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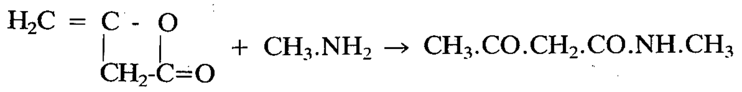
(54) MANUFACTURE OF ACETOACETAMIDES

(71) We, WACKER-CHEMIE GMBH, a body corporate organised according to the laws of the Federal Republic of Germany, of 8 München 22, Prinzregentenstrasse 22, Federal Republic of Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to a process for the continuous manufacture of N-alkylacetoacetamides and N,N-dialkylacetoacetamides.

An N-alkylacetoacetamide or an N,N-dialkylacetoacetamide may be manufactured by the reaction of a primary or secondary alkyl amine, respectively, with an equivalent amount of diketene, for example according to the equation



diketene + methylamine → N-methylacetoacetamide

This reaction is generally carried out in the presence of an inert organic solvent or water, but this necessitates an additional process step for the removal of the solvent, which can also lead to a loss in the yield of the desired product. Attempts have therefore been made to carry out the reaction in the absence of solvents but this has generally resulted in the formation of increased amounts of undesired by-products, which again have to be removed with a resultant loss in yield.

It is suggested in German Patentschrift No. 1 142 859 that the above-mentioned disadvantages can be met, and that the desired products can be obtained in an almost quantitative yield and in an industrially useful purity, by carrying out the reaction at a temperature not exceeding 80°C and using the reaction product as the reaction medium. These claims are not entirely verified by the worked examples given in the specification since only the yield or the quality of the product is given in each case and, moreover, all the examples use reaction temperatures not exceeding 60°C and use primary amines having at least 6 carbon atoms. Methylamine, which is especially reactive with diketene, is mentioned in a general manner but is used in none of the examples.

It is implicit from their absence from the worked examples of the said Patentschrift that the reaction of lower-alkylamines - and, indeed, even of secondary lower-alkylamines - with diketene can be controlled only with difficulty, and this is confirmed by Swiss Patent Specifications Nos. 421 932 and 532 223, which describe the use of complicated electrochemical potential measurements, in conjunction with the use of excess amine and an inert solvent (for example an alkyl acetate or the reaction product), for the reaction of dimethylamine or diethylamine with diketene.

The present invention provides a process for the continuous manufacture of an acetoacetamide of the general formula

$$CH_3.CO.CH_2.CO.NR^1R^2$$

in which R^1 denotes an alkyl radical having not more than 18 carbon atoms and R^2 denotes a hydrogen atom or an alkyl radical having not more than 18 carbon atoms, which comprises causing diketene to react in a continuous process with an amine of the general formula

$$HNR^1R^2$$

in which R^1 and R^2 are defined as above, for a dwell time not exceeding 15 minutes and at a temperature of not less than 60°C under atmospheric pressure, the amount of diketene used being within the range of from the stoichiometric amount to an excess of 2% above the stoichiometric amount.

It has been found that, by means of this process, acetoacetamides can be manufactured, with a satisfactory yield and purity, by the reaction of diketene with primary or secondary alkylamines, without the use of a solvent or diluent and without the need for a complicated electrochemical potential measurement.

The alkyl radicals denoted by R^1 and R^2 may be identical to or different from one another, and each may be a straight-chain or branched-chain alkyl radical. Each alkyl radical advantageously has not more than 8 carbon atoms and preferably not more than 4 carbon atoms. The symbol R^1 preferably denotes a methyl radical and the symbol R^2 preferably denotes a hydrogen atom or a methyl radical.

Examples of primary amines that may be used in the present process are methylamine, ethylamine, n-propylamine, isopropylamine, n-butylamine, isobutylamine, n-pentylamine, n-hexylamine, n-heptylamine, 1,4-dimethylpentylamine, n-octylamine, 2-ethylhexylamine, n-dodecylamine and n-tridecylamine. Examples of secondary amines that may be used are dimethylamine, diethylamine, di-n-propylamine, diisopropylamine, N-n-propyl-N-isobutylamine, di-n-butylamine, di-n-pentylamine, di-n-hexylamine, di-n-heptylamine, di-n-octylamine, bis-2-ethylhexylamine, di-n-nonylamine, di-n-decylamine, di-n-dodecylamine, N-ethyl-N-isopropylamine, N-ethyl-N-n-butylamine and N-methyl-N-isobutylamine.

Methylamine or dimethylamine is preferably used as the amine.

The reactants, that is the amine and the diketene, are preferably used in a pure form, for example in freshly distilled form.

The reaction is preferably effected for a dwell time within the range of from 2 to 10 mins, and preferably at a temperature within the range of from 80 to 150°C. The dwell time for the reaction is determined by the volume of the vessel or other apparatus in which the reaction is carried out and by the throughput of the reactants, by which is meant the volume of reactants passed through the vessel or other apparatus per unit time. The use of a relatively short dwell time of not more than 15 min and a relatively high reaction temperature of at least 60°C is important to the present process. The removal of the reaction product from the reaction system after only a short dwell time assists in preventing the accumulation of reaction product and of heat (the reaction being exothermic), both of which could disrupt the reaction and affect its selectivity.

