carrier production steps and involves more expensive raw materials than when usual alumina is used. These facts inevitably raise the carrier production cost.

[0008]

From the viewpoints described above, the development of a low-cost and simple process which can produce cyclohexanone with a high yield is desired.

CITATION LIST

PATENT LITERATURE

[0009]

Patent Literature 1: US3305586

Patent Literature 2: US3076810

Patent Literature 3: US4918239

Patent Literature 4: GB1063357

Patent Literature 5: US5395976

SUMMARY

[0009a]

In one aspect of the present disclosure, there is provided a process for producing a cyclohexanone compound by performing hydrogenation reaction of a phenol compound in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the corresponding cyclohexanone compound, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from amine compounds and heteroaromatic compounds,

wherein the nitrogen compound is free from a structure formed by the bonding of a hydrogen atom to a nitrogen atom,

wherein the palladium catalyst supported on the carrier further includes at least one metal element selected from lithium, sodium, potassium, magnesium, calcium and barium, and

wherein the palladium catalyst supported on the carrier is obtained by impregnating the supported palladium catalyst still free from any alkali metal and/or alkaline earth metal compounds with an aqueous solution of hydroxides, nitrate salts, acetate salts or carbonate salts of at least one metal element selected from lithium, sodium, potassium, magnesium, calcium or barium, followed by drying or calcination.

[0009b]

In another aspect of the present disclosure, there is provided a process for producing cyclohexanone by performing hydrogenation reaction of phenol in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the cyclohexanone, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from amine compounds and heteroaromatic compounds,

wherein the nitrogen compound is free from a structure formed by the bonding of a hydrogen atom to a nitrogen atom,

wherein the palladium catalyst supported on the carrier further includes at least one metal element selected from

lithium, sodium, potassium, magnesium, calcium and barium, and

wherein the palladium catalyst supported on the carrier is obtained by impregnating the supported palladium catalyst still free from any alkali metal and/or alkaline earth metal compounds with an aqueous solution of hydroxides, nitrate salts, acetate salts or carbonate salts of at least one metal element selected from lithium, sodium, potassium, magnesium, calcium or barium, followed by drying or calcination.

TECHNICAL PROBLEM

[0010]

In light of the problems in the art discussed above, an object of the disclosure is to provide an economical and highly efficient process for producing a cyclohexanone compound such as cyclohexanone.

SOLUTION TO PROBLEM

[0011]

In order to achieve the above object, the present inventors carried out extensive studies on the production of a cyclohexanone compound such as cyclohexanone by the gas-phase hydrogenation reaction of a phenol compound such as phenol using a palladium catalyst supported on a carrier. As a result, the present inventors have found that the presence of a specific nitrogen compound in the hydrogenation reaction enhances the catalytic activity, suppresses the formation of byproducts to improve the selectivity for the cyclohexanone compound such as cyclohexanone, and retards the decrease in catalytic activity. The present disclosure has been completed based on the finding.

[0012]

Specifically, the present disclosure provides the following.

[0013]

[1] A process for producing a cyclohexanone compound by performing hydrogenation reaction of a phenol compound in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the corresponding cyclohexanone compound, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from ammonia, amine compounds and heteroaromatic compounds.

[0014]

[2] A process for producing cyclohexanone by performing hydrogenation reaction of phenol in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the cyclohexanone, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from ammonia, amine compounds and heteroaromatic compounds.

[0015]

[3] The process for producing cyclohexanone described in [2], wherein the nitrogen compound is free from a structure formed by the bonding of a hydrogen atom to a nitrogen atom.

[0016]

[4] The process for producing cyclohexanone described in [3], wherein the nitrogen compound is an amine compound having a tertiary amine structure.

[0017]

[5] The process for producing cyclohexanone described in [4], wherein the nitrogen compound is composed solely of hydrogen, carbon and nitrogen atoms.

[0018]

[6] The process for producing cyclohexanone described in any of [2] to [5], wherein the nitrogen compound is the nitrogen compound attached to the surface of the catalyst as a result of a contact with the palladium catalyst before the hydrogenation reaction.

