

Description

The present invention relates to a continuous process for the preparation of alkyl propionates.

Alkyl propionates are of interest as solvents, as flavourings and as perfumes. They may be prepared by reacting an alkanol in the liquid phase with ethene and carbon monoxide in a reaction vessel in the presence of a carbonylation catalyst, for example as described in European patent applications publication Nos. 0106379, 0235864 and 0279477.

The components of carbonylation catalysts are expensive, and so it is important to minimize the amounts of components consumed per tonne of alkyl propionate produced. Thus, the continuous process described in EP-A-0279477 involves a step in which catalyst removed from the reaction vessel during recovery of alkyl propionate is recycled back to the reaction vessel.

The continuous process described in EP-A-0279477 is relatively complex and, in spite of the catalyst recycle step, consumes relatively large amounts of catalyst components per tonne of alkyl propionate produced.

Surprisingly, it has now been found that alkyl propionates may be prepared by a carbonylation process in which the amounts of catalyst components consumed are relatively small.

Accordingly, the present invention provides a continuous process for the preparation of an alkyl propionate, which comprises reacting an alkanol in a liquid phase with ethene and carbon monoxide in a reaction vessel in the presence of a carbonylation catalyst, and removing alkyl propionate from the reaction vessel in a stream of vapour.

Surprisingly, the process according to the invention has been found to consume smaller amounts of catalyst components per tonne of alkyl propionate produced than the process described in EP-A-0279477.

The vapour stream may be formed by passing a gas through the reaction vessel. The gas strips alkyl propionate from the liquid phase in the reaction vessel and so forms the stream of vapour. Any other volatile materials present in the liquid phase, for example alkanol, will also be removed in the stream of vapour. Accordingly, the stream of vapour comprises alkyl propionate, gas, and alkanol.

The rate at which gas is passed through the reaction vessel should be sufficient to strip alkyl propionate from the liquid phase. It may be determined by simple experimentation.

The gas used to form the stream of vapour may be blown onto the surface of the liquid phase, but is preferably bubbled through it. When gas is bubbled through the liquid phase, it stirs the liquid phase. In this case, a mechanical stirrer is generally not required. Preferably, ethene and carbon monoxide are bubbled through the liquid phase.

The gas used to form the stream of vapour may comprise ethene, carbon monoxide and/or one or more inert gases, for example nitrogen, carbon dioxide and noble gases such as argon. Preferably the gas consists substantially of ethene and carbon monoxide.

The molar ratio of ethene to carbon monoxide is preferably in the range of from 9:1 to 1:9, more preferably from 2:1 to 1:2, and most preferably about 1:1.

The process may be performed in the presence of a solvent, but is preferably not.

The carbonylation catalyst may be any carbonylation catalyst that gives an acceptable reaction rate under the conditions prevailing in the reaction vessel. Examples of suitable catalysts may be found in European patent applications publication Nos. 0106379, 0235864 and 0279477.

In one preferred class of carbonylation catalysts, the catalyst comprises a palladium compound, a ligand and a protonic acid.

The palladium compound may be a salt of palladium, for example a salt with nitric acid, sulphuric acid, a hydrohalic acid or a carboxylic acid such as acetic acid, or a complex of palladium such as palladium acetylacetonate, tetrakis(triphenylphosphine) palladium, bis-tri-*o*-tolylphosphine palladium acetate or bis-triphenylphosphine palladium sulphate.

The number of gram atoms of palladium used per mole of ethene is not critical. Preferably it is in the range of from 10^{-5} to 10^{-1} .

The ligand may be a phosphorus-, arsenic- or antimony-containing ligand. Preferably the ligand is a phosphine. Particularly preferred ligands are triaryl phosphines, for example phosphines of the general formula $PR^1R^2R^3$ in which each of R^1 , R^2 and R^3 represents an aryl group (e.g. phenyl) optionally substituted by one or more substituents selected from halogen atoms and alkyl, aryl, alkoxy, carboxy, acyl, trihalomethyl, cyano, dialkylamino, sulphonylalkyl and alkanoyloxy groups. Examples of suitable phosphines are tri-*p*-tolylphosphine, tri-*p*-methoxyphosphine and triphenylphosphine.

When a phosphine ligand is used, it is preferably present in an amount of at least 5 moles per gram atom of palladium, more preferably at least 10 moles per gram atom. The concentration of phosphine is preferably at least 10 mmoles per litre, more preferably at least 20 mmoles per litre.