It has been found that the selectivity of the reaction as regards the desired acetoacetamide increases with decreasing dwell time and with increasing reaction temperature. This was particularly surprising since, when using very reactive starting materials which can form numerous by-products, it is generally expected that a decrease in the reaction time and an increase in the reaction temperature will result in a decreased selectivity.

The optimum dwell time and reaction temperature, with the above ranges, for any particular amine will, however, depend on the reactivity of the amine but can easily be determined by means of simple experiments.

It has also been found advantageous to use a slight excess of diketene, that is up to 2% above the stoichiometric amount, since this helps to prevent the premature reaction of unreacted amine with the reaction product and thus helps to increase the selectivity of the reaction, especially when using primary amines. The diketene is advantageously used in an excess of from 0.1 to 2%, preferably from 0.1 to 0.5%, above the stoichiometric amount.

The process of the invention is advantageously carried out in a reaction cycle, that is to say that the reactants are fed into and pumped around a circulatory system and the reaction product is withdrawn from the said system. A reaction cycle suitable for carrying out the process of the invention is shown diagrammatically in the accompanying drawing.

The reaction cycle 1 includes a pump 2, a pressure-equalising vessel 3 and a heat-exchanger 4. It is provided with inlet pipes 5, 6 and with an outlet pipe 7. Additionally, the pressure-equalising vessel 3 is provided with a ventilation pipe 8 which includes a condenser 9.

The process may suitably be carried out by continuously feeding the amine into the reaction cycle 1 through the inlet pipe 5 and continuously feeding diketene into the reaction cycle 1 through the inlet pipe 6, circulating the reaction mixture around the reaction cycle 1 by means of the pump 2 while passing water at, for example, about 15°C through the heat-exchanger 4 in order that the temperature of the reaction mixture is maintained at at least 60°C, and preferably at from 80 to 150°C, and continuously withdrawing reaction mixture through the outlet pipe 7, with cooling if necessary, while so controlling the throughput of the reactants that the average dwell time of the reactants in the reaction cycle is not more than 15 min and is preferably from 2 to 10 min. The amount of reactants circulated around the reaction cycle 1 per hour may be from 50 to 500 times the amount of reactants fed into the reaction cycle 1 per hour depending on the particular amine used.

The process according to the invention has the advantage that it enables a high space/time yield to be achieved with a low expenditure on apparatus, which is important for the economic viability of the process. Moreover, by means of this process, secondary lower-alkylamines may be converted into the corresponding N,N-dialkylacetoacetamides with practically the same selectivity as that achieved in known processes, but with considerably lower industrial expenditure; and primary lower-alkylamines may be converted into the corresponding N-alkylacetoacetamides with a purity of up to 96 %. This is particularly important with regard to the manufacture of N-methylacetoacetamide, which may be further purified by simple means, such as thin-layer distillation in a falling-film evaporator or thin-layer evaporator, to give a high-purity storage-stable product. Such distillation is only possible when the mixture to be distilled already contains a high proportion of N-methylacetoacetamide (as is the case with the product of the process of the invention) because with lower-purity mixtures (for example 86 %) azeotropic mixtures form during distillation thus rendering further purification difficult.

The N-alkylacetoacetamides and N,N-dialkylacetoacetamides manufactured according to the present process are useful as intermediates in the manufacture of dyestuffs. They are also useful for conversion to the corresponding halogen compounds, which may then be used in the manufacture of organic phosphoric acid derivatives for use as plant protective agents. The purity of the acetoacetamides is particularly important in the latter case since impurities here can be removed only with great difficulty and, moreover, can promote the formation of toxic by-products which both impair the desired action of the plant protective agents and cause pollution of the environment.

The following examples illustrate the process of the invention. The relationship between parts by volume and parts by weight is as that between millilitres and grams.

Example 1

The apparatus used was that shown in the accompanying drawing. The reaction cycle 1 had a total volume of 1.7 parts by volume, and the circulation rate was 200 parts by volume of the reaction mixture per hour.

Liquid methylamine (almost 100% purity) was continuously fed into the reaction cycle 1 through the inlet pipe 5 at a rate of 10.2 parts by volume (6.724 parts by weight) per hour; and freshly distilled diketene (about 99% purity) was continuously fed into the reaction cycle 1 through the inlet pipe 6 at a rate of 16.79 parts by volume (18.422 parts by weight) per hour. The operation of the heat-exchanger 4 was so controlled that the reaction temperature was maintained at 82°C. The withdrawal of reaction mixture through the outlet pipe (siphon) 7 was controlled at a rate of 23.18 parts by volume (25.146 parts by weight) per hour, such that the average dwell time was 4.4 minutes. On cooling, the reaction product solidified to form yellow-tinged crystalline needles, having a melting point of 50°C. The product was analysed and found to contain 95% by weight of N-methylacetoacetamide, corresponding to a yield of 95.8%. Distillation of the product at 2 torr in a thin-layer evaporator gave a colourless distillate at 104°C, which was found to consist of 99.3% by weight of N-methylacetoacetamide.

