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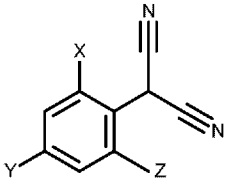
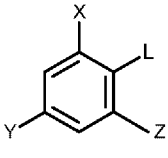
(54) Title: PROCESS FOR THE PREPARATION OF PHENYLMALONIC ACID DINITRILES




(I)




(II)

(57) Abstract: Process for the preparation of a compound of Formula (I), the process comprising the reaction of a compound of Formula (II) with malononitrile in the presence of a base and a palladium catalyst, Formula (II) wherein X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl; and L is a leaving group; with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro.

WO 2018/015489 A1

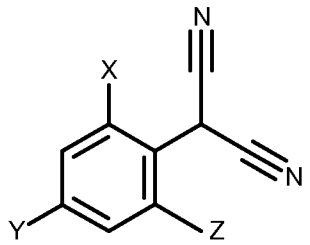
# PROCESS FOR THE PREPARATION OF PHENYLMALONIC ACID DINITRILES

The present invention relates to a process for the preparation of certain phenyl acetic acid derivatives, to intermediate dinitrile compounds useful in the process for the preparation of certain phenyl acetic acid derivatives, and to a process for the preparation of the intermediate dinitrile compounds.

Phenyl acetic acid derivatives have been disclosed in WO 97/002243 and WO 2015/007640 as intermediates in the preparation of spiroheterocyclic pyrrolidine diones, which are useful for combating and controlling pests such as insect, acarine, mollusc and nematode pests. Improved processes for the preparation of phenyl acetic acid derivatives, in particular, halogenated (eg, mono- or dichlorinated) phenyl acetic acid derivatives, have subsequently been sought.

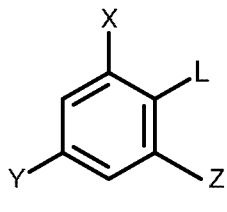
WO 00/78712 and WO 2004/050607 disclose the preparation of phenylmalonic acid dinitriles.

According to the present invention, there is provided a process for the preparation of a compound of Formula (I):




(I)

the process comprising the reaction of a compound of Formula (II) with malononitrile in the presence of a base and a palladium catalyst,




(II)

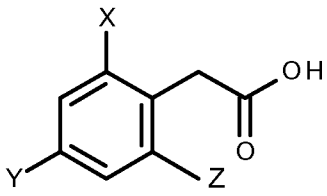
wherein

X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl; and

L is a leaving group;

with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro.

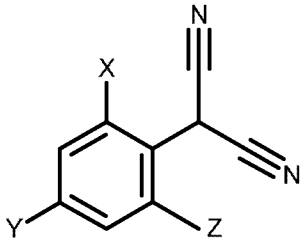
According to a second aspect of the invention, there is provided a process for the preparation of a compound of Formula (III):




(III)

the process comprising the reaction of a compound of Formula (I) according to the invention with an acid (or a base) in the presence of water, and optionally a further diluent.

According to a third aspect of the invention, there is provided a compound of Formula (I):




(I)

wherein

X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl; and

with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro.

It has been found that the processes according to the invention result in high yielding syntheses of the compounds according to Formulae (I) and (III). Furthermore, the processes according to the invention may provide accelerated reaction rates. Additionally, the processes according to the invention are suitable for the large-scale preparation of compounds according to Formulae (I) and (III).

Compounds of Formula (III) may find utility in the so-called Ugi multi-component reaction (Ugi-MCR) which is a one-pot condensation of a carboxylic acid (eg, compound according to Formula (III)), another carbonyl-containing moiety, an isocyanide and an amine (eg, an alkylamine such as methyl amine), each of which may be introduced simultaneously or in any sequence to a reaction vessel to form a diamide compound (eg, see WO 2015/007640). Such diamide compounds may be ring-closed to yield a spirone compound (which may be derivatised with the addition of a latentiating group), such as those which are useful for combating and controlling pests such as insect, acarine, mollusc and nematode pests (eg, see WO 2010/066780).