The protonic acid preferably has a non-coordinating anion, by which is meant that little or no co-valent interaction takes place between palladium and the anion. Typical examples of such anions are PF_6^- , SbF_6^- , BF_4^- and ClO_4^- .

The protonic acid is preferably selected from sulphuric acid; sulphonic acids such as fluorosulphonic acid, chlorosulphonic acid, 2-hydroxypropane-2-sulphonic acid, p-toluenesulphonic acid, methanesulphonic acid and trifluoromethanesulphonic acid; perhalic acids such as perchloric acid; 2,6-disubstituted benzoic acids such as 2,6-dichlorobenzoic acid; phosphoric acid; phosphonic acids such as benzenephosphonic acid and 2-bromobenzenephosphonic acid; arsenic acid; and complexes of HF with fluorine-containing Lewis acids such as BF_3 , SiF_4 , SbF_5 , PF_5 , TaF_5 and NbF_5 .

The acid is preferably used in an amount in the range of from 1 to 50 moles per gram atom of palladium.

When a carbonylation catalyst comprising a palladium compound, a phosphine and a protonic acid is used in the process according to the invention, phosphine and protonic acid are preferably supplied intermittently, more preferably continuously to the reaction vessel, in order to maintain constant catalyst activity.

The ratio of the molar amounts of ligand and acid added during the reaction period may conveniently range from 0.5 to 10, preferably 0.75 to 5, more preferably 0.75 to 3.5. At the beginning of the reaction, the molar ratio will normally be in the range of from 0.5 to 10, preferably 0.75 to 5, more preferably 1 to 3.5, and during the reaction, the molar ratio of the added ligand and acid will conveniently be in the range of from 0.75 to 1.25, and is preferably about 1.

The pressure and temperature within the reactor are chosen so as to maintain sufficient alkanol in the liquid phase in the reaction vessel, and yet allow alkyl propionate to be removed in a stream of vapour. In general, the temperature in the reaction vessel is in the range of from 80 to 125 °C, preferably from 90 to 120, more preferably 110 °C. The pressure in the reaction vessel is conveniently in the range of from 5 to 20 bar, preferably from 8 to 12 bar.

The alkanol used in the process according to the invention is preferably a C_1 - C_6 alkanol, more preferably a C_1 - C_4 alkanol. Specific examples of alkanols are methanol, 2-propanol and 1-butanol. Preferably the alkanol is methanol, in which case the alkyl propionate produced is methyl propionate.

The stream of vapour leaving the reaction vessel may be cooled to afford a gas phase and a liquid phase. The gas phase may conveniently be recycled back to the reaction vessel. Alkyl propionate may be recovered from the liquid phase by distillation. Unreacted alkanol recovered from the liquid phase may be recycled back to the reactor.

When a mixture of methyl propionate and methanol is subject to distillation, an azeotropic mixture of methyl propionate and methanol is formed. This mixture is very conveniently recycled back to the reaction vessel.

The invention will now be described in more detail, by way of example with reference to the accompanying drawing (Figure 1) which represents a simplified process flow scheme for the preparation of an alkyl propionate.

Figure 1 shows a reaction vessel (1), a condenser (2), a gas/liquid separator (3), first and second distillation columns (4 and 5), a gas compressor (6) and flow lines (10 to 24).

The reaction vessel (1) contains a liquid phase (7) and a vapour phase (8). The internal volume of the reaction vessel is 600 ml. The volume of the liquid phase in the reaction vessel is kept at a constant 400 ml using a level controlling device (not shown).

The liquid phase comprises alkanol, alkyl propionate and a carbonylation catalyst which comprises palladium acetate, triphenylphosphine and methane sulphonic acid.

Ethene, supplied via lines (10) and (13), carbon monoxide supplied via lines (11) and (13), and recycled gas, supplied via lines (12) and (13), enter the liquid phase (7) in the reaction vessel (1) through a sparger (9) and bubble through to the vapour phase (8). The bubbles of gas stir the liquid phase as they rise.

Fresh and recycled alkanol supplied via lines (14) and (15) enter the reaction vessel via line (16). Triphenylphosphine and methane sulphonic acid are continuously supplied to the reaction vessel via line (17) at a rate sufficient to maintain constant catalyst activity. A small heavy ends bleed is taken from the reaction vessel via line (18). A very small quantity of palladium acetate is also added continuously to the reaction vessel via line (17) to make up for losses through the bleed.

A vapour stream, comprising alkyl propionate and alkanol, passes via line (19) through condenser (2) to gas/liquid separator (3). Separated gas is conducted via line (20) to compressor (6) and thence via line (12) back to the reaction vessel.

