

migration of the phenyl, *p*-tolyl and anisyl groups occurs practically exclusively.

ANN ARBOR, MICHIGAN

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

THE INTERACTION OF AMIDES WITH ANILINE

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Very little information is to be found in the literature regarding the interaction of amides with aniline. To study this question, two methods were chosen: (1) to leave the amides in contact with aniline for varying periods at several temperatures, and (2) to conduct the amide vapors through a hot tube, discharging them into cold aniline.

Except for a catalytic transformation of acetamide into methylamine (or $\text{HCN} + \text{H}_2$) and carbon monoxide using nickel¹ at 400° , the only recorded course of pyrolysis of acetamide is the one into acetonitrile² and water. In our high temperature experiments there was the possibility of deammonation into ketene. With acetamide the equation would be $\text{CH}_3\text{CONH}_2 \rightarrow \text{CH}_2\text{CO} + \text{NH}_3$. If so, the acetanilide might originate either from acetamide or ketene.

Actually, aniline was found to be quite non-reactive at 100° with such amides as acetamide, propionamide or isobutyramide. In fact, a mixture of the amide and aniline could be distilled (to 240°) without giving rise to anilide in the residue. Continued refluxing, however, was found to generate small yields of anilide, the best yields coming from propionamide. It was found that isobutyramide was exceedingly sluggish.

When the amides were passed through a tube which was maintained at 500 – 700° , some pyrolysis undoubtedly occurred because of nitrile formation. By passing the hot, effluent gases directly into cold aniline, fairly good yields of propionanilide or acetanilide, but no isobutyranilide, were obtained. The data for a few representative runs out of seventy-five which were performed are collected in Table I. The percentage yield of anilide is based on the amide which was not recovered. Examination of the data shows the best yields of acetanilide and propionanilide at tube temperatures of about 500° and contact times of but a few seconds. As high as 45–49% yields of propionanilide resulted, as compared with a 28% yield of acetanilide and no yield of isobutyranilide. Somewhat higher yields of acetanilide were obtained on a few occasions, but the selected runs seem more characteristic.

¹ Mailhe, *Mat. grasses*, 15, 6488, 6531 (1923); *Bull. soc. chim.*, 37, 1394 (1925).

² Boehner and Andrews, *THIS JOURNAL*, 38, 2503 (1916); Boehner and Ward, *ibid.*, p. 2505.

Whether or not ketene and methyl ketene were pyrolytic products cannot be answered. If they were, they never persisted in the gases when a condenser (to remove amide, etc.) was inserted between the hot tube and the cold aniline. To establish whether or not an amide as such could react with aniline, benzamide was passed through the hot tube and thence into cold aniline. In this case there exists no possibility of deammonation into a ketene, yet a 33% yield of benzanilide was obtained. While this does not eliminate the possibility of ketenes as intermediates in the case of acetamide and propionamide, certainly they are not essential intermediates for anilide formation.

Experimental Part

Liquid Phase Experiments.—When 15 cc. of aniline was left for four hours with 5 g. of either acetamide, propionamide or isobutyramide³ and then distilled at 20 mm. until the aniline and amide were removed, no residue of the anilide remained. Heating

TABLE I
DATA FOR HOT TUBE REACTIONS OF AMIDES

Temp., ±5°C.	Amide, g. Taken, Recov.		Inner diam. tube, cm.	Dura- tion, min.	Hot contact time, sec.	Nitrile, g. %		Water, g.	Anilide, g. %	
Acetamide										
505	50	33	2.2	20	3.4	6.3	53.5	..	10.6	27.2
510	50	24.5	1.6	17	2.5	9.5	51.6	4.0	17	28.1
505	50	12.1	1.6	62	8.8	15.7	59.6	9.3	25	28.8
550	50	9.8	1.6	33	4.5	20	71.6	11.6	18	19.5
600	50	14.5	1.6	16	1.8	20.5	83.3	9.3	8.5	10.4
650	50	3.0	1.6	23	3.2	27.6	84.5	14.8	2.8	2.6
710	50	0.0	1.6	16	1.8	24.2	69.8	13.1	7.5	6.6
710	50	0.0	1.6	21	2.4	24.5	70.6	13.3	1.5	1.3
Propionamide										
505	40	17.5	1.1	12	0.9	2.5	14.8	1.0	22.5	49.1
500	75	35.5	1.6	20	2.5	5.5	18.5	2.5	36.5	45.3
500	40	16.0	1.6	8	1.8	3.0	16.6	1.0	24.0	49.0
530	50	32.5	2.2	25	5.1	7.0	53.1	4.2	10.0	28.2
545	40	18.0	1.1	10	0.7	5.5	33.2	2.0	20.5	45.6
560	50	22	2.2	15	2.9	12.0	57.0	5.1	14.0	24.5
645	50	5	2.2	90	16.0	12.5	36.9	11.0	2.5	2.7
Isobutyramide										
510	50	47.8	1.6	20	4.2	Trace		Trace	Nil	0.0
650	50	12.5	1.6	20	3.6	20.0	67.5	8.0	Trace	0.0
Benzamide										
500	50	6.2	1.6	16	5.1	22.1	59.2	..	23.5	33

³ By stirring a mixture of ethyl isobutyrate (250 g.) and concd. ammonium hydroxide (1 liter), an 80% yield of isobutyramide resulted in fifty days, whereas the yield was negligible in five days.

the mixtures for an hour at 100° prior to distillation gave no acetanilide or isobutyranilide but yielded a minute quantity of propionanilide. Reaction was produced by refluxing. When equal weights (20 g. each) of aniline and the three amides (three separate experiments) were refluxed for forty minutes, ammonia was evolved. Distillation at atmospheric pressure to 240° revealed a 13.7% yield of acetanilide, a 17% yield of propionanilide and a 5% yield of isobutyranilide: $RCONH_2 + C_6H_5NH_2 \longrightarrow RCONHC_6H_5 + NH_3$.

Reaction of Cold Aniline with Hot Amide Vapors.—Each amide was distilled in turn into a quartz or Pyrex combustion tube, packed with porcelain chips, which was heated by an electric furnace. A slow stream of nitrogen was blown through the system to maintain a uniform flow of the vapors. Experiments were performed at temperatures varying from 400 to 800°, the temperature being measured by a thermocouple placed inside of the tube. The thermocouple wires were encased in a sealed-off piece of Pyrex tubing. The vapors passed from the hot tube into a flask containing an excess of ice-cold aniline. Any carbon which formed was burned from the tube at the end of each run.

Distillation methods were used in working up the contents of the aniline solution. The nitrile and water were taken off below 105°. Aniline was then collected to 200° and the original amide between 200–240°. For the most part, the residue was the anilide, which was recrystallized from water.

The details of seventeen out of seventy-five experiments have been collected in Table I. Less than a liter of gases, collected over water, was formed in the 500° experiments. At 800°, the volume was 5 to 6 liters. Carbon monoxide was present, together with lesser amounts of carbon dioxide and methane.

Summary

Amides do not react with aniline at room temperature or at 100° but refluxing for an extended period gives rise to small yields of anilides. Amide vapors issuing from hot tubes were found to react with cold aniline to give fair yields of anilides. These results were obtained with acetamide, propionamide and benzamide, but isobutyramide gave almost negligible yields in all cases. The possibility of ketene formation from amides was discussed.

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