

The preparation of carboxylic acid derivatives

The invention relates to a process for preparing carboxylic acid derivatives from carbonitriles and alcohols at elevated temperatures on titanium oxide catalysts.

DE-A 27 14 767 discloses a process for preparing carboxylic acid derivatives by gas-phase reaction of nitriles with alcohols and water on solid, metal-containing catalysts such as copper, zinc, chromium, bismuth, manganese, iron, nickel, cadmium on carriers such as Al_2O_3 , SiO_2 , ZrO_2 or TiO_2 . Dehydration and etherification are found as side reactions.

EP-A 412 310, for example, discloses a process for preparing carboxamides by hydration of nitriles with water on manganese-containing catalysts, which can subsequently be reacted with alcohols by acid catalysis, in the presence of metal salts, eg. as disclosed in US-A 4 613 684, or in the gas phase on solid catalysts, eg. as disclosed in EP-A 561 614, or with formic ester resulting in formamide formation, eg. as disclosed in EP-A 392 361, on metal oxides to give the carboxylic acid derivatives.

The disadvantages for industrial application are the two stages and the formation of byproducts, such as production of salt or formamide formation.

DE-A 43 39 648 discloses a process for preparing caprolactam (a cyclic amide) by reacting aminocapronitrile with water in an ethanolic solution on a titanium oxide catalyst.

It is an object of the present invention to remedy the above-mentioned disadvantages.

We have found that this object is achieved by a novel and improved process for preparing carboxylic acid derivatives of the general formula I



where

X is OR^2 or NH_2 ,

R^1 is C_1 - C_{20} -alkyl, C_1 - C_{20} -hydroxyalkyl, C_3 - C_{12} -cycloalkyl, C_4 - C_{12} -alkylcycloalkyl, C_4 - C_{12} -cycloalkylalkyl, C_5 - C_{20} -alkylcycloalkylalkyl, aryl, C_7 - C_{20} -aralkyl, C_7 - C_{20} -alkylaryl, a

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heteroaliphatic or heteroaromatic ring with 5 to 8 carbon atoms and

R² is C₁-C₂₀-alkyl,

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from carbonitriles of the general formula II



10 where R¹ has the abovementioned meanings, and alcohols of the general formula III



15 where R² has the abovementioned meanings, at from 50 to 300°C under from 0.1 to 350 bar in the presence of a heterogeneous catalyst, wherein the reaction is carried out in liquid phase.

The process according to the invention can be carried out in the
20 following way:

The carbonitrile II can be brought into contact with an alcohol III, preferably dissolved in the alcohol III, at from 50 to 300°C, preferably 100 to 290°C, particularly preferably 140 to
25 270°C, under from 0.1 to 350 bar, preferably 1 to 200 bar, particularly preferably 30 to 140 bar, in liquid phase with a titanium oxide catalyst, as a rule in pressure-stable apparatus such as autoclaves and tubular reactors, preferably tubular reactors. The result is, as a rule, an alcoholic solution of the carboxylic
30 ester and of the carboxamide I, from which the carboxylic ester and the carboxamide I can be obtained by conventional methods, for example by distillation, extraction or crystallization.

The carboxamide can be returned to the reactor together with
35 fresh carbonitrile II.

The reaction of solid carbonitriles II or solid alcohols III can be carried out in inert solvents, for example in ethers, preferably ethers with 2 to 20 carbon atoms, particularly preferably
40 ethers with 4 to 12 carbon atoms, such as diethyl ether, methyl tert-butyl ether or tetrahydrofuran, hydrocarbons, preferably hydrocarbons with 5 to 30 carbon atoms, particularly preferably hydrocarbons with 5 to 12 carbon atoms, such as toluene and xylene or, advantageously, in the appropriate carboxylic ester I.

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Examples of suitable heterogeneous catalysts are acidic, basic or amphoteric oxides of elements of groups IIA, IIIA, IVA of the Periodic Table of the Elements, such as calcium oxide, magnesium oxide, boron oxide, aluminum oxide, tin oxide or silicon dioxide, 5 pyrogenic silica, as silica gel, kieselguhr, quartz, furthermore oxides of metals of groups IIB, IIIB, IVB, VB, VIB and VIIB of the Periodic Table of the Elements, such as titanium oxide, especially titanium dioxide, eg. amorphous, as anatase or rutile, zirconium oxide, zinc oxide, manganese oxide, vanadium oxide, 10 niobium oxide, iron oxide, chromium oxide, molybdenum oxide, tungsten oxide, oxides of the lanthanides and actinides such as cerium oxide, thorium oxide, praseodymium oxide, samarium oxide, rare earth mixed oxides or mixtures thereof. Some sulfides, selenides and tellurides such as zinc telluride, tin selenide, molybdenum sulfide, tungsten sulfide, sulfides of nickel, zinc and 15 chromium, can also be used.