Preferably, the process for the preparation of a compound of Formula (I), comprises steps (i) and (ii), wherein:

(i) malononitrile is reacted with base to form a malononitrile anion ($[NCCHCN]^-$); and

(ii) the compound of Formula (II) is reacted with the malononitrile anion of step (i) in the presence of palladium catalyst to form a compound of Formula (I).

In the compounds of Formulae (I), (II) and (III) according to the invention, X, Y and Z independently of each other represent fluoro, chloro or $C_{1-4}$alkyl. Preferably, X, Y and Z independently of each other represent fluoro, chloro or methyl. More preferably, X, Y and Z independently of each other represent chloro or methyl. Most preferably, X is methyl, Y is chloro and Z is methyl.

In the compounds of Formula (II), Y is a leaving group. The leaving group may be selected from halogen, $RS(O)_2O$- wherein R is $C_{1-4}$alkyl, preferably methyl, $C_{1-4}$haloalkyl, preferably halomethyl or n-$C_4F_9$-, aryl, preferably phenyl, or phenyl substituted from one to three times by halogen, methyl or by halomethyl; and mono-, di- and tri-arylmethoxy. The aryl radicals of the mono-, di- and tri-arylmethoxy groups are preferably phenyl radicals, which may be substituted, for example, from one to three times by methyl, the substituents preferably being in the 2-, 4- and/or 6-positions of the phenyl ring. Examples of such leaving groups are methylsulfonyloxy (mesylate), trifluoromethylsulfonyloxy (triflate), p-tolylsulfonyloxy (tosylate), $CF_3(CF_2)_3S(O)_2O$- (nonaflate), diphenylmethoxy, di (methylphenyl)methoxy, triphenylmethoxy (trityl) and tri(methylphenyl)methoxy. Preferably, Y is a halogen, and most preferably bromo.

The diluents (eg, solvents, suspending agents) suitable for the preparation of a compound of Formula (I) according to the present invention include aliphatic, cycloaliphatic and aromatic hydrocarbons, for example pentane, hexane, petroleum ether, cyclohexane, methylcyclohexane, benzene, toluene or xylenes, aliphatic halohydrocarbons, for example, methylene chloride, chloroform, or di- or tetra-chloroethane, nitriles, for example acetonitrile, propionitrile or benzonitrile, ethers, for example diethyl ether, dibutyl ether, tert-butyl methyl ether, ethylene glycol dimethyl ether, ethylene glycol diethyl ether, diethylene glycol dimethyl ether, tetrahydrofuran or dioxane, alcohols, for example methanol, ethanol, propanol, butanol, ethylene glycol, diethylene glycol, ethylene glycol monomethyl or monoethyl ether or diethylene glycol monomethyl or monoethyl ether, ketones, for example acetone or methyl isobutyl ketone, esters or lactones, for example, ethyl or methyl acetate or valerolactone, N-substituted lactams, for example N-methyl-2-pyrrolidone (NMP or 1-methyl-2-pyrrolidone), amides, for example N,N-dimethylformamide (DMF) or dimethylacetamide (DMA), acyclic ureas, for example N,N'dimethylethyleneurea (DMI), sulfoxides, for example dimethyl sulfoxide (DMSO), or mixtures of such diluents. Water may also be used as a component of a biphasic mixture. Preferably, the process for the preparation of a compound of Formula (I) is carried out in the presence of a dipolar aprotic diluent, such as N,N-dimethylformamide, dimethyl sulfoxide, N-methyl-2-pyrrolidone, N,N-dimethylacetamide, N,N'-dimethylethyleneurea. N-methyl-2-pyrrolidone is most preferred.

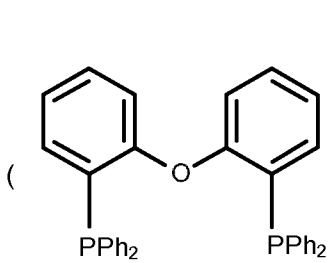
The process for the preparation of compounds of Formula (I) generally proceeds via two steps, firstly involving the generation of a malononitrile anion generated by reacting malononitrile with a base (eg, hydroxide), and, secondly, reaction of the malononitrile anion (*in situ*) with the compound of Formula (II) to carbon couple the anion to the phenyl ring of the compound of Formula (II), with loss of the leaving group L (eg, bromo). Preferably, the process is performed at a temperature of 50 to 200 °C, more

preferably at 80 to 170 °C, and most preferably at 110 to 150 °C. In some embodiments, increased pressure may be applied to the reaction conditions.

