

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 665 210 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
04.11.1998 Bulletin 1998/45

(21) Application number: **94922379.6**

(22) Date of filing: **16.08.1994**

(51) Int. Cl.⁶: **C07C 53/08**, C07C 53/12,
C07C 51/12, C07C 51/44,
B01J 31/16, C07C 51/56,
C07C 51/573

(86) International application number:
PCT/JP94/01354

(87) International publication number:
WO 95/05356 (23.02.1995 Gazette 1995/09)

(54) PROCESS FOR PRODUCING ACETIC ANHYDRIDE ALONE OR BOTH OF ACETIC ANHYDRIDE AND ACETIC ACID

VERFAHREN ZUR HERSTELLUNG VON ACETANHYDRID ODER EINER MISCHUNG VON ACETANHYDRID UND ESSIGSÄURE

PROCEDE POUR PRODUIRE DE L'ANHYDRIDE ACETIQUE SEUL OU EN COMBINAISON AVEC DE L'ACIDE ACETIQUE

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **18.08.1993 JP 203896/93**

(43) Date of publication of application:
02.08.1995 Bulletin 1995/31

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Description

The present invention relates to a process for producing acetic anhydride alone or acetic anhydride and acetic acid by

(a) continuously reacting dimethyl ether and/or methyl acetate and optionally water and/or methanol with carbon monoxide alone or carbon monoxide and hydrogen in the presence of a rhodium compound and methyl iodide as the principal catalysts in a carbonylation reactor,

(b) introducing the resulting liquid reaction mixture into an evaporator having a pressure lower than that of the reactor to separate said reaction mixture into a volatile phase containing the product, unreacted dimethyl ether and/or methyl acetate, and methyl iodide, and a nonvolatile phase containing said rhodium compound,

(c) distilling said volatile phase from step (b) to obtain the product and a distillate containing the unreacted dimethyl ether and/or methyl acetate and methyl iodide, and

(d) recirculating said liquid distillate from step (c) to said reactor while recirculating said nonvolatile phase from step (b) containing said rhodium compound to said reactor,

characterized in that

- the distillate of step (c) is distilled before it is recirculated to said carbonylation reactor to remove acetaldehyde therefrom; and/or
- the bottoms obtained in step (c) containing the product and vinylacetate are introduced into a next distillation column, from the top of which the vinylacetate is separated and removed.

RELATED ART

Acetic acid is an essential compound necessary in many industries including polymer industry and chemical industry, wherein acetic acid is used in a large amount as a starting material of acetic esters, acetic anhydride, vinyl acetate, and terephthalic acid. On the other hand, acetic anhydride not only is used in a large amount as a starting material of cellulose acetate, but also is a useful compound as a starting material of chemicals such as drugs, perfumes, and dyes. Further, acetic acid and acetic anhydride are mutually related compounds in practical uses. For example, in the cellulose acetate industry, acetic anhydride is produced from acetic acid and then reacted with cellulose to give cellulose acetate and acetic acid, which is reused.

Although acetic anhydride has heretofore been produced from ketene obtained by thermal decomposition of acetic acid, there has recently been developed a process wherein acetic anhydride is produced from

methyl acetate or dimethyl ether, and carbon monoxide. A reaction involved in this process is a catalytic reaction wherein a rhodium compound and methyl iodide are used as the principal catalysts. Since the reaction rate is low when only the principal catalysts are used, however, various promoters have been proposed.

A function required of the promoters is to promote the reaction of methyl acetate or dimethyl ether with carbon monoxide to such an extent as to enable the reaction to be industrially operable. A desirable promoter is one which can exhibit a great reaction-promoting effect even when added in an amount as small as possible and is reduced in the formation of by-products including tar.

Although various promoters have been proposed for this purpose, the formation of such by-products is not always dependent on the kind of promoter alone. A primary factor of the formation of these by-products is believed to be a rhodium hydride complex formed by a reaction of the rhodium compound as one of the principal catalysts with hydrogen present in the liquid reaction mixture. Since rhodium serves as a catalyst in the main reaction, the concentration thereof in the liquid reaction mixture must be maintained at a necessary level. On the other hand, hydrogen is necessary for enabling rhodium as one of the principal catalysts to be maintained in a highly active monovalent state, and must therefore be fed together with carbon monoxide as one of the starting materials into a reactor according to known techniques (U.S. Patent No. 4,374,070).