Separated liquid is conducted via line (21) to first distillation column (4). The top product comprising unreacted alkanol is recycled to the reaction vessel via line (15). When the alkanol is methanol, the top

product is an azeotropic mixture of methanol and methyl propionate.

The bottom product from the first distillation column (4) is conducted via line (22) to second distillation column (5), from which pure alkyl propionate is removed as top product via line (23), and heavy ends as bottom product via line (24).

Table 1 below details the process conditions and results of a 500-hour run using methanol as the alkanol.

Table I

Temperature	100 °C
Pressure	11 bar
Gas flow (CO and ethene) (molar ratio 1:1)	110 NI/h
Gas conversion per pass	10-15 %
Methanol level	18 w%
Methanol conversion per pass	25-30 %
Stripping efficiency	100 %
Initial concentrations of:-	
palladium acetate	2.2 mmol/l
triphenylphosphine	45 mmol/l
methane sulphonic acid	13 mmol/l
Triphenylphosphine consumption	1.6 kg/tonne

From Table I, the ligand consumption is 1.6 kg/tonne. This may be compared with a figure of 2.9 kg/tonne, which may be calculated from the data given in the Example of European patent application publication No. 0279477. Thus the process achieves a reduction of ligand consumption in excess of 40% compared with the known process.

2-Propyl propionate and 1-butyl propionate were prepared from 2-propanol and 1-butanol using procedures similar to that described above. In each case the run length was 75 hours. The runs were performed for the purpose of demonstrating that alkyl propionates other than methyl propionate can be prepared by the process according to the invention, and no attempts to optimize the process conditions were made. Table II gives details of the process conditions and the results.

Table II

Alkanol	2-propanol	1-butanol
Temperature	115-120 °C	110-115 °C
Pressure	11 bar	7 bar
Gas flow (CO and ethene) (molar ratio 1:1)	30-25 NI/h	40 NI/h
Alkanol level	20 %w	20 %w
Stripping efficiency	95%	93%
Initial concentrations of:-		
palladium acetate	1 mmol/l	2 mmol/l
triphenylphosphine	50 mmol/l	50 mmol/l
methane sulphonic acid	20 mmol/l	20 mmol/l
Triphenylphosphine consumption	5.5 kg/tonne	3.3 kg/tonne (0-19 hrs) 6.8 kg/tonne (19-43 hrs)
Rate of production of alkyl propionate	about 350 mol/molPd/hr	initially 500 mol/molPd/hr falling to 100 mol/mol Pd/hr during first 20 hrs, then remaining substantially constant

Claims

1. A continuous process for the preparation of an alkyl propionate, which comprises reacting an alkanol in a liquid phase with ethene and carbon monoxide in a reaction vessel in the presence of a carbonylation catalyst, and removing alkyl propionate from the reaction vessel in a stream of vapour.
2. A process as claimed in claim 1, in which ethene and carbon monoxide are bubbled through the liquid phase.
3. A process as claimed in claim 1 or claim 2, in which the carbonylation catalyst comprises a palladium compound, a ligand and a protonic acid.
4. A process as claimed in claim 3, in which the ligand is a triarylphosphine present in an amount of at least 5 moles per gram atom of palladium.
5. A process as claimed in claim 3 or claim 4, in which the protonic acid is selected from sulphuric acid; sulphonic acids; perhalic acids; 2,6-disubstituted benzoic acids; phosphoric acid; phosphonic acids; arsenic acid and complexes of HF with fluorine-containing Lewis acids.
6. A process as claimed in any one of claims 3 to 5, in which phosphine and protonic acid are supplied continuously to the reaction vessel.
7. A process as claimed in any one of claims 1 to 6, in which the pressure in the reaction vessel is in the range of from 8 to 12 bar.
8. A process as claimed in any one of claims 1 to 7, in which the reaction temperature is in the range of from 90 to 120 °C.
9. A process as claimed in any one of claims 1 to 8, in which the alkanol is methanol, 2-propanol or 1-butanol.
10. A process as claimed in claim 9, in which the alkanol is methanol.
11. A process as claimed in claim 10, in which the stream of vapour is cooled to afford a gas phase and a liquid phase, the gas phase is recycled back into the reaction vessel, and an azeotropic mixture of methanol and methyl propionate is distilled off from the liquid phase, condensed, and recycled back into the reaction vessel.

