

CONDENSATION OF MALONANILIC ACID WITH AROMATIC ALDEHYDES.

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AHLUWALIA, HAQ AND RAY¹ have carried out condensations of certain aromatic aldehydes with malonanilic acid and its derivatives in pyridine-piperidine solution. The method is essentially the widely-used method of Robinson and Shinoda.² The aldehyde and the acid are in molecular proportions, while about 3.5 mols. of pyridine are taken with a few drops of piperidine.

In studying the condensations of aromatic aldehydes with malonic acid, one of the authors (P.) had occasions to make a comparative study of this method with that of using a trace only of a single base like pyridine or piperidine.³ We have, therefore, extended our study to the condensation, by both the methods, of malonanilic acid with several aromatic aldehydes. We find that as a rule the condensations take place equally well when a trace of a single base is used; in this case we have used only pyridine and piperidine. Not only so, but the condensation-products are formed in greater yields by our method.

Three of the aldehydes selected by us are those which Ahluwalia, Haq and Ray have also used, *viz.*, piperonal, salicylaldehyde and *o*-nitrobenzaldehyde. In addition, five more aldehydes have been condensed with malonanilic acid, *viz.*, benzaldehyde, *m*-hydroxybenzaldehyde, *p*-hydroxybenzaldehyde, *m*-nitrobenzaldehyde and *p*-nitrobenzaldehyde, all of which condense readily with malonanilic acid by both the methods and give decidedly higher yields with the trace-method. Excepting in the case of the last two aldehydes, Ahluwalia, Haq and Ray's method also has been applied to each case, in order to make a fair comparison and in order also to obtain figures of the yields not available in the paper of these authors. Even when the figures are available there, the yields and the products obtained by us are not always identical with those reported by these authors.

These differences are indicated in the experimental account. The main difference lies in the nature of the products obtained in the condensation of *o*-nitrobenzaldehyde. Ahluwalia, Haq and Ray obtain *o*-nitrobenzylidenemalonanilic acid "in good yield," with "very little of the decarboxylated

product in the reaction at 100°." Our general experience of a higher temperature, in this case 100° in place of 50–60° originally employed, would lead us to expect greater decarboxylation, and in this particular case, when the experiment was repeated, we got only the decarboxylated anilide and no acid. The anilide happened to be in two forms, one white and the other pale yellow, which could be separated and which gave each different melting-points, the white melting at 172° and the yellow at 188–90°. As the expected acid has also the same melting-point, 172°, as one of these, [(¹), p. 2061], it was at first taken to be the *o*-nitrobenzylidenemalonanilic acid. But it did not react at all with sodium carbonate solution, and the determinations of its nitrogen, carbon and hydrogen contents clearly established it as the *o*-nitrocinnamanilide. The yellow substance also behaved exactly alike with sodium carbonate solution and gave almost identical figures for the carbon, hydrogen and the nitrogen contents. There is thus no doubt that none of them is the acid, and that both have the same composition of the anilide. During the time these points were settled, it was observed that the white was very unstable to light and gradually, though quickly in the beginning, changed over into the pale yellow. Starting with the white, m.p. 172°, in diffused light, a distinct colour had developed and the melting-point was lowered to 161° in one week, to 159° in ten days and remained there for two weeks more. During this period, the mixed anilide could at any time be resolved, by means of suitable solvents, into the white and the yellow.

It is hoped to study this more closely with a view to understand clearly the structure-relationship of the two and to ascertain whether the change is isomerisation or polymerisation.

It may be noted that the yields obtained with the *m*- and the *p*-, hydroxy-and-nitro-benzaldehydes were greater than those obtained with the corresponding *o*-isomers.

p-Tolylaldehyde has also been condensed and gave about 71% yield of the cinnamanilide. It has, however, not been reported under the experimental, as sufficient sample was not available for purification and full analysis.

EXPERIMENTAL.