Further, as the partial pressure of hydrogen in the gaseous phase portion in the reactor is increased, the amount of the by-products formed is increased. Aside from the magnitude of the amount of the by-products formed, this tendency is always recognized even when any promoter is used. Accordingly, it is a known fact that it is important in industrially carrying out the reaction to maintain the partial pressure of hydrogen in the gaseous phase portion in the reactor at a necessary but minimum and constant level.

In view of the foregoing, U.S. Patent No. 4,364,907 discloses a method of removing tar formed as a by-product, wherein tar extracted with an aqueous solution of HI is further extracted with aqueous ammonia to recover an additional amount of rhodium from the tar. However, this method necessarily involves the use of ammonia and subsequent removal of the ammonia from the process stream that must be returned to the reaction. Although various other methods have been attempted (U.S. Patent No. 4,476,238), the fact is that no methods of easily and effectively removing tar have been found out yet. Further, the presence of tar sometimes decreases the catalytic activity of the catalysts, and entrap the catalysts of an iodine and a noble metal to inactivate the catalyst and terminate the carbonylation reaction. It is therefore desired that as little tar, if any, as possible exists in the reaction system. EP-A-497521 discloses a process wherein alkanes and

alkane-like materials are removed from the recycle during the manufacture of acetic acid.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a flow diagram of an example of the process for producing acetic acid and acetic anhydride according to the present invention.

In Fig. 1, reference numeral 1 refers to a reactor, 2 to an evaporator, 3 to the first distillation column, 4 to the second distillation column, and 5 to the third distillation column.

DISCLOSURE OF THE INVENTION

The inventors of the present invention have found out that there is a close correlation between the amount of tar formed and the concentrations of by-products such as acetaldehyde, vinyl acetate and ethylidene diacetate formed in trace amounts simultaneously with the production of acetic anhydride alone or acetic acid and acetic anhydride with production equipment including a series of continuous units. More specifically, they have completed an effective process capable of remarkably decreasing the amount of tar formed as a by-product in a reactor or the subsequent evaporator by preventing the accumulation of at least one component of these by-products.

Specifically, the present invention relates to a process for continuously producing acetic anhydride alone or acetic anhydride and acetic acid by continuously reacting dimethyl ether and/or methyl acetate and optionally water and/or methanol with carbon monoxide or carbon monoxide and hydrogen in the presence of a rhodium compound and methyl iodide as the principal catalysts, wherein trace impurities causative of tar formation are separated in an evaporator and/or the subsequent refining step to remove the same.

The present invention provides a process for producing acetic anhydride alone or acetic anhydride and acetic acid by continuously reacting dimethyl ether and/or methyl acetate and optionally water and/or methanol with carbon monoxide alone or carbon monoxide and hydrogen in the presence of a rhodium compound and methyl iodide as the principal catalysts in a carbonylation reactor, introducing the resulting liquid reaction mixture into an evaporator having a pressure lower than that of the reactor to separate the reaction mixture into a volatile phase containing the product, unreacted dimethyl ether and/or methyl acetate, and methyl iodide, and a nonvolatile phase containing the rhodium compound, distilling the volatile phase to obtain the product and a distillate containing the unreacted dimethyl ether and/or methyl acetate and methyl iodide, and recirculating the liquid distillate to the reactor while recirculating the nonvolatile phase containing the rhodium compound to the reactor, wherein trace impurities causative of tar formation are distilled in the evaporator of distilla-

tion column type and/or distilled and separated in the subsequent refining step.

According to the present invention, the acetaldehyde and/or vinyl acetate formed as by-product(s) in the reactor or the following evaporator is separated and removed in the evaporator and/or the subsequent refining step to minimize the amount of tar formed as a by-product. Further, the ethylidene diacetate formed as a by-product in the reactor or in the following evaporator is decomposed by adding water to the catalyst solution to be recycled from the evaporator vessel to the reactor.