The abovementioned compounds can be doped with compounds of groups IA, IIA, IIIA, IVA, VA, VIA and VIIA of the Periodic Table 20 of the Elements or contain the later.

Further suitable catalysts are zeolites, phosphates and heteropolyacids, and acidic and alkaline ion exchangers such as Naphion [sic].

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These catalysts may, where appropriate, in each case contain up to 50% by weight of copper, tin, zinc, manganese, iron, cobalt, nickel, ruthenium, palladium, platinum, silver or rhodium.

30 The catalysts can, depending on the composition of the catalyst, be used as unsupported or supported catalyst. Thus, for example, titanium dioxide can be used as titanium dioxide pellets or as titanium dioxide applied in a thin layer to a support. The methods used for applying TiO_2 to a support such as silicon dioxide, 35 aluminum oxide or zirconium dioxide can be all those described in the literature. Thus, a thin TiO_2 layer can be applied by hydrolyzing organotitanium compounds such as titanium isopropoxide or butoxide or by hydrolyzing TiCl_4 or other inorganic Ti-containing compounds. It is also possible to use brines containing titanium 40 oxide.

The reaction can be carried out, for example, in suspension, preferably in a fixed bed. The reaction is preferably carried out in a fixed bed because this makes it easy to carry out continuously, 45 the yields and selectivities in the fixed bed are, as a rule, very high and thus result in short holdup times with very high throughputs. Since the heterogeneous catalysts used have, accord-

ing to observations to date, a long useful life, the consumption of catalyst is extremely low.

The substituents X, R¹ and R² in the compounds I, II and III have the following meanings:

- X
- OR²
 - NH₂
- 10 R¹, R²
- C₁-C₂₀-alkyl, preferably C₁-C₁₂-alkyl, particularly preferably C₁-C₈-alkyl such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, isopentyl, 15 n-hexyl, isohexyl, n-heptyl, isoheptyl, n-octyl and isooctyl, especially C₁-C₄-alkyl such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl and tert-butyl,
 - C₁-C₂₀-hydroxyalkyl, preferably C₁-C₈-hydroxyalkyl, particularly preferably C₁-C₄-hydroxyalkyl such as hydroxymethyl, 20 1-hydroxyethyl, 2-hydroxyethyl and 1-methyl-1-hydroxyethyl,
 - C₃-C₁₂-cycloalkyl, preferably C₅-C₈-cycloalkyl such as cyclopentyl, cyclohexyl, cycloheptyl and cyclooctyl, particularly preferably cyclopentyl and cyclohexyl,
 - 25 - C₄-C₁₂-alkylcycloalkyl, preferably C₅-C₁₀-alkylcycloalkyl, particularly preferably C₅-C₈-alkylcycloalkyl,
 - C₄-C₁₂-cycloalkylalkyl, preferably C₅-C₁₀-cycloalkylalkyl, particularly preferably C₅-C₈-cycloalkylalkyl,
 - C₅-C₂₀-alkylcycloalkylalkyl, preferably C₆-C₁₆-alkylcycloalkylalkyl, 30 alkylalkyl, particularly preferably C₇-C₁₂-alkylcycloalkylalkyl,
 - aryl such as phenyl, 1-naphthyl and 2-naphthyl, preferably phenyl,
 - C₇-C₂₀-alkylaryl, preferably C₇-C₁₆-alkylaryl, [lacuna] preferably C₇-C₁₂-alkylphenyl such as 2-methylphenyl, 3-methylphenyl, 4-methylphenyl, 2-ethylphenyl, 3-ethylphenyl 35 and 4-ethylphenyl,
 - C₇-C₂₀-aralkyl, preferably C₇-C₁₆-aralkyl, [lacuna] preferably C₇-C₁₂-phenalkyl [sic] such as phenylmethyl, 1-phenylethyl and 2-phenylethyl, 40
 - a heteroaliphatic ring with 5 to 8 carbon atoms such as 2-morpholinyl, 3-morpholinyl, 2-piperidinyl, 3-piperidinyl and 4-piperidinyl,
 - a heteroaromatic ring with 5 to 8 carbon atoms such as 2-pyridyl, 3-pyridyl, 4-pyridyl, 2-pyrazolyl, 2-imidazolyl, 45 4(5)-imidazolyl, preferably 3-pyridyl.