Malonanilic acid was prepared according to the method of Chattaway and Olmsted⁴ as modified by Ahluwalia, Haq and Ray.¹

Condensation of malonanilic acid with piperonal.—

(i) *With pyridine-piperidine mixture.*—Ahluwalia, Haq and Ray's experiment was exactly repeated. We obtained only piperonylidene-malonanilic acid (1 g., yield = 32%), m.p. 202–03°, pale yellow needles. Ray

and co-workers report only 0.5 g. of this acid, but they obtained 1.3 g. of 3 : 4-methylenedioxcinnamanilide, which was not obtained by us. The non-acid fraction which we obtained was a brown oil, which solidified on keeping in a freezing mixture and was the unchanged piperonal (0.5 g.).

The same experiment was repeated in two different ways. In the one case, the reactants were in the same proportions but they were heated to a slightly higher temperature, 60–70°, and for 2 hours instead of one: the acid came out in the same amount, 1 g., but 0.1 g. of the cinnamanilide was also obtained (yield = 3.7%), m.p. 157°.

In the other case, the proportions of the two bases were changed, and 1.5 g. piperonal, 1.8 g. malonanilic acid, 3 c.c. of pyridine (instead of 4) and 2 drops of piperidine (instead of 4) were heated at 50–60° for one hour. The usual treatment gave 0.2 g. of the anilide (yield = 7.4%) and 1.0 g. of the acid.

(ii) *With a trace of one base only.*—The same amounts of the aldehyde and the acid were now taken with a trace of pyridine, the three being in 1 : 1 : 0.15 mol. proportions. The mixture was heated for five hours at 55–60°, and then one hour more at 60–65°. Some piperonal was still recovered unchanged (about 0.2 g.), no cinnamanilide was formed, and the piperonylidenemalonanilic acid was obtained, 1.1 g. (yield = 41%).

In the next experiment, the temperature was raised: the same quantities of the two were heated with piperidine on the water-bath for one hour only. The non-acid portion was wholly piperonal, about 0.7 g. and the acid was also about 0.7 g. Calculating on the 1.5 g. of piperonal taken, the yield would be about 26% only, but calculating on the piperonal actually used up, the yield would be about twice as much, or about 50%.

In the next two experiments, the same amounts of the aldehyde and of the acid were set up on the water-bath with 0.15 mol. of pyridine and of piperidine respectively. The heating was continued for four hours. The effect of this longer heating was to increase the yield: the pyridine-containing flask gave only 0.2 g. of the acid (yield 6.5%) and 1.2 g. of the decarboxylated anilide (yield = 45%), and the piperidine-containing mixture gave 0.1 g. of the acid and 1.5 g. of the cinnamanilide (yield = 3.7% and 56.2%, *i.e.*, total 60% nearly). Some piperonal was still recovered unchanged. Ahluwalia, Haq and Ray found this anilide—"when kept or exposed to light, undergoes a change, possibly partial transformation into the geometric isimeride or an allo-form, which affects its m.p." We have been unable to confirm this, as a crude specimen, kept in an ordinary specimen-tube, examined after several months, retained its melting-point.

It is probable that the admixture of the unused piperonal is responsible for this reported change in the melting-point.

Condensation with salicylaldehyde.—

(i) *With pyridine-piperidine mixture.*—A., H. and R.'s experiment was repeated and 0.5 g. of yellow needles of coumarin-3-carboxyanilide was obtained, m.p. 247°. A., H. and R. do not state their yield: our yield was 18.9 % only.

The same experiment was repeated, but the mixture was heated, not on a water-bath but in an oil-bath at 100–04° for 4 hours, instead of one hour only. The yield increased to 0.8 g. or to 30.2 %.

(ii) *With only one base.*—The same amounts of the malonanilic acid and salicylaldehyde were heated with only 0.15 mol. of pyridine, at 100–104° for four hours. The yield was the same, viz., 0.8 g. Repeating with the same but at a higher temperature still, 110–12°, the yield did not improve and remained stationary.

With piperidine, however (1 : 1 : 0.15 mol.), at 100–04° for four hours, the yield increased to 1.0 g., i.e., to 37.8 %.