Compounds that can be suitably used as the starting materials in the present invention are methyl acetate, dimethyl ether, and methanol. The amount of methanol that may be used as the starting material for the reaction is closely correlated with the amount of the acetic acid to be produced. Accordingly, the use of methanol may be dispensed with if necessary. Methyl acetate and dimethyl ether may be used simultaneously. Further, water may be used if necessary. Carbon monoxide is used as another starting material to be fed into the reactor, and a small amount of hydrogen gas may additionally be fed into the reactor as already known (U.S. Patent No. 4,374,070). The amount of hydrogen gas that may be fed into the reactor may be such that the partial pressure of hydrogen inside the reactor is at least 0.5 atm. The partial pressure of hydrogen is preferably at most 5 atm. The partial pressure of carbon monoxide may be in the range of 10 to 100 atm.

Any kind of rhodium compound may be used as one of the principal catalysts for the reaction in so far as it can be dissolved in the liquid reaction mixture under reaction conditions. Usable examples of the rhodium compound include inorganic salts of rhodium, such as halide, nitrate, and sulfate of rhodium; organic acid salts of rhodium, such as carboxylates of rhodium; and organorhodium complexes having carbon monoxide, an amine or a phosphine coordinated with rhodium. The concentration of rhodium is preferably 100 to 3,000 ppm. The concentration of methyl iodide as another principal catalyst for the first carbonylation reaction in the liquid reaction mixture may be in the range of 5 to 30 wt. %.

The reaction is carried out under a reaction pressure of 10 to 100 atm, preferably 20 to 50 atm, at a temperature of 150 to 250°C.

Acetic anhydride and/or acetic acid is preferably used as a reaction solvent, though other organic solvents may be used as well. The mode of the reaction may be either a batch-wise reaction mode or a continuous reaction mode. From a more practical point of view, however, a continuous reaction mode is preferred.

A description will now be made of an example of the process according to the present invention while referring to Fig. 1. Where the reaction is carried out according to the continuous reaction mode, the starting materials, the catalysts and the solvent are continuously fed into a reactor (1). The liquid reaction mixture in the

reactor is continuously withdrawn therefrom and introduced into an evaporator (2) having a pressure lower than that of the reactor to separate the product therefrom. In this step, the product may be withdrawn either in the form of vapor or in the form of the reaction liquid.

Acetic anhydride as the product, methyl iodide as one of the catalysts, unreacted methyl acetate and/or dimethyl ether, acetic acid as the solvent, and trace amounts of acetaldehyde and vinyl acetate as by-products are evaporated when introduced from the high-temperature and high-pressure reactor to the low-pressure evaporator and sent to the refining step. Meanwhile a liquid containing the rhodium compound as the other one of the principal catalysts is withdrawn from the bottom of the evaporator and circulated to the reactor to be used again. In this step, the evaporator may be either of flash evaporation type or distillation column type with one or more plates (at least one plate). In order to lower the acetaldehyde and/or vinyl acetate content of the liquid to be circulated from the bottom of the evaporator to the reactor, however, the evaporator is preferably of distillation column type. When the evaporator is of distillation column type, the acetaldehyde and/or vinyl acetate content of the liquid to be circulated from the bottom of the evaporator to the reactor can be lowered to a greater extent to decrease the amount of tar formed. In other words, the impurities may advantageously be separated and removed through distillation in the evaporator of distillation column type instead of flash evaporation.

The liquid fraction not evaporated in the evaporator and containing rhodium, promoter, etc., is returned to the reactor. A trace amount of ethylidene diacetate causative of tar formation is concentrated in this liquid, but ethylidene diacetate is easily decomposed with water. Ethylidene diacetate is converted into vinyl acetate as a trace component having a very low boiling point through decomposition thereof with water, but vinyl acetate is easily distilled and separated in the evaporation vessel. Accordingly, a suitable amount of water may be added to the liquid fraction not evaporated in the evaporator. However, addition of water to the liquid not evaporated in the evaporator changes the acetic acid to acetic anhydride production ratio. In this case, the balance between acetic acid and acetic anhydride in the production thereof is controlled with methanol and methyl acetate and/or dimethyl ether and/or water to be fed into the reactor. The method of adding water to the liquid not evaporated in the evaporator vessel may be either mere direct feed of water into a bottoms withdrawal piping of the evaporator or provision of a hydrolysis reactor. The temperature of hydrolysis is preferably 10 to 300°C.