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REPLACED

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5 Examples

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Example 1

A 20% by weight ethanolic solution of nicotinonitrile was passed
10 with the addition of 1 mol of water (3.5% by weight based on the solution) at 220°C and 80 bar through a tube packed with titanium oxide (1.5 mm pellets). The holdup time was set variably via the flow rate.

15 The composition of the discharge from the reaction is summarized in Table 1.

Table 1

20

Holdup time	Nicotino- nitrile	Ethyl nicotinate	Nicotin- amide	Others
[min]	[%]	[%]	[%]	[%]
15	5.1	5.4	9.4	0.1
25 30	1.9	8.6	9.1	0.4
60	0.6	11.3	7.4	0.7

Example 2

30 A 20% by weight ethanolic solution of nicotinonitrile was pumped as in Example 1 in the presence of 1 mol of water at 220°C at 80 bar through an empty tube. No reaction took place.

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We claim:

1. A process for preparing carboxylic acid derivatives of the
5 general formula I



10 where

X is OR^2 or NH_2 ,

15 R^1 is C_1 - C_{20} -alkyl, C_1 - C_{20} -hydroxyalkyl, C_3 - C_{12} -cycloalkyl, C_4 - C_{12} -alkylcycloalkyl, C_4 - C_{12} -cycloalkylalkyl, C_5 - C_{20} -alkylcycloalkylalkyl, aryl, C_7 - C_{20} -aralkyl, C_7 - C_{20} -alkyl-aryl, a heteroaliphatic or heteroaromatic ring with 5 to 8 carbon atoms and

20 R^2 is C_1 - C_{20} -alkyl,

from carbonitriles of the general formula II



25

where R^1 has the abovementioned meanings, and alcohols of the general formula III



30

where R^2 has the abovementioned meanings, at from 50 to 300°C under from 0.1 to 350 bar in the presence of a heterogeneous catalyst, wherein the reaction is carried out in liquid phase.

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2. A process for preparing carboxylic acid derivatives as claimed in claim 1, wherein acidic, basic or amphoteric oxides of elements of groups IIA, IIIA, IVA, IIB, IIIB, IVB, VB, VIB and VIIB of the Periodic Table of the Elements, 40 oxides of lanthanides or actinides, of [sic] rare earth mixed oxides or mixtures thereof, or zeolites, phosphates, heteropolyacids, acidic and alkaline ion exchangers, which may be doped by compounds of groups IA, IIA, IIIA, IVA, VA, VIA and VIIA of the Periodic Table of the Elements or contain the latter, and may contain from 0.001 to 50% by weight of cop- 45 per, tin, zinc, manganese, iron, cobalt, nickel, ruthenium,

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palladium, platinum, silver, rhodium or mixtures thereof, are used as heterogeneous catalysts.

3. A process for preparing carboxylic acid derivatives as
5 claimed in either of claims 1 and 2, wherein calcium oxide, magnesium oxide, boron oxide, aluminum oxide, tin oxide, silicon dioxide, silica gel, kieselguhr, quartz, titanium dioxide, zirconium oxide, zinc oxide, manganese oxide, vanadium oxide, niobium oxide, iron oxide, chromium oxide, molybdenum oxide, tungsten oxide, cerium oxide, thorium oxide,
10 praseodymium oxide, samarium oxide or mixtures thereof are used as heterogeneous catalysts.
4. A process for preparing carboxylic acid derivatives as
15 claimed in any of claims 1 to 3, wherein aluminum oxide, titanium oxide, zirconium oxide or mixtures thereof are used as heterogeneous catalysts.
5. A process for preparing carboxylic acid derivatives as
20 claimed in any of claims 1 to 4, wherein anatase, rutile or mixtures thereof is used as titanium dioxide.
6. A process for preparing carboxylic acid derivatives as
25 claimed in any of claims 1 to 5, wherein the reaction is carried out at from 100 to 290°C.
7. A process for preparing carboxylic acid derivatives as
30 claimed in any of claims 1 to 6, wherein the reaction is carried out at from 140 to 270°C.
8. A process for preparing carboxylic acid derivatives as
claimed in any of claims 1 to 7, wherein the reaction is carried out in liquid phase under from 1 to 200 bar.
- 35 9. A process for preparing carboxylic acid derivatives as claimed in any of claims 1 to 8, wherein the reaction is carried out under from 30 to 140 bar.
- 40 10. A process for preparing carboxylic acid derivatives as claimed in claim 1, wherein R¹ is 3-pyridyl, 1-methyl-1-hydroxyethyl, 1-hydroxyethyl or 2-hydroxyethyl.