For the preparation of the malononitrile anion, inorganic or organic bases may be used. In particular, alkali metal hydroxides or mixtures of alkali metal hydroxides, alkali metal alkoxides or carbonates (eg, potassium carbonate, sodium carbonate, calcium carbonate, cesium carbonate) may be used. Hydroxides of alkali metals or mixtures of hydroxides of alkali metals are preferred. Sodium and potassium hydroxide (and mixtures thereof) are preferred, and especially sodium hydroxide. Preferably, the base is used from a molar equivalent to an excess of 10 equivalents in relation to malononitrile. More preferably, the base is used in amounts of 2 to 5 equivalents, or 2 to 4 equivalents in relation to malononitrile.

The process for the preparation of a compound of Formula (I) is carried out in the presence of a palladium catalyst, ie, to catalyse the carbon coupling reaction of the malononitrile anion. The palladium catalysts which may be useful for the carbon coupling anion are generally palladium (II) or palladium (0) complexes, for example palladium (II) dihalides, palladium (II) acetate, palladium (II) sulfate, bis(triphenylphosphine) palladium (II) dichloride, bis-(tricyclopentylphosphine) palladium (II) dichloride, bis(tricyclohexylphosphine) palladium (II) dichloride, bis(dibenzylideneacetone) palladium (0) or tetrakis(triphenylphosphine) palladium (0). Preferably, the palladium catalyst is prepared *in situ* from palladium (II) or palladium (0) compounds by complexing with phosphine ligands.

Examples of such ligands, include trimethylphosphine, triethylphosphine, tris(tert-butyl)phosphine, tricyclopentylphosphine, tricyclohexylphosphine ($PCy_3$), tri(methylcyclohexyl)phosphine, methyl(tetramethylene)phosphine, tert-butyl(pentamethylene) phosphine, triphenylphosphine ($PPh_3$), tri(methylphenyl)phosphine, 1,2-diphenylphosphinecyclohexane, 1,2-diphenylphosphinecyclopentane, 2,2'-(diphenylphosphine)-biphenyl, 1,2-bis(diphenylphosphine)ethane, 1,3-bis(diphenylphosphine) propane, 1,4-bis(diphenylphosphine)butane, 3,4-bis(diphenylphosphine)pyrrolidine, 2,2'-(diphenylphosphine)-bisnaphthyl (Binap), 1,1'-bis(diphenylphosphine)-ferrocene, 1,1'-bis (di-tert-butylphosphine) ferrocene, diphenyl ether bisdiphenylphosphine

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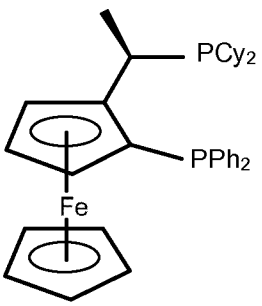
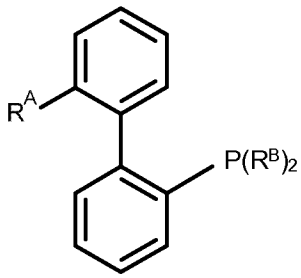



and




,

wherein $R^A$ is hydrogen or dimethylamino, and $R^B$ is cyclohexyl or tert-butyl.

The palladium catalyst used in the preparation of a compound of Formula (I) is present in an effective catalytic amount, which may for example be at a molar ratio to the compound of Formula (II) of 1:100 to 1:500, and preferably 1:200 to 1:400.