The above procedure was repeated using different dwell times and reaction temperatures. The reaction conditions and the results obtained are summarised in Table 1, from which it can be seen that the yield and purity decrease with decreasing temperature and increasing dwell time. (The experiments marked with an asterisk are not according to the invention but are included for comparison purposes.)

TABLE 1

Reaction temperature (°C)	Dwell time (min)	Product purity (weight %)	Yield (%)
82	4.4	95	95.8
70	10	87.4	86.6
60	30*	80.1	79.4
40 *	60 *	66.2	63.5
30 *	60 *	65.4	62.0
20 *	120 *	55.8	55.8

Example 2

The apparatus used was that shown in the accompanying drawing except that the inlet pipes 5, 6 both entered the reaction cycle 1 at the same point immediately upstream of the heat exchanger 4. The circulation rate of the reaction mixture was 400 parts by volume per hour and the total volume of the reaction cycle 1 was 1.7 parts by volume.

12.32 parts by volume (8.145 parts by weight) of liquid dimethylamine (almost 100% purity) and 13.99 parts by volume (15.353 parts by weight) of freshly distilled diketene (about 99% purity) were fed into the reaction cycle 1 per hour, and 22.66 parts by volume (23.498 parts by weight) of reaction mixture were removed per hour, giving an average dwell time of 4.5 minutes. The reaction temperature was 85°C. The product obtained boiled at 100°C/5 torr and had a purity of 98.7% by weight, corresponding to a yield of N-methyl-acetoacetamide of 99.4%.

Examples 3 to 9

Various experiments were carried out analogously to Example 1 using the amines and reaction conditions listed in Table 2, which also summarises the results obtained.

TABLE 2

Example	Reaction temperature (°C)	Average dwell time (min)	Amine (about 99 % purity)	Product	Product purity (weight %)	Yield (%)	Product boiling point (°C/torr)
3	90	4	diethylamine	N,N-diethylacetoacetamide	99.0	98.5	114/4
4	85	6	2-ethylhexylamine	N-2-ethylhexylacetoacetamide	96.0	98.0	130/0.01
5	95	6	bis-2-ethylhexylamine	N,N-bis-2-ethylhexylacetoacetamide	97.0	98.5	152/0.02
6	80	10	diisopropylamine	N,N-diisopropylacetoacetamide	93.5	97.5	74/0.03
7	90	15	N-n-propyl-N-s-butylamine	N-n-propyl-N-s-butylacetoacetamide	97.0	97.0	86/0.01
8	115	6	dodecylamine	N-dodecylacetoacetamide	95.5	98.0	(m.p. 82°C)
9	95	8	tridecylamine	N-tridecylacetoacetamide	96.5	98.0	191/1.5

WHAT WE CLAIM IS:-

1. A process for the continuous manufacture of an acetoacetamide of the general formula

$$CH_3.CO.CH_2.CO.NR^1R^2$$

in which R^1 denotes an alkyl radical having not more than 18 carbon atoms and R^2 denotes a hydrogen atom or an alkyl radical having not more than 18 carbon atoms, which comprises causing diketene to react in a continuous process with an amine of the general formula

$$HNR^1R^2$$

in which R^1 and R^2 are defined as above, for a dwell time not exceeding 15 minutes and at a temperature of not less than 60°C under atmospheric pressure, the amount of diketene used being within the range of from the stoichiometric amount to an excess of 2% above the stoichiometric amount.

2. A process as claimed in claim 1, wherein R^1 denotes an alkyl radical having not more than 8 carbon atoms and R^2 denotes a hydrogen atom or an alkyl radical having not more than 8 carbon atoms.

3. A process as claimed in claim 2, wherein R^1 denotes an alkyl radical hving not more than 4 carbon atoms and R^2 denotes a hydrogen atom or an alkyl radical having not more than 4 carbon atoms.

4. A process as claimed in claim 3, wherein the amine is methylamine or dimethylamine.

5. A process as claimed in any one of claims 1 to 4, wherein both reactants are used in freshly distilled form.

6. A process as claimed in any one of claims 1 to 5, wherein the dwell time is within the range of from 2 to 10 mins.

7. A process as claimed in any one of claims 1 to 6, wherein the temperature is within the range of from 80 to 150°C.

8. A process as claimed in any one of claims 1 to 7, wherein the diketene is used in an excess of from 0.1 to 2% above the stoichiometric amount.

9. A process as claimed in claim 8, wherein the diketene is used in an excess of from 0.1 to 0.5% above the stoichiometric amount.

10. A process as claimed in any one of claims 1 to 9, carried out in a reaction cycle.

11. A process as claimed in claim 10, carried out in a reaction cycle substantially as described herein with reference to, and as shown in, the accompanying drawing.

12. A process as claimed in claim 1, carried out substantially as described herein with reference to the accompanying drawing.

13. A process as claimed in claim 1, carried out substantially as described in any one of Examples 1 to 9 herein.

14. An acetoacetamide that has been manufactured by a process as claimed in any one of claims 1 to 13.

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1588027 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*