In the refining step, methyl iodide, methyl acetate, dimethyl ether, etc., as comparatively low-boiling components evaporated from the evaporator are separated in the first distillation column (3) and returned to the reactor to be used again. Part of the acetaldehyde

and/or vinyl acetate causative of tar formation is contained in the distillate from the distillation column and composed of the comparatively low-boiling components, when the distillate is circulated to the reactor. Accordingly, vinyl acetate is preferably withdrawn as much as possible as a bottom product from the first distillation column by adopting sufficient number of plates and/or reflux ratio in the first distillation column.

The liquid mixture of comparatively high-boiling acetic acid and acetic anhydride is separated into respective products in the second distillation column (4). Where vinyl acetate is withdrawn as a bottom product from the first distillation column, it must be separated and removed from product acetic acid and product acetic anhydride in the second distillation column. Specific methods of separating vinyl acetate from product acetic acid and product acetic anhydride in the second distillation column include a method wherein low-boiling components causative of tar formation are distilled from the top of the second distillation column and acetic acid is separated as a side cut withdrawn from a position below the feed plate of the second distillation column, while acetic anhydride is withdrawn as a bottom product from the bottom of the second distillation column; and a method wherein the mixture of acetic acid and acetic anhydride is withdrawn from the second distillation column and then separated and refined into product acetic acid and product acetic anhydride in another distillation column.

On the other hand, a trace amount of acetaldehyde contained in the liquid distilled from the first distillation column and comprising methyl iodide, methyl acetate and dimethyl ether is distilled and removed in the third distillation column (5), while methyl iodide, methyl acetate and dimethyl ether are withdrawn as bottom products from the third distillation column and circulated to the reactor to be used again. In the foregoing distillation procedure, separation and removal of acetaldehyde and separation and removal of vinyl acetate may be adopted either alone or in combination with each other. According to a conventional procedure, a liquid is directly circulated from the first distillation column to a reactor to contain large amounts of vinyl acetate and acetaldehyde. By contrast, distillation and separation of acetaldehyde in the third distillation column enable the amount of tar formed to be decreased.

The method of removing trace impurities causative of tar formation through distillation in the evaporator of distillation column type, the method of withdrawing vinyl acetate as a bottom product as much as possible from the first distillation column 3, and the method of distilling and removing acetaldehyde in the third distillation column 5 may be employed either alone or in combination with each other. However, they are preferably employed in combination with each other.

EXAMPLE

The following Examples will specifically illustrate the present invention, but should not be construed as limiting the scope of the invention.

Example 1

A continuous withdrawal type autoclave was charged with 420 g/hr of a catalyst solution (0.94 wt. % RhI_3 , 7.8 wt. % LiI , 45.6 wt. % acetic acid, and 45.6 wt. % acetic anhydride), 140 g/hr of methyl acetate, 140 g/hr of methyl iodide and 21 g/hr of methanol, and pressurized to a CO pressure of 17 atm and a hydrogen pressure of 2 atm and heated up to a temperature of 185°C. A liquid was continuously withdrawn from the autoclave and fed into an evaporator kept under a pressure of 2.4 atm at a temperature of 130°C. In the evaporator, acetic anhydride as the product, methyl iodide as the catalyst, unreacted methyl acetate and dimethyl ether, acetic acid as the solvent, and a trace amount of by-products were evaporated by flash evaporation and fed to the refining step. The liquid fraction not evaporated in the evaporator were recycled to the reactor since they contained rhodium, the promoter, etc. The fraction evaporated from the evaporator was fed to the first distillation column with 40 effective plates to effect separation thereof at a reflux ratio of 3. The distillate from the first distillation column was recycled as such to the reactor, while the bottoms from the first distillation column were fed to the second distillation column. In this Example, the proportion of tar formed as a by-product was 0.002 g (tar)/100 g (product acetic acid + product acetic anhydride).

