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(54) Title: SYNTHESIS OF A, Ω -DIESTERS

(57) Abstract: The present invention relates to the transformation of alicyclic ketones with an α -hydrogen into the corresponding α , ω -diesters, by the reaction with organic carbonates, in the presence of cesium carbonate or potassium carbonate as catalysts and of a phase-transfer agent.



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SYNTHESIS OF alpha , omega - DIESTERS

Description of WO0214257 (A2)

SYNTHESIS OF α , ω -DIESTERS

The present invention relates to the transformation of alicyclic ketones with an α -hydrogen into the corresponding α , ω -diesters (also known as α , ω -dicarboxylic acid diesters), by the reaction with organic carbonates. α , ω -dicarboxylic acid diesters are important intermediates for the preparation of dicarboxylic acids which are used in huge amounts in the industrial synthesis of polyesters and polyamides. Adipic acid, the starting material in the synthesis of nylon-6,6, is produced by catalytic oxidation of cyclohexanone with nitric acid, a process which generates N₂O as a byproduct. This production alone, causes a 10% of the annual increase of in N₂O levels with consequences on the ozone layer and on the greenhouse effect.

This serious drawback can be avoided by the process of the invention, which allows to convert alicyclic ketones, and most importantly cyclopentanone and cyclohexanone into dialkyl adipate and pimelate, these latter being also an important intermediates for the preparation of polyesters and polyamides, such as nylon-7,7.

US5453535 and US5786502 describe a process for preparing α , ω -dicarboxylic acid diesters by reaction of cycloalkanones with carbonic diesters in the presence of nitrogen bases and strongly basic agents, respectively.

The preparation of dimethyl pimelate and dimethyl adipate by reaction of cyclohexanone, respectively cyclopentanone, with dimethyl carbonate, in the presence of potassium carbonate, has been reported in Gazzetta Chimica

Italiana 1993, 123, 515-518. Whereas the conversion of these alicyclic ketones was relatively high (88% and 80%), the molar yield referred to the converted ketone was unsatisfactory (11% and 14% respectively).

It has now been found that alicyclic ketones of formula I can be transformed in α , ω -dicarboxylic acid diesters of formula III, according to the following scheme 1,

EMI2.1

in satisfactory yields, when the reaction of the ketones with dialkylcarbonates is carried out in the presence of cesium or potassium carbonates as catalysts, preferably cesium carbonate, and of a phase-transfer agent. In the scheme 1 above, R₁, R₂ and R₃, which can be the same or different, are hydrogen, linear or branched C₁-C₈-alkyl, alkenyl or aryl groups ; R₄ is a C₁-C₂ alkyl group, benzyl or phenyl; n can vary from 1 to 20; where n > 1, R₂ and R₃ are independently bonded to each carbon atom. The reaction with an asymmetrical carbonate gives the corresponding products structurally similar to III.

In the present invention, it is shown that the reaction of scheme 1 is performed in a one-pot procedure. Since Cs₂CO₃ and K₂CO₃ are weak bases, a high temperature is used for the generation of the α -ketoester, a reactive intermediate of the process. In the presence of an alcohol (R₄OH, z where R₄ is as above defined), under the conditions found by the inventors, this moiety undergoes a retro-Dieckmann, rather than C-alkylations at the α -carbonyls promoted by dialkylcarbonates. Moreover, both conversion and selectivity are improved by the presence of phase-transfer agents.

The reaction is carried out in the presence of phase transfer agents, such as phosphonium salts, ammonium salts, crown ethers or preferably polyethylene glycols (PEGs), at temperatures of 100 to 250 C, for 1 to 24 hours.

It has been found that the best results are obtained at a temperature of 180-220 C, for times ranging from 4 to 8 hours, more preferably for about 6 hours. The reaction is preferably carried out under N₂. Even though PEGs having different molecular weight can be used as phase transfer agents, PEG 250 (CH₃(OCH₂CH₂)_nOCH₃ n=3-8) is particularly preferred.