The process for the preparation of compounds of Formula (III) relates to the acid hydrolysis of the nitrile groups of the compounds of Formula (I). An inorganic acid may be used. Preferably, the acid is hydrochloric acid or sulphuric acid, and more preferably sulphuric acid. Additionally, preferably, the acid is present in at least two molar equivalents to the compound of Formula (I). More preferably, the acid is present at 2 to 5 molar equivalents, and even more preferably 3 to 4 molar equivalents to the compound of Formula (I).

The process for the preparation of a compound of Formula (III) is carried out in the presence of water (preferably, at least 4 molar equivalents) and optionally a further diluent. In some embodiments, the acid will be present in aqueous form and the compound of Formula (I) as a solution in a hydrocarbon solvent, such as benzene, toluene, xylene, mesitylene, and preferably, toluene or xylene. The reaction may be carried out in a water/toluene or water/xylene azeotrope under distillation conditions to reduce toluene/xylene and enrich water content in the reaction mixture.

Preferably, the process for the preparation of a compound according to Formula (III) is performed at a temperature of 100 to 180 °C, more preferably at 110 to 160 °C, and most preferably at 120 to 155 °C. In some embodiments, increased pressure may be applied to the reaction conditions.

Compounds of Formula (II) may be prepared from methods known in the literature, eg, WO 2010/102761 and WO 2006/084663.

Scheme 1: General reaction scheme of a process for the preparation of the compounds of Formula (I) and (III).

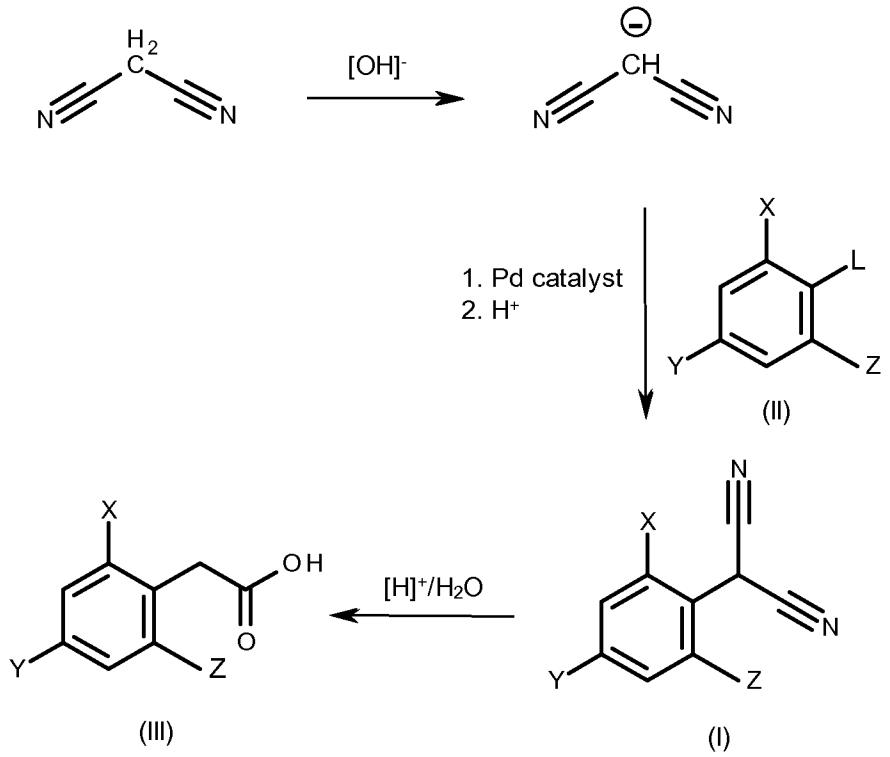
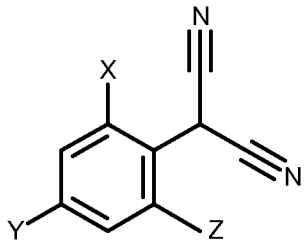


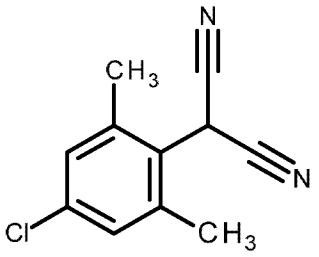

Table 1: This table discloses compounds 1.1 to 1.6 according to Formula (I) of the present invention, wherein X, Y and Z are defined in the following table.