[12] The process for producing cyclohexanone described in any of [2] to [11], wherein the reaction is performed in the presence of water.

[0025]

[13] A process for producing caprolactam, wherein the process uses cyclohexanone produced by the production process described in any of [2] to [12].

[0026]

[14] A catalyst obtained by bringing at least one nitrogen compound selected from ammonia, amine compounds and heteroaromatic compounds into contact with a palladium catalyst supported on a carrier so as to attach the nitrogen compound to the surface of the catalyst.

ADVANTAGEOUS EFFECTS

[0027]

The process for producing a cyclohexanone compound according to the present disclosure is excellent in particular in terms of production cost, and the target cyclohexanone compound may be produced while achieving process advantages and economic advantages.

[0028]

Further, the process for producing cyclohexanone according to the present disclosure has the following effects and is excellent in particular in terms of production cost.

CLAIMS

[Claim 1]

A process for producing a cyclohexanone compound by performing hydrogenation reaction of a phenol compound in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the corresponding cyclohexanone compound, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from amine compounds and heteroaromatic compounds,

wherein the nitrogen compound is free from a structure formed by the bonding of a hydrogen atom to a nitrogen atom,

wherein the palladium catalyst supported on the carrier further includes at least one metal element selected from lithium, sodium, potassium, magnesium, calcium and barium, and

wherein the palladium catalyst supported on the carrier is obtained by impregnating the supported palladium catalyst still free from any alkali metal and/or alkaline earth metal compounds with an aqueous solution of hydroxides, nitrate salts, acetate salts or carbonate salts of at least one metal element selected from lithium, sodium, potassium, magnesium, calcium or barium, followed by drying or calcination.

[Claim 2]

A process for producing cyclohexanone by performing hydrogenation reaction of phenol in a gas phase in the presence of a palladium catalyst supported on a carrier to produce the cyclohexanone, wherein the hydrogenation reaction is carried out in the presence of at least one nitrogen compound selected from amine compounds and heteroaromatic compounds,

wherein the nitrogen compound is free from a structure formed by the bonding of a hydrogen atom to a nitrogen atom,

wherein the palladium catalyst supported on the carrier further includes at least one metal element selected from

lithium, sodium, potassium, magnesium, calcium and barium, and

wherein the palladium catalyst supported on the carrier is obtained by impregnating the supported palladium catalyst still free from any alkali metal and/or alkaline earth metal compounds with an aqueous solution of hydroxides, nitrate salts, acetate salts or carbonate salts of at least one metal element selected from lithium, sodium, potassium, magnesium, calcium or barium, followed by drying or calcination.

[Claim 3]

The process for producing cyclohexanone according to claim 2, wherein the nitrogen compound is an amine compound having a tertiary amine structure.

[Claim 4]

The process for producing cyclohexanone according to claim 3, wherein the nitrogen compound is composed solely of hydrogen, carbon and nitrogen atoms.

[Claim 5]

The process for producing cyclohexanone according to claim 2, wherein the nitrogen compound is the nitrogen compound attached to the surface of the catalyst as a

result of a contact with the palladium catalyst before the hydrogenation reaction.

[Claim 6]

The process for producing cyclohexanone according to claim 2, wherein the nitrogen compound is the nitrogen compound added together with the raw material phenol.

[Claim 7]

The process for producing cyclohexanone according to claim 6, wherein the amount of the supply of the nitrogen compound is 0.005 to 0.05 wt% relative to the amount of the feed of phenol taken as 100 wt%.

[Claim 8]

The process for producing cyclohexanone according to claim 6, wherein the amount of the supply of the nitrogen compound is 0.01 to 0.05 wt% relative to the amount of the feed of phenol taken as 100 wt%.

[Claim 9]

The process for producing cyclohexanone according to claim 2, wherein the carrier is porous alumina.

[Claim 10]

The process for producing cyclohexanone according to claim 2, wherein the reaction is performed in the presence of water.