Example 2

Substantially the same procedure as that of Example 1 was repeated except that the fraction evaporated from the evaporator was fed to the first distillation column with 60 effective plates to effect separation thereof at a reflux ratio of 3. In this case, the separability of vinyl acetate in the first distillation column was improved to decrease the amount of vinyl acetate circulated in the reaction system to 16% of that in Example 1. The proportion of tar formed as a by-product was 0.0004 g (tar)/100 g (product acetic acid + product acetic anhydride).

Example 3

Substantially the same procedure as that of Example 1 was repeated except that the reflux ratio in the first distillation column was altered to 5. In this case, the separability of vinyl acetate in the first distillation column was improved to decrease the amount of vinyl acetate circulated in the reaction system to 42% of that of Example 1. The proportion of tar formed as a by-product

was 0.001 g (tar)/100 g (product acetic acid + product acetic anhydride).

Example 4

Substantially the same procedure as that of Example 1 was repeated except that the extent of firing in the first distillation column was a little controlled to make the amount of methyl acetate withdrawn as a bottom product from the bottom of the first distillation column 10 times as much as that of Example 1 and the distillate from the first distillation column was fed to the third distillation column, from the top of which acetaldehyde was distilled off. Acetic acid and acetic anhydride were withdrawn as bottom products from the first distillation column and separated from each other in the second distillation column to make respective products. In this case, the amount of vinyl acetate circulated in the reaction system was decreased to 4.8% of that of Example 1. The proportion of tar formed as a by-product was 0.0001 g (tar)/100 g (product acetic acid + product acetic anhydride).

Example 5

Substantially the same procedure as that of Example 1 was repeated except that a distillation column with 15 effective plates was used as the evaporator at a reflux ratio of 1. In this case, the amount of vinyl acetate circulated in the reaction system was decreased to 10% of that of Example 1. The proportion of tar formed as a by-product was 0.0002 g (tar)/100 g (product acetic acid + product acetic anhydride).

35 Example 6

Substantially the same procedure as that of Example 1 was repeated except that water was added in a molar amount 10 times as much as that of the ethylidene diacetate contained in the bottoms from the evaporator to the bottoms from the evaporator midway of a piping and that no methanol was fed to the reactor. The proportion of tar formed as a by-product was 0.001 g (tar)/100 g (product acetic acid + product acetic anhydride).

Claims

1. A process for producing acetic anhydride alone or acetic anhydride and acetic acid by

- (a) continuously reacting dimethyl ether and/or methyl acetate and optionally water and/or methanol with carbon monoxide alone or carbon monoxide and hydrogen in the presence of a rhodium compound and methyl iodide as the principal catalysts in a carbonylation reactor,
- (b) introducing the resulting liquid reaction mix-

ture into an evaporator having a pressure lower than that of the reactor to separate said reaction mixture into a volatile phase containing the product, unreacted dimethyl ether and/or methyl acetate, and methyl iodide, and a non-volatile phase containing said rhodium compound,

(c) distilling said volatile phase from step (b) to obtain the product and a distillate containing the unreacted dimethyl ether and/or methyl acetate and methyl iodide, and

(d) recirculating said liquid distillate from step (c) to said reactor while recirculating said non-volatile phase from step (b) containing said rhodium compound to said reactor, characterized in that

- the distillate of step (c) is distilled before it is recirculated to said carbonylation reactor to remove acetaldehyde therefrom; and/or
- the bottoms obtained in step (c) containing the product and vinylacetate are introduced into a next distillation column, from the top of which the vinylacetate is separated and removed.

2. The process of claim 1, wherein the evaporator used in step (b) is a distillation column having at least one plate.
3. The process of claim 1 or 2, further comprising the step of adding water to the nonvolatile phase of step (b) containing the rhodium compound before recirculating same to the reactor.