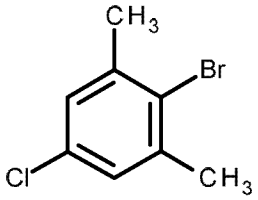

(I)

| Compound no. | X | Y | Z |
|---|---|---|---|
| 1.1 | $CH_3$ | F | $CH_3$ |
| 1.2 | $CH_3$ | Cl | $CH_3$ |
| 1.3 | F | $CH_3$ | $CH_3$ |
| 1.4 | Cl | $CH_3$ | $CH_3$ |
| 1.5 | F | F | $CH_3$ |
| 1.6 | Cl | Cl | $CH_3$ |

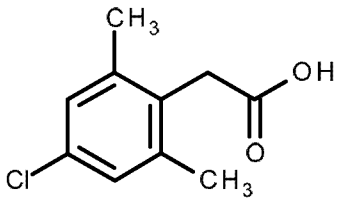
Preferably, the compound of Formula (I) is 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile.



Preferably, the compound of Formula (II) is 2-bromo-5-chloro-1,3-dimethyl-benzene.

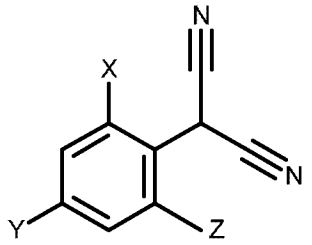


Preferably, the compound of Formula (III) is 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid.



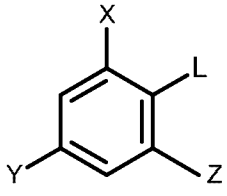
The processes of the present invention may be used in the preparation of any of the compounds of Formulae (IV), (VII) or (VIII) according to steps (i) to (v) as follows (and with reference in particular to the disclosure and examples of WO 2009/049851, WO 2010/066780 and WO 2015/007640):

(i) the preparation of a compound of Formula (I)



(I)

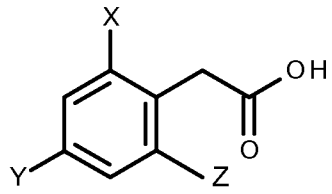
comprising the reaction of a compound of Formula (II) with malononitrile in the presence of a base and a palladium catalyst,



(II)

wherein X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro, and L is a leaving group;

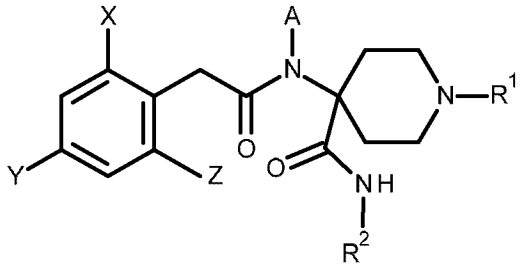
(ii) reacting the compound of Formula (I) with an acid (or a base) in the presence of water, and optionally a further diluent, to form a compound of Formula (III),



(III)

wherein X, Y and Z are as defined for step (i);

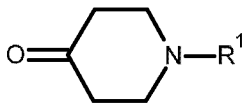
(iii) the preparation of a compound of Formula (IV)



(IV),

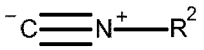
wherein A is $C_{1-4}$alkyl (preferably methyl), $R^1$ is $C_{1-4}$alkoxy (preferably methoxy), $R^2$ is phenyl or phenyl substituted by one or more substituents selected from the group consisting of $C_{1-4}$alkyl, $C_{1-4}$haloalkyl, $C_{1-4}$alkoxy, halogen and nitro, and X, Y and Z are as defined for step (i),

comprising reacting a compound of Formula (III) with a compound of Formula (V),



(V),

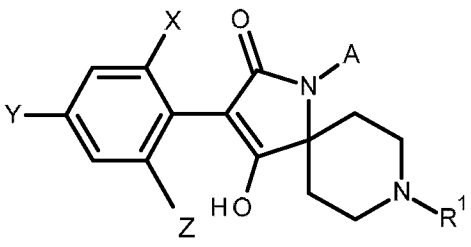
a compound of Formula (VI)