Patentansprüche

1. Ein kontinuierliches Verfahren zur Herstellung eines Alkylpropionats, umfassend das zur-Reaktion-bringen eines Alkanols in einer flüssigen Phase mit Ethen und Kohlenmonoxid in einem Reaktionsgefäß in Gegenwart eines Carbonylierungskatalysators und das Entfernen von Alkylpropionat aus dem Reaktionsgefäß in einem Dampfstrom.
2. Verfahren wie in Anspruch 1 beansprucht, in welchem Ethen und Kohlenmonoxid durch die flüssige Phase hindurchgeperlt werden.
3. Verfahren wie in Anspruch 1 oder 2 beansprucht, in welchem der Carbonylierungskatalysator eine Palladiumverbindung, einen Liganden und eine Protonsäure umfaßt.
4. Verfahren wie in Anspruch 3 beansprucht, in welchem der Ligand ein Triarylphosphin ist, das in einer Menge von mindestens 5 Mol pro Grammatom Palladium vorliegt.
5. Verfahren wie in Anspruch 3 oder 4 beansprucht, in welchem die Protonsäure ausgewählt wird aus Schwefelsäure; Sulphonsäuren; Perhalogensäuren; 2,6-disubstituierten Benzoesäuren; Phosphorsäure; Phosphonsäuren; Arsensäuren und Komplexen von HF mit fluorhaltigen Lewis-Säuren.



6. Verfahren wie in einem der Ansprüche 3 bis 5 beansprucht, in welchem das Phosphin und die Protonsäure dem Reaktionsgefäß kontinuierlich zugeführt werden.
- 5 7. Verfahren wie in einem der Ansprüche 1 bis 6 beansprucht, in welchem der Druck in dem Reaktionsgefäß im Bereich von 8 bis 12 bar liegt.
8. Verfahren wie in einem der Ansprüche 1 bis 7 beansprucht, in welchem die Reaktionstemperatur im Bereich von 90 bis 120 °C liegt.
- 10 9. Verfahren wie in einem der Ansprüche 1 bis 8 beansprucht, in welchem das Alkanol Methanol, 2-Propanol oder 1-Butanol ist.
10. Verfahren wie in Anspruch 9 beansprucht, in welchem das Alkanol Methanol ist.
- 15 11. Verfahren wie in Anspruch 10 beansprucht, in welchem der Dampfstrom abgekühlt wird, um eine Gasphase und eine flüssige Phase zu bilden, die Gasphase in das Reaktionsgefäß zurückgeführt wird und ein azeotropisches Gemisch aus Methanol und Methylpropionat aus der flüssigen Phase abdestilliert, kondensiert und in das Reaktionsgefäß zurückgeführt wird.

20 Revendications

1. Procédé continu de préparation d'un propionate d'alkyle, selon lequel on fait réagir un alcanol en phase liquide avec de l'éthène et du monoxyde de carbone, dans un réacteur en présence d'un catalyseur de carbonylation, et on évacue le propionate d'alkyle du réacteur dans un courant de vapeur.
- 25 2. Procédé selon la revendication 1, dans lequel l'éthène et le monoxyde de carbone barbotent à travers la phase liquide.
3. Procédé selon la revendication 1 ou 2, dans lequel le catalyseur de carbonylation comprend un composé du palladium, un ligand et un acide protique.
- 30 4. Procédé selon la revendication 3, dans lequel le ligand est une triarylphosphine présente en une quantité d'au moins 5 moles/mole de palladium.
- 35 5. Procédé selon la revendication 3 ou 4, dans lequel l'acide protique est choisi parmi l'acide sulfurique, les acides sulfoniques ; les acides perhaliques, les acides benzoïques 2,6-substitués ; l'acide phosphorique ; les acides phosphoniques ; l'acide arsénique et les complexes de HF avec des acides de Lewis fluorés.
- 40 6. Procédé selon l'une quelconque des revendications 3 à 5, dans lequel la phosphine et l'acide protique sont introduits de manière continue dans le réacteur.
7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel la pression dans le réacteur, est de 8 à 12 bars.
- 45 8. Procédé selon l'une quelconque des revendications 1 à 7, dans lequel la température réactionnelle est de 90 à 120 °C.
9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel l'alcanol est le méthanol, le propanol ou le 1-butanol.
- 50 10. Procédé selon la revendication 9, dans lequel l'alcanol est le méthanol.
11. Procédé selon la revendication 10, dans lequel le courant de vapeur est refroidi pour obtenir une phase gazeuse et une phase liquide, la phase gazeuse est recyclée dans le réacteur, et on sépare par distillation un mélange azeotropique de méthanol et de propionate de méthyle à partir de la phase liquide, on le condense et on le recycle dans le réacteur.
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