolved
Benzaldehyde[d]	175–7/760	1.2(6)	—	—	—
Toluene[e]	110/760	4(20)	6(30)	6(30)	4(20)
Dibenzyl[f]	115–120/5	210)	2.5(12.5)	2.3(11.5)	2(10)
trans-Stilbene[h]	150/160/5	0.52(2)	0.3(1.5)	0.2(1.0)	0.2(1.0)
Aniline	184/760	7.3(36.0)	6(30)	5.7(2.85)	6.2(31.0)
o- and *p*-Aminodiphenylmethane[i]	165–175/5	1.3(6.5)	0.78(3.9)	0.65(3.25)	0.6(3.0)
9-Phenylacridine[j]	235–240/5	—	1.5(7.5)	1.3(6.5)	1.4(7.0)
2,3-Diphenylindole[k]	220–230/5	—	2.4(1.2)	2.3(1.15)	2.2(1.1)
Benzyl deriv. of solvent used	—	—	—	4.25(70.8)[l]	6.5(90.2)[m]
Non-volatile residue	—	2	3.2	4.1	6.3[n]

†In sealed tube, in nitrogen atmosphere.

[a] *o*-Toluidine; used 10 g, consumed 6 g.

[b] Iso-quinoline; used 10 g, consumed 7.2 g.

[c] Trapped as its hydrochloride.

[d] n_D^{20}: 1.5450, D.N.P. deriv. m.p. 236°.

[e] n_D^{20}: 1.4970, 2:4-dinitro deriv. mixed m.p. 72°.

[f] Mixed m.p. 52°, 4:4′-dinitro deriv. mixed m.p. 179–180°.

[h] Mixed m.p. 124°.

[i] Separated by column chromatography on silica gel (100–150 mesh) using benzene as eluent into *o*-isomer 0.2 g, N-acetyl deriv. mixed m.p. 135° and *p*-isomer 0.35 g, picrate mixed m.p. 179°.

[j] Mixed m.p. 182–3°.

[k] Present among the neutral products, mixed m.p. 123–4°.

[l] Calc. on basis of solvent consumed, 4-amino-3-methyl diphenylmethane 3.5 g, b.p. 160–6°/5 Torr., mixed m.p. 63°, picrate mixed m.p. 181–2° in addition to 2:3-diphenyl-7-methylindole 0.75 g, b.p. 210–5°/5 Torr. mixed m.p. 129–130°.

[m] Calc. on basis of solvent consumed, 1-benzylisoquinoline b.p. 155–160°/5 Torr., mixed m.p. 54–56°, picrate mixed m.p. 181–2°.

[n] On trituration with petroleum ether (40–60°) gave 1:1′-bi-isoquinolyl 1.2 g mixed m.p. 162–3°; micrate mixed m.p. 206–7.

amines), benzene : petroleum ether (60–80°) as eluents (for neutral components) or by glc on a Pye-Unicam gas chromatograph, Series 104, with a dual flame ionisation detector, temperature programmed, Model 24. The column used was 20% SE 30 on Chromosorb W (35–80 mesh). Molecular weight determination of some reaction products was carried out by Mass Spectrophotometer, Model A.E.I.M.S. 902.

General procedure. α-Phenylacetanilide (20 g) was pyrolysed by reflux or heating in a sealed tube under N_2 at about 310° for 7 days either alone or in presence of *o*-toluidine or isoquinoline as solvents. The CO formed was detected by platinum chloride test paper and absorbed in a trap containing ammoniacal cuprous chloride. The products were separated as indicated in previous work[10] and identified by tlc, glc or mixed m.p. with authentic samples and their derivatives whenever possible as summarised in Table 1.

Preparation of reference compounds. *o*-Aminodiphenylmethane:[14] m.p. 52°; N-acetyl deriv. m.p. 135°. *p*-Aminodiphenylmethane:[15] m.p. 34–5°; picrate m.p. 179°. 4-Amino-3-methyldiphenylmethane:[3d] m.p. 63°; picrate m.p. 181–2°. 2,3-Diphenylindole:[16] m.p. 123–4°. 9-Phenylacridine:[17] m.p. 182–3°. 2,3-Diphenyl-7-methylindole:[18] m.p. 128–9°. 1-Benzylisoquinoline:[19] m.p. 56°; picrate m.p. 207°. 1,1′-Bi-isoquinolyl:[20] m.p. 162–3°; picrate m.p. 207°.

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