(VI), and

an amine of formula A-$NH_2$;

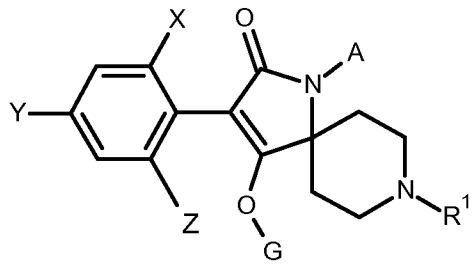
(iv) the preparation of a compound of Formula (VII)



(VII),

wherein X, Y, Z, A and $R^1$ are as defined for step (iii), comprising treating a compound of Formula (IV) with a suitable base in an appropriate solvent (or diluent); and

(v) the preparation of a compound of Formula (VIII)



(VIII)

wherein X, Y, Z, A and $R^1$ are as defined for step (iv) and G is a latentiating group C(O)R wherein R is $C_{1-4}$alkoxy (preferably ethoxy), comprising reacting a compound of Formula (VII) with an acid halide, in particular an acid halide of the formula RC(O)Cl, preferably in the presence of at least one equivalent of a base.

It is understood that the preferred embodiments for X, Y and Z in accordance with the present invention may apply equally to steps (i) to (v).

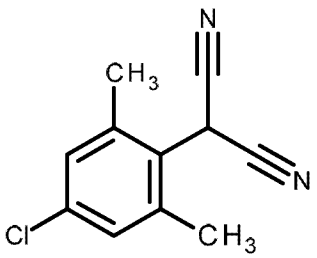
PREPARATION EXAMPLES:

The Examples which follow serve to illustrate the present invention.

Compounds of Formula (I) are prepared using malononitrile (N≡C-$CH_2$-C≡N), which is commercially available. Other reagents used in accordance with the preparation examples are also commercially available. 2-Bromo-5-chloro-1,3-dimethyl-benzene and 2-iodo-5-chloro-1,3-dimethyl-benzene may be prepared according to literature methods as described in, eg, WO 2006/084663.

**Example 1**:

*Preparation of 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile*



To a 400 mL vessel equipped with a mechanical stirrer, thermometer, distillation head and dropping funnel, solid sodium hydroxide (10.9 g, 0.27 mol, microprills with 0.5 - 1 mm diameter) is charged under an inert atmosphere.

1-Methyl-2-pyrrolidone (NMP, 137 g) is added to the vessel in one portion through the dropping funnel and the reaction mixture cooled to 10 - 15 °C while stirring. A solution of malononitrile (N≡C-$CH_2$-C≡N) (6.6 g, 0.10 mol) in NMP (8.9 g) is added through the dropping funnel over 10 - 15 minutes

maintaining the temperature at 10 - 15 °C. The reaction mixture is then heated to 100 °C and a vacuum (30 mbar) applied, upon which solvent (40 g) is distilled off.

2-Bromo-5-chloro-1,3-dimethyl-benzene (20 g, 0.089 mol) is then added through the dropping funnel over 5 - 10 minutes, whilst maintaining the temperature at 100 - 110 °C. A mixture containing palladium (II) chloride (0.19 g, solution in conc. hydrochloric acid, assay 20% Pd, 0.36 mmol), triphenylphosphine (0.45 g, 1.6 mmol) and NMP (18 g) is then added through the dropping funnel over a 5 - 10 minute period. The temperature is allowed to rise to 124 °C and the reaction mixture stirred at this temperature for 2 - 3 hours. Conversion is monitored by pulling samples and subsequent HPLC analysis.

When conversion is complete, a vacuum (20 - 40 mbar) is applied and solvent (90 g) is distilled off. The resulting residue is cooled below 100 °C and water (95 g) is added. After cooling to room temperature, the resulting mixture is filtered through hyflo (Hyflo® SuperCel® diatomaceous earth, ca. 10 g) and the filter cake washed with water (20 g). To the combined filtrates, hydrochloric acid (20.6 g, assay 32%, 0.18 mol) is added to adjust the pH from 13.3 to 2.7.