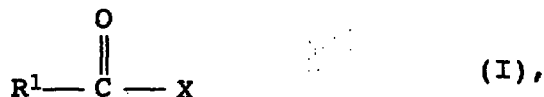
The preparation of carboxylic acid derivatives

Abstract

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A process for preparing carboxylic acid derivatives of the general formula I

10



where

X is OR² or NH₂,

15

R¹ is C₁-C₂₀-alkyl, C₁-C₂₀-hydroxyalkyl, C₃-C₁₂-cycloalkyl, C₄-C₁₂-alkylcycloalkyl, C₄-C₁₂-cycloalkylalkyl, C₅-C₂₀-alkylcycloalkylalkyl, aryl, C₇-C₂₀-aralkyl, C₇-C₂₀-alkylaryl, a heteroaliphatic or heteroaromatic ring with 5 to 8 carbon atoms and

20

R² is C₁-C₂₀-alkyl,

from carbonitriles of the general formula II

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where R¹ has the abovementioned meanings, and alcohols of the general formula III

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where R² has the abovementioned meanings, at from 50 to 300°C under from 0.1 to 350 bar in the presence of a heterogeneous catalyst, wherein the reaction is carried out in liquid phase.

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REPLACEMENT SHEET

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5 Examples

Example 1

A 20% by weight ethanolic solution of nicotinonitrile was passed 10 with the addition of 1 mol of water (3.5% by weight based on the solution) at 220°C and 80 bar through a tube packed with titanium oxide (1.5 mm pellets). The holdup time was set variably via the flow rate.

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25 30	1.9	8.6	9.1	0.4
60	0.6	11.3	7.4	0.7

Comparative Example

30 A 20% by weight ethanolic solution of nicotinonitrile was pumped as in Example 1 in the presence of 1 mol of water at 220°C at 80 bar through an empty tube. No reaction took place.

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20 R^2 is C_1 - C_{20} -alkyl,

from carbonitriles of the general formula II



25

where R^1 has the abovementioned meanings, and alcohols of the general formula III



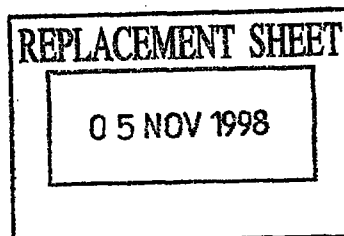
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where R^2 has the abovementioned meanings, at from 50 to 300°C under from 0.1 to 350 bar in the presence of a heterogeneous catalyst in liquid phase, wherein titanium dioxide is used as heterogeneous catalyst.

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2. A process for preparing carboxylic acid derivatives as
20 claimed in claim 1 wherein anatase, rutile or
mixtures thereof is used as titanium dioxide.
3. A process for preparing carboxylic acid derivatives as
25 claimed in either of claims 1 and 2, wherein the reaction is car-
ried out at from 100 to 290°C.
4. A process for preparing carboxylic acid derivatives as
30 claimed in any of claims 1 to 3, wherein the reaction is car-
ried out at from 140 to 270°C.
5. A process for preparing carboxylic acid derivatives as
claimed in any of claims 1 to 4, wherein the reaction is car-
ried out in liquid phase under from 1 to 200 bar.
- 35 6. A process for preparing carboxylic acid derivatives as
claimed in any of claims 1 to 5, wherein the reaction is car-
ried out under from 30 to 140 bar.
7. A process for preparing carboxylic acid derivatives as
40 claimed in claim 1, wherein R¹ is 3-pyridyl, 1-methyl-1-
hydroxyethyl, 1-hydroxyethyl or 2-hydroxyethyl.

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