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PROCESS FOR ESTERIFYING CARBOCYCLIC CARBOXYLIC ACIDS

Alan Bell and M B. Knowles, Kingsport, Tenn., assignors to Eastman Kodak Company, Rochester, N. Y., a corporation of New Jersey

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This invention relates to a process for preparing alkyl or β-chloroethyl esters of a carbocyclic carboxylic acid. More particularly the invention relates to a process of esterifying a hindered carbocylic carboxylic acid with a trialkyl phosphate or tri-β-chloroethyl phosphate.

We have discovered that hindered carbocyclic carboxylic acids can be readily esterified by treatment with a trialkyl phosphate or tri-β-chloroethyl phosphate. While all carbocylic carboxylic acids, whether hindered or not, can be esterified by treatment with a trialkyl phosphate or tri-β-chloroethyl phosphate, our invention is primarily of value in connection with the esterification of hindered carbocyclic carboxylic acids, that is, carbocyclic carboxylic acids which cannot be esterified in the normal manner or which can be esterified only in low conversions. Accordingly, our invention is primarily directed to the esterification of hindered carbocyclic carboxylic acids by means of a trialkyl phosphate or tri-β-chloroethyl phosphate. It is especially directed to the esterification of bicyclohexyl-1-carboxylic acid and our invention will be illustrated primarily in connection with this acid.

It is an object of our invention to provide a new, satisfactory process for esterifying carbocyclic carboxylic acids, particularly hindered carbocyclic carboxylic acids. Another object is to provide a satisfactory process for preparing alkyl esters of bicyclohexyl-1-carboxylic acid. A specific object is to provide a satisfactory process for preparing the ethyl ester of bicyclohexyl-1-carboxylic acid. Other objects will be apparent from the following description of the invention.

In carrying out the process of our invention, a carbocyclic carboxylic acid is heated with the trialkyl phosphate or tri-β-chloroethyl phosphate esterifying agent. The reaction can be carried out using one-third mole of the esterifying agent to one mole of the carbocyclic carboxylic acid. In this case all three alkyl or β-chloroethyl groups are used for esterifying the acid. We have found, however, that the reaction is smoother and more rapid where an excess of the esterifying agent is employed and accordingly, an excess of the esterifying agent is preferred.

The esterification process of our invention can be carried out in the absence of a base such as sodium carbonate but we have found that the reaction proceeds more rapidly if the base is present. Suitable bases or alkaline agents that can be employed include, for example, sodium carbonate, sodium bicarbonate, potassium carbonate, lithium carbonate and potassium bicarbonate.

So far as we are aware any trialkyl phosphate can be used in the process of our invention. However, normally a tri(alkyl having 1 to 4 carbon atoms) phosphate is employed.

Trimethyl phosphate, triethyl phosphate, tri(n-propyl) phosphate, triisopropyl phosphate, tri(n-butyl) phosphate and tri-β-chloroethyl phosphate are illustrative of the esterifying agents used in carrying out the process of the invention. Bicyclohexyl-1-carboxylic acid, 2,6-dinitrobenzoic acid and 2,6-dietertiarybutylbenzoic acid are illustrative of the hindered carbocyclic carboxylic acids that can be esterified in accordance with the process of our invention. Other carbocyclic carboxylic acids that can be esterified in accordance with the process of our invention include, for example, benzoic acid, o-nitrobenzoic acid, m-nitrobenzoic acid, p-nitrobenzoic acid, o-chlorobenzoic acid, m-chlorobenzoic acid, p-chlorobenzoic acid, α-naphthoic acid, β-naphthoic acid, anthraquinone-1-carboxylic acid and anthraquinone-2-carboxlic acid.

The examples given hereinafter fully illustrate the manner in which the process of our invention is carried out as well as the advantages to be obtained thereby. Thus, in Examples 1 and 2, when bicyclohexyl-1-carboxylic acid was esterified with triethyl phosphate, an 85%–95% and a 90% yield, respectively, of the ethyl ester of bicyclohexyl-1-carboxylic acid was obtained. Similarly, as shown in Example 3, when bicyclohexyl-1-carboxylic acid was esterified with tri(n-butyl) phosphate, a 90%–98% yield of n-butyl bicyclohexyl-1-carboxylate was obtained. In each of these examples the reaction took place smoothly with practically no tar formation. In contrast, when it was attempted to esterify bicyclohexyl-1-carboxylic acid with ethyl alcohol and sulfuric acid in accordance with the procedure described in Example 4, no ester was formed and the bicyclohexyl-1-carboxylic acid was recovered unchanged. When bicyclohexyl-1-carboxylic acid was attempted to be esterified with diethyl sulfate, a 19% yield of the ethyl ester of bicyclohexyl-1-carboxylic acid was obtained. As shown in Example 6, when dimethyl sulfate was the esterifying agent, a 38% yield of the methyl ester of bicyclohexyl-1-carboxylic acid was obtained. Again using the procedure of Example 7 wherein dimethyl sulfate is the esterifying agent, a 41% yield of the methyl ester of bicyclohexyl-1-carboxylic acid was obtained. Following the procedure of Example 8 and using dimethyl sulfate as the esterifying agent, a 55% yield of crude methyl bicyclohexyl-1-carboxylate was obtained.

From the above it is seen that when one attempts to esterify bicyclohexyl-1-carboxylic acid by the conventional esterification methods, the yields obtained are not nearly as good as those obtained when applicants' process is used. Also, in some cases considerable tarry material is formed when the conventional esterification methods are employed.

The following examples illustrate the process of our invention.

Example 1

231 parts of bicyclohexyl-1-carboxylic acid and 200 parts of triethyl phosphate were heated together to 190° C. and then 120 parts of solid sodium carbonate were gradually added thereto over a period of one-half hour. Carbon dioxide was evolved. The reaction mixture was kept at 185° C.–190° C. for one hour, after which it was cooled and poured into ice water. The mixture thus obtained was extracted with hexane and the hexane layer was removed, washed well with water, dried and then distilled under a reduced pressure of about 6–8 mm. A yield of 225–245 parts (85%–95%) of the ethyl ester of bicyclohexyl-1-carboxylic acid which distilled at 139° C.–145° C. (6–8 mm.) was obtained.

Example 2

7 parts of bicyclohexyl-1-carboxylic acid and 18.2 parts of triethyl phosphate were heated together to reflux and 16 parts of sodium carbonate were gradually added over a period of one-half hour. Refluxing was continued for one hour, after which the reaction product was worked up in accordance with the procedure described in Example 1. 7 parts (90%) of the ethyl ester of bicyclohexyl-1-carboxylic acid which distilled at 130.5° C. (4 mm.) were obtained.

Example 3

21 parts of bicyclohexyl-1-carboxylic acid and 30 parts of tri(n-butyl) phosphate were heated together to 165° C. and 12 parts of anhydrous sodium carbonate were added portionwise. The temperature of the reaction mixture was increased to 215° C. and maintained at this temperature for 1½ hours. Then the reaction mixture was cooled and poured into water and the organic layer which separated was removed and extracted with pentane. The pentane extract was washed with water, dried and distilled under reduced pressure to give 24–26 grams (90–98%) of n-butyl bicyclohexyl-1-carboxylate boiling at 93° C.–95° C. (0.06 mm.).

Example 4

38 parts of bicyclohexyl-1-carboxylic acid, 300 parts of absolute ethyl alcohol, 150 parts of toluene and 13 parts of 95% sulfuric acid were refluxed together for 48 hours and then the ethyl alcohol and toluene were slowly distilled off. The bicyclohexyl-1-carboxylic acid was recovered unchanged. No ethyl ester of bicyclohexyl-1-carboxylic acid was formed by the procedure described.

Example 5

30.8 parts of diethyl sulfate were slowly added to a mixture consisting of 37 parts of bicyclohexyl-1-carboxylic acid, 300 parts of 50% aqueous ethyl alcohol and 20 parts of sodium hydroxide and the resulting reaction mixture was refluxed for 1–2 hours. Upon working up the reaction mixture, 8 parts (19%) of the ethyl ester of bicyclohexyl-1-carboxylic acid and 27 parts (73%) of bicyclohexyl-1-carboxylic acid were obtained.

Example 6

25.2 parts of dimethyl sulfate were slowly added to a mixture consisting of 37 parts of bicyclohexyl-1-carboxylic acid, 300 parts of 50% aqueous ethyl alcohol and 20 parts of sodium hydroxide and the resulting reaction mixture was refluxed for 1–2 hours. Upon working up the reaction mixture, 15 parts (38%) of the methyl ester of bicyclohexyl-1-carboxylic acid and 18.5 parts (50%) of bicyclohexyl-1-carboxylic acid were recovered.

Example 7

25.2 parts of dimethyl sulfate were slowly added to a mixture consisting of 37 parts of bicyclohexyl-1-carboxylic acid, 240 parts of 85% aqueous methyl alcohol and 28 parts of potassium hydroxide and the reaction mixture resulting was refluxed for 1–2 hours. Upon working up the reaction mixture, 16.3 parts (41%) of the methyl ester of bicyclohexyl-1-carboxylic acid and 21.1 parts (57%) of bicyclohexyl-1-carboxylic acid were recovered.

Example 8

21 parts of bicyclohexyl-1-carboxylic acid and 12.6 parts of dimethyl sulfate were heated together to 150° C.–160° C. and 11 parts of sodium carbonate were added in small increments. Heating at 150° C.–160° C. was continued for one hour. Considerable tarry material was formed and 12.6 parts (55%) of the methyl ester of bicyclohexyl-1-carboxylic acid were obtained in crude form. No unreacted bicyclohexyl-1-carboxylic acid was recovered.

Example 9

When Example 8 was repeated omitting sodium carbonate, only 8.5 parts (38%) of the methyl ester of bicyclohexyl-1-carboxylic acid were obtained in crude form. About 8 parts (38%) of very impure bicyclohexyl-1-carboxylic acid were also recovered.

Example 10

By the use of 314 parts of tri-β-chloroethyl phosphate in place of triethyl phosphate in Example 1, the β-chloroethyl ester of bicyclohexyl-1-carboxylic acid is obtained.

By the use of an equivalent amount of tri(n-propyl) phosphate and triisopropyl phosphate, respectively, in place of triethyl phosphate in Example 1, the tri(n-propyl) ester and the triisopropyl ester, respectively, of bicyclohexyl-1-carboxylic acid are obtained. Similarly, when other carbocyclic carboxylic acids such as benzoic acid, p-nitrobenzoic acid, β-naphthoic acid and anthraquinone-2-carboxylic acid, for example, are reacted with triethyl phosphate, for example, the ethyl esters of said acids are obtained.

We claim:

1. The process of preparing an ester of a carbocyclic carboxylic acid which comprises esterifying a carbocyclic carboxylic acid with a member selected from the group consisting of a trialkyl phosphate and a tri-β-chloroethyl phosphate.

2. The process of preparing an alkyl ester of a carbocyclic carboxylic acid which comprises esterifying a carbocyclic carboxylic acid with a trialkyl phosphate.

3. The process of preparing an alkyl ester of a hindered carbocyclic carboxylic acid which comprises esterifying a hindered carbocyclic carboxylic acid with a trialkyl phosphate.

4. The process of preparing an alkyl ester of a hindered carbocyclic carboxylic acid which comprises esterifying a hindered carbocyclic carbox-

ylic acid with a tri(alkyl having 1 to 4 carbon atoms) phosphate.

5. The process of preparing a β-chloroalkyl ester of a hindered carbocyclic carboxylic acid which comprises esterifying a hindered carbocyclic carboxylic acid with tri-β-chloroethyl phosphate.

6. The process of preparing an alkyl ester of a hindered carbocyclic monocarboxylic acid which comprises esterifying a hindered carbocyclic monocarboxylic acid with a tri(alkyl having 1 to 4 carbon atoms) phosphate.

7. The process of preparing an alkyl ester of a hindered carbocyclic monocarboxylic acid which comprises esterifying a hindered carbocyclic monocarboxylic acid with a tri(alkyl having 1 to 4 carbon atoms) phosphate in the presence of an alkaline agent selected from the group consisting of sodium carbonate, sodium bicarbonate, potassium carbonate, potassium bicarbonate and lithium carbonate.

8. The process of preparing an alkyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carboxylic acid with a tri(alkyl having 1 to 4 carbon atoms) phosphate.

9. The process of preparing the ethyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carboxylic acid with triethyl phosphate.

10. The process of preparing the ethyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carboxylic acid with triethyl phosphate in the presence of an alkaline agent selected from the group consisting of sodium carbonate, sodium bicarbonate, potassium carbonate, potassium bicarbonate and lithium carbonate.

11. The process of preparing the ethyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carboxylic acid with triethyl phosphate in the presence of sodium carbonate.

12. The process of preparing the n-butyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carboxylic acid with tri(n-butyl) phosphate.

13. The process of preparing the n-butyl ester of bicyclohexyl-1-carboxylic acid which comprises esterifying bicyclohexyl-1-carbocyclic acid with tri(n-butyl) phosphate in the presence of sodium carbonate.

ALAN BELL.
M B. KNOWLES.

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