The resulting mixture is extracted with tert-butyl-methyl ether (2 x 110 g). The organic phases are washed with water (2 x 50g) and the combined organic phases evaporated to dryness. The resulting solid residue is recrystallized from iso-propanol (63 g) and the resulting crystals filtered, washed with cold iso-propanol (5 g) and dried under vacuum to yield 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile (melting point (m.p.) 145 - 147 °C).

$^1$H-NMR ($CDCl_3$) $\delta$(ppm): 2.6 (s), 6H; 5.3 (s), 1H; 7.2 (s), 2H.

**Example 2**:

*Preparation of 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile*

To a 1 litre vessel equipped with mechanical stirrer, thermometer, distillation head, joints for dosing liquids by pump, and gas inlet tube (below surface) solid sodium hydroxide (87.1 g, 2.18 mol, microprills with 0.5 - 1 mm diameter) is charged under an inert atmosphere.

1-Methyl-2-pyrrolidone (NMP, 682 g) is added in one portion while stirring and the resulting mixture cooled to 10 - 14°C. A solution of malononitrile (49.2 g, 0.736 mol) in NMP (65 g) is added via a pump over 15 - 20 minutes while maintaining the temperature at 10 - 14 °C. A vacuum (30 mbar) is applied and the resulting mixture is heated to 100 - 110°C until solvent (198 g) is distilled off. The mixture is then heated to 130 °C and a stream of nitrogen (4.5 litres/hour) is passed through.

A mixture containing palladium (II) chloride (1.15 g, solution in conc. hydrochloric acid; assay 20% Pd, 2.17 mmol), triphenylphosphine (1.50 g; 5.72 mmol) and NMP (147g) is dosed in via a pump within a 70 minute period. After 20 minutes feeding the aforementioned mixture, 2-bromo-5-chloro-1,3-dimethyl-benzene (160 g, 0.715 mol) is also dosed in in parallel via a pump within 50 minutes.

After both additions have been completed, the reaction mixture is maintained at 130 °C for a further 3 hours. A vacuum (20 - 30 mbar) is applied and solvent (603 g) is distilled off. The resulting residue is cooled below 100°C and water (450 g) is added. The resulting mixture is cooled to 40°C.

Hydrochloric acid (180 g, assay 32%,1.58 mol) is added in order to reduce the pH from 13.1 to 2.0. Toluene (535 g) is added for extraction of the product.

The two phase mixture is filtered through hyflo (ca. 15 g) and the filter-cake washed with toluene (45 g). The combined filtrates are transferred to a separation funnel, the aqueous phase separated and the organic phase washed with water (400 g). All aqueous phases are re-extracted with toluene (360 g) and all organic phases combined and evaporated to dryness. The solid residue is recrystallized with iso-propanol (650 g). The resulting crystals are filtered and washed with iso-propanol (55 g) and dried under vacuum to yield 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile (m.p. 145 - 147 °C).

**Example 3**:

*Preparation of 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile*

To a 250 mL vessel equipped with a mechanical stirrer, thermometer, distillation head and dropping funnel, solid sodium hydroxide (3.9 g, 0.10 mol, microprills with 0.5 - 1 mm diameter) is charged under an inert atmosphere.

1-Methyl-2-pyrrolidone (NMP, 68 g) is added to the vessel in one portion through the dropping funnel and the reaction mixture cooled to 10 - 15 °C while stirring. A solution of malononitrile ($N{\equiv}C\text{-}CH_2\text{-}C{\equiv}N$) (2.27 g, 0.034 mol) in NMP (2.7 g) is added through the dropping funnel over 5 minutes maintaining the temperature at 10 - 15 °C. The reaction mixture is then heated to 100 °C and a vacuum (30 mbar) applied, upon which solvent (32 g) is distilled off. The mixture is then heated to 130 °C and a stream of nitrogen is passed through.