Patentansprüche

1. Verfahren zur Herstellung von Acetanhydrid allein oder von Acetanhydrid und Essigsäure durch

(a) kontinuierliche Umsetzung von Dimethylether und/oder Methylacetat und gegebenenfalls Wasser und/oder Methanol mit Kohlenmonoxid allein oder mit Kohlenmonoxid und Wasserstoff in Anwesenheit einer Rhodiumverbindung und Methyljodid als die Hauptkatalysatoren in einem Carbonylierungsreaktor,

(b) Einleiten der erhaltenen flüssigen Reaktionsmischung in einen Verdampfer mit einem Druck, der niedriger ist als der des Reaktors, um die Reaktionsmischung in eine flüchtige Phase, enthaltend das Produkt, nicht umgesetzten Dimethylether und/oder Methylacetat und Methyljodid, und eine nicht-flüchtige Phase, enthaltend die Rhodiumverbindung, zu trennen,

(c) Destillieren der flüchtigen Phase aus Stufe (b), um das Produkt und ein Destillat, enthaltend nicht umgesetzten Dimethylether und/oder Methylacetat und Methyljodid, zu erhalten, und

(d) Rückführen des flüssigen Destillats aus Stufe (c) zu dem Reaktor, während die nicht-flüchtige Phase von Stufe (b), enthaltend die Rhodiumverbindung, in den Reaktor zurückgeführt wird,

dadurch gekennzeichnet, daß

- das Destillat von Stufe (c) destilliert wird, bevor es in den Carbonylierungsreaktor zurückgeführt wird, um Acetaldehyd daraus zu entfernen; und/oder
- der in Stufe (c) erhaltene Sumpf, enthaltend das Produkt und Vinylacetat in eine nächste Destillationskolonne eingeführt werden, an deren Kopf das Vinylacetat abgetrennt und entfernt wird.

2. Verfahren nach Anspruch 1, worin der in Stufe (b) verwendete Verdampfer eine Destillationskolonne mit mindestens einem Boden ist.
3. Verfahren nach Anspruch 1 oder 2, welches außerdem die Stufe der Zugabe von Wasser zu der nicht-flüchtigen Phase von Stufe (b), enthaltend die Rhodiumverbindung, umfaßt, bevor diese in den Reaktor zurückgeführt wird.

Revendications

1. Procédé de production d'anhydride acétique seul, ou d'anhydride acétique et d'acide acétique, par

(a) réaction en continu de diméthyléther et/ou d'acétate de méthyle et éventuellement d'eau et/ou de méthanol, avec du monoxyde de carbone seul ou avec du monoxyde de carbone et de l'hydrogène, en présence d'un composé du rhodium et d'iodure de méthyle servant de catalyseurs principaux dans un réacteur de carbonylation,

(b) introduction du mélange réactionnel liquide résultant dans un évaporateur ayant une pression inférieure à celle du réacteur pour séparer ledit mélange réactionnel en une phase volatile contenant le produit, le diméthyléther et/ou l'acétate de méthyle n'ayant pas réagi, et l'iodure de méthyle, et en une phase non volatile contenant ledit composé du rhodium,

(c) distillation de ladite phase volatile venant de l'étape (b) pour obtenir le produit et un distillat contenant le diméthyléther et/ou l'acétate de

méthyle n'ayant pas réagi et l'iodure de méthyle, et

(d) remise en circulation dudit distillat liquide venant de l'étape (c), dans ledit réacteur, tout en faisant recirculer ladite phase non volatile venant de l'étape (b) contenant ledit composé du rhodium, dans ledit réacteur, caractérisé en ce que

- le distillat de l'étape (c) est distillé avant d'être remis en circulation dans ledit réacteur de carbonylation, pour en extraire l'acétaldéhyde; et/ou
- les queues de distillation obtenues dans l'étape (c), contenant le produit et de l'acétate de vinyle, sont introduites dans une colonne de distillation suivante, de la tête de laquelle l'acétate de vinyle est séparé et éliminé.

2. Procédé selon la revendication 1, dans lequel l'évaporateur utilisé dans l'étape (b) est une colonne de distillation ayant au moins un plateau.

3. Procédé selon la revendication 1 ou 2, comportant en outre l'étape consistant à ajouter de l'eau à la phase non volatile de l'étape (b) contenant le composé du rhodium avant de la remettre en circulation dans le réacteur.

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Fig. 1/A