PEG is preferably used in 0.05-1.0 wt ratio with respect to the ketone, preferably of 0.1-0.6 and even more preferably of about 0.2. The molar ratio between dialkylcarbonate and ketone may be from 1 : 1 to 30: 1 preferably about 20: 1.

Cesium and potassium carbonates are used in amounts of 0.01-3 moles per mole of ketone. A ratio of 0. 1-2. 0 is advantageous, preferably of about 0.2 mols/mole ketone. It has been moreover surprisingly found that the reaction takes place in a particularly favourable way if an alcohol (R₄OH) is used as a co-solvent, in amount of 1-50 mols per mole of ketone, preferably 2-20 mols per mole of ketone and even more preferably of about 5 mols per mole of ketone.

Depending on the reaction temperature, the catalyst and on the dialkylcarbonate/alcohol ratio, a, co-diester alkylated in position 2 or in positions 2 and (cl-1) are formed in a variable amount. The presence of such intermediates may possibly be desired in the industrial synthesis of polyesters and polyamides.

According to a further embodiment of the invention, the synthesis of a, co-diester can be carried out starting from the p-ketoesters IV, as shown in the following scheme 2:

EMI4.1

The P-ketoesters IV are reacted with an alcohol R₄OH, where R₄ is as above defined, in a 2-20 molar excess with respect to IV, in the presence of cesium or potassium carbonates as catalyst and of a phase-transfer agent, in the conditions indicated above, yielding III.

The following Examples further illustrate the invention.

Example1

EMI4.2

1, 6-hexanedioic acid 2-methyl-1, 6-hexanedioic 2,5-dimethyl-1,6-hexanedioic dimethylester acid dimethylester acid dimethylester

Cyclopentanone (0. 5 g, 0.006 mols), dimethylcarbonate (11. 8 g, 0.12 mols), cesium carbonate (3.9 g, 0.012 mols), PEG 250 (0. 5 g, 100% weight), and methanol (3.7 g, 0.12 mols) are reacted in autoclave at 200 C for 6 hours, under magnetical stirring. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures. Unreacted cyclopentanone was 4%; 1,6-hexanedioic acid dimethylester (dimethyladipate) was 54% and 2-methyl-1,6-hexanedioic acid dimethylester was 8%.

Example 2

EMI5.1

1,7-heptanedioic acid 2-methyl-1, 7-heptanedioic 2,6-dimethyl-1,7 dimethylester acid dimethylester heptanedioic acid dimethylester

Cyclohexanone (0.6 g, 0.006 mols), dimethylcarbonate (11.8 g, 0.12 mols), cesium carbonate (3.9 g, 0.012 mols), PEG 250 (0.6 g, 100% weight) and methanol (3.7 g, 0.12 mols) are reacted in autoclave at 200 C for 6 hours, under magnetical stirring. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures. Unreacted cyclohexanone was 23%; 1, 7-heptanedioic acid dimethylester (dimethylpimelate) was 41% and 2-methyl-1,7-heptanedioic acid dimethylester was 3%.

Example 3

Cyclohexanone (0.6 g, 0.006 mols), dimethylcarbonate (5.9 g, 0.06 mols), cesium carbonate (0.1 g, 0.0003 mols), PEG 250 (0.06 g, 10% weight) and methanol (1. 9 g, 0.06 mols) are reacted in autoclave at 200 C for 6

hours, under magnetic stirring. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures. Unreacted cyclohexanone was 2%; 1,7-heptanedioic acid dimethylester (dimethylpimelate) was 40% and 2-methyl-1,7-heptanedioic acid dimethylester was 7%.