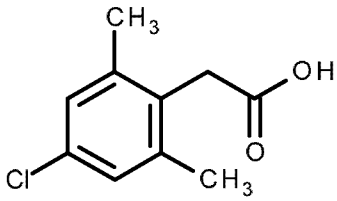
2-Iodo-5-chloro-1,3-dimethyl-benzene (9.0 g, 95% purity, 0.032 mol) is then added through the dropping funnel over 5 minutes at 130 °C. A mixture containing palladium (II) chloride (0.150 g, solution in conc. hydrochloric acid, assay 20% Pd, 0.281 mmol), triphenylphosphine (0.186 g, 0.709 mmol) and NMP (13.7 g) is then added through the dropping funnel over a 2-minute period. The temperature is allowed to rise to 130 °C and the reaction mixture stirred at this temperature for 80 min. Conversion is monitored by pulling samples and subsequent HPLC analysis. A second portion of a mixture containing palladium (II) chloride (0.103 g, solution in conc. hydrochloric acid, assay 20% Pd, 0.194 mmol), triphenylphosphine (0.132 g, 0.504 mmol) and NMP (9.76 g) is then added through the dropping funnel over a 2-minute period and the reaction mixture stirred at 130 °C for 40 min.

When conversion is complete, a vacuum (20 - 40 mbar) is applied and solvent (38 g) is distilled off. The resulting residue is cooled to 80 °C and water (30 g) is added. After cooling to room temperature, the resulting mixture is filtered through a filter paper and the filter cake washed with water (10 g). To the combined filtrates, hydrochloric acid (9.6 g, assay 32%, 0.084 mol) is added to adjust the pH from 13.3 to 1.3.

The resulting mixture is extracted with toluene (50 g). The organic phase is washed with water (2 x 20g) and evaporated to dryness. The resulting solid residue is recrystallized from 1-pentanol (17 g) and the resulting crystals filtered, washed with 1-pentanol (4 g) and dried under vacuum to yield 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile (melting point (m.p.) 145 - 147 °C).

**Example 4**:

*Preparation of 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid*



To a 500 mL reaction vessel equipped with thermometer, mechanical stirrer, distillation head with water trap and dropping funnel is added water (100 g) and concentrated sulphuric acid (assay 98%, 179g, 1.79 mol).

The mixture is stirred and heated to 120 - 130 °C, and a solution of 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile (assay 92.8%, 91.5 g, 0.415 mol) in toluene (1070 g) dosed in over 2 hours. The solvent (toluene/water azeotrope) is distilled off, and the water separated in the water trap is transferred back to the reaction mixture. After all of the organic solvent has been distilled off, the resulting reaction mass is heated to 140 °C for an additional 4 hours. Conversion is monitored by sampling and HPLC-analysis.

After complete conversion, the reaction mass is cooled to 60 °C and introduced into well-agitated water (900 g). The resulting mixture, a suspension, is cooled to 25 °C and filtered. The filter-cake, the desired product, is washed with water (2 x 220 g) and dried under vacuum. Crude 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid is obtained, which is recrystallized from toluene (608 g) affording pure 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid (m.p. 187 - 189 °C).

$^1$H-NMR ($CDCl_3$) $\delta$(ppm): 2.2 (s), 6H; 3.6 (s), 2H; 7.0 (s), 2H.

**Example 5**:

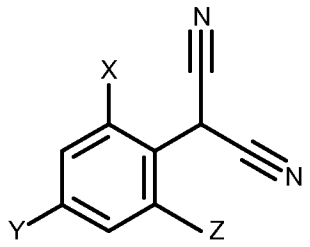
*Preparation of 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid*

To a 300 mL reaction vessel equipped with thermometer, mechanical stirrer and reflux condenser is added water (41 g) and concentrated sulphuric acid (assay 98%, 72 g, 0.72 mol). The mixture is stirred and heated to 140 °C.

Solid 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile (assay 98.4%, 50 g, 0.24 mol) is added over a 70 minute period in 10 equal portions while maintaining the temperature at 140 °C. The reaction mixture is stirred at 140 °C for another 2 - 3 hours and conversion is controlled by