Condensation with *m*-hydroxybenzaldehyde.—

(i) *With pyridine-piperidine mixture.*—Malonanilic acid 1.8 g., *m*-hydroxybenzaldehyde 1.3 g. and a mixture of 3 c.c. of pyridine and 2 drops of piperidine were heated on the water-bath for one hour. On working up the product *m*-hydroxycinnamanilide was obtained, which recrystallised from aqueous alcohol, came out in brown silky needles, melting at 155–56°. Yield 1.6 g. or about 67 %.

(ii) *With any one base.*—The same amounts of the acid and of the aldehyde with a trace of pyridine were heated on the water-bath for five hours. The orange-coloured solid mass was dissolved in 10% aqueous sodium hydroxide, and dilute hydrochloric acid was added to precipitate the anilide. It was purified as before: yield 1.8 g. or 75.5 %.

The same experiment was repeated with a trace of piperidine and gave under the same conditions 1.9 g. or 79.6 % of the anilide.

The *m*-hydroxycinnamanilide gave a green colour with ferric chloride solution and gave a green fluorescence in NaOH solution. (Found: N = 5.7, 5.9 %; C = 75.3 %; H = 5.6 %. $C_{15}H_{13}O_2N$ requires N = 5.8 %; C = 75.3 %; H = 5.4 %.)

Condensation with *p*-hydroxybenzaldehyde.—

(i) *With pyridine-piperidine mixture.*—By repeating the above experiment with the *p*-aldehyde, 1.5 g. (62.7 %) of the *p*-hydroxycinnamanilide,

m.p. 208°, was obtained as pale yellow needles from dilute alcohol. It also gave a green colour with alcoholic ferric chloride.

(ii) *With a trace of one base.*—With pyridine and piperidine respectively in traces, on the water-bath for five hours, the yields were respectively 1.8 g. and 1.9 g., *i.e.*, 75.3 % and 79.6 %. (Found: N = 6.2, 5.87 %; C = 75.4 %; H = 5.39 %. $C_{15}H_{13}O_2N$ requires N = 5.8 %; C = 75.3 %; H = 5.4 %.)

Condensation with benzaldehyde.—

(i) *With pyridine-piperidine mixture.*—1.8 g. malonanilic acid, 1.1 g. benzaldehyde, 3 c.c. pyridine, and 2 drops of piperidine, heated on the water-bath for one hour, and worked up in the usual way, gave 1.8 g. cinnamanilide (80.7 %), in small silky white needles, m.p. 149–50°.

(ii) *With a trace of one base—i.e.*, with 0.15 mol. of pyridine and of piperidine respectively, on the water-bath with 4 hours' heating, the yields were 1.9 g. and 2 g. (= 85.2% and about 89.7 %).

On analysis cinnamanilide gave: N = 6.4, 6.3 %; C = 80.99 %; H = 6.2 %. $C_{15}H_{13}ON$ requires N = 6.28 %; C = 80.7 %; H = 5.8 %.

Condensation with *o*-nitrobenzaldehyde.—

(i) *With pyridine-piperidine mixture.*—On heating on the water-bath for one hour a mixture of 1.8 g. malonanilic acid, 1.5 g. *o*-nitrobenzaldehyde, 3 c.c. pyridine and 2 drops of piperidine (according to A., H. and R.'s method) and treating as usual, a pale yellow solid separated, which did not dissolve in sodium carbonate solution and which was later on separable (by repeated fractional crystallisations, with alcohol, acetone and benzene respectively), into two substances, one pale yellow, melting at 190°, and the other white, melting at 172°. The sodium carbonate extract on acidification gave nothing, indicating that no *o*-nitrobenzylidenemalonanilic acid was formed (contrast A., H. and R.). Both came out as small needles, the white was slightly more soluble in alcohol, while the yellow was slightly more soluble in benzene. The white was very unstable in ordinary light and gradually assumed a pale yellow tint and changed in melting-point. An observation of several weeks showed that this photochemical change continued for a long time though there was no evidence of a complete transformation of all the white into the yellow. Analysis showed that both had the same percentage composition, *viz.*, that of the anilide. (The white gave: C = 67.63, 67.20 %; H = 4.72, 4.52 %; N = 10.4, 10.62 %; $C_{15}H_{12}O_3N_2$ requires C = 67.15 %; H = 4.47 %; N = 10.45 %. The yellow gave: C = 67.23 %; H = 4.53 %; N = 10.37, 10.29 %; which also conform to the requirements of the same

formula.) The total yield was 1.1 g. which, assuming that the two forms were isomeric, would give 41 %. (A., H. and R. do not state the yield of their "acid", though they say it was "good," and the decarboxylated product was "very little".)

The same experiment was repeated with the difference that the heating was conducted at 100–04° for one hour. On cooling, as no solid was observable, the heating was continued for two more hours, and then finished by ten minutes' heating on a wire-gauze. The mass had a dark chocolate colour and some solid had separated. The resulting products were the same and the yield also was the same, 1.1 g.

(ii) *With a trace of a single base.*—Two experiments with a trace of pyridine in one and a trace of piperidine in the other (1:1:0.15 mol.) were then set up. The pyridine-containing flask, heated at 100–04° for 45 minutes gave a mixture of the two anilides, total weight 1.2 g. or 44.8 % yield.

The piperidine-containing flask was heated at 110–14° for one hour and a quarter, and gave 1.9 g. of mostly the yellow form. (Yield 70.9 %.)

Condensation with *m*-nitrobenzaldehyde.—

Two condensations were set up, one with a trace of pyridine and the other with that of piperidine (1:1:0.15). As the condensation appeared to go well on the water-bath, a higher temperature was not used and the heating was continued only for 75 minutes. The product from both was *m*-nitrocinnamanilide, yellow silky needles (from acetone or alcohol), melting at 194–95°. Yield 1.4 g. (52 %) from the first and 1.8 g. (67 %) from the other. (Found: C = 67.7 %, H = 4.7 %; N = 10.43 %. $C_{15}H_{12}O_3N_2$ requires C = 67.15 %; H = 4.47 %; N = 10.45 %.)

Condensation with *p*-nitrobenzaldehyde.—

p-Nitrobenzaldehyde gave in the same way *p*-nitrocinnamanilide, pale yellow needles, m.p. 208°. Yield, with pyridine, 2 g., 74.6 %; with piperidine, 1.9 g., 70.9 %. (Found: C = 67.4 %; H = 4.42 %; N = 10.5, 10.7 %. $C_{15}H_{12}O_3N_2$ requires C = 67.15 %; H = 4.47 %; N = 10.45 %.)

In the table given below, the figures given under I are the highest yields obtained by us (not by Ahluwalia, Haq and Ray) by using the mixture method. Under II, the figures are the highest yields obtained by the trace-method, *i.e.*, with a trace of either pyridine in some case, or with that of piperidine in the others.

TABLE.

Aldehyde	I per cent.	II per cent.
Piperonal	Acid 32 Anilide 7.4	Acid 3.7 Anilide 56.2
Salicylaldehyde	Acid 0.0 Anilide 30.2	Acid 0.0 Anilide 37.8
<i>m</i> -OH Benzaldehyde	„ 67	„ 79.6
<i>p</i> -OH „	„ 62.7	„ 79.6
Benzaldehyde	„ 80.7	„ 89.2
<i>o</i> -NO ₂ Benzaldehyde	„ 41.0	„ 70.9
<i>m</i> -NO ₂ „	Not tried	„ 67.0
<i>p</i> -NO ₂ „	„	„ 74.6
<i>p</i> -Tolylaldehyde	„	„ 71.0

SUMMARY.

1. Malonanilic acid has been condensed with several aromatic aldehydes and a comparative study is made of the yields obtained by (i) the method of using pyridine in large excess together with a trace of piperidine and (ii) the method of using only a trace of either of the two.

2. The yields obtained by applying method (i) as Ahluwalia, Haq and Ray have done, are increased further by some modifications adopted in his paper. But even the highest yields so obtained, are lower than those obtained by the application of method (ii).

3. Incidentally, therefore, the utility of method (ii), observed in condensations of aldehydes with malonic acid, is thus extended further.

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