Example 4

Cyclopentanone (0.5 g, 0.006 mols), dimethylcarbonate (11.8 g, 0.12 mols), potassium carbonate (0.08 g, 0.0006 mols), PEG 250 (0.25 g, 50% weight), and methanol (3.7 g, 0.12 mols) are reacted in autoclave at 220 C for 4 hours, under magnetical stirring. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures. Unreacted cyclopentanone was 8%; 1,6-hexanedioic acid dimethylester (dimethyladipate) was 24%, 2-methyl-1, 6-hexanedioic acid dimethylester was 22% and 2,5-dimethyl-1,6-hexanedioic acid dimethylester was 28%.

Example 5

EMI6.1

2-methoxycarbonyl 1,6-hexanedioic cyclopentanone acid dimethyl ester

The ss-ketoester 2-methoxycarbonyl cyclopentanone (1.5 g, 0.01 mols) is reacted with Cs₂CO₃ (0.16 g, 0.0005 mols), PEG250 (0.33 g, 20% weight) and methanol (6.2 g, 0.2 mols), at 200 C for 6 hours, under N₂. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures.

Conversion was 100%; 1,6-hexanedioic acid dimethylester (dimethyladipate) formation was 98%.

Example 6

EMI6.2

2-methoxycarbonyl 1,7-heptanedioic cyclohexanone acid dimethyl ester The P-ketoester 2-methoxycarbonyl cyclohexanone (1.6 g, 0.01 mols) is reacted with Cs₂CO₃ (0.16 g, 0.0005 mols), PEG 250 (0.33 g, 20% weight) and methanol (6.2 g, 0.2 mols), at 200 C for 6 hours, under N₂. The reaction mixture is dried under vacuum and analysed by GC with the usual procedures. Conversion was 100%; 1,7-heptanedioic acid dimethylester (dimethylpimelate) formation was 98%.

CLAIMS

1. A process for the preparation of α , co-diester of formula III

EMI7.1

III wherein R₁, R₂ and R₃, which can be the same or different, are hydrogen, linear or branched C₁-C₈-alkyl, alkenyl or aryl groups; R₄ is a C₁-C₂ alkyl group, benzyl or phenyl ; n can vary from 1 to 20, by reacting alicyclic ketones of formula I

EMI7.2

wherein R₁-R₂ and R₃ are as defined above, with dialkylcarbonates of formula II H wherein R₄ is as defined above, characterized in that the reaction is carried out in the presence of cesium carbonate or potassium carbonate as catalysts and of a phase-transfer agent.

2. A process for the preparation of a, co-diester of formula III

EMI8.1

wherein R₁, R₂ and R₃, which can be the same or different, are hydrogen, linear or branched C₁-C₈-alkyl, C₂-C₈ alkenyl groups, or aryl groups; R₄ is a C₁--C₂ alkyl group, benzyl or phenyl; n can vary from 1 to 20, which comprises the reaction of (3-ketoesters IV

EMI8.2

with a C₁-C₃ alcohol in the presence of cesium or potassium carbonates and of a phase transfer agent.

3. A process according to claims 1-2, characterized in that the reaction is carried out in the presence of an alcohol R₄OH, where R₄ is as above defined.

4. A process according to claims 1-3, wherein the phase-transfer catalyst is selected from phosphonium,

ammonium salts, crown ethers and polyethylene glycols.

5. A process according to claim 4, wherein the phase-transfer catalyst is a polyethylene glycol.
6. A process according to claim 5, wherein the polyethylene glycol has a molecular weight of 200-250.
7. A process according to claims 5-6 wherein the polyethylene glycol is used in amount of 0.1-5 equivalents per mole of ketone.
8. A process according to claim 7 wherein the polyethylene glycol/ketone weight ratio is 0.1-0.6.
9. A process according to claim 3, wherein the alcohol R₄OH is used in amounts of 1-50 mols/mole of ketone.
10. A process according to claims 1-9 wherein the reaction is carried out at temperatures from 100 to 250 C.
11. A process according to claims 1-10, wherein 0.01-3 moles of cesium carbonate or potassium carbonate per mole of ketone are used.
12. A process according to claims 1-11 for the preparation of a, diesters alkylated in position 2 or in positions 2 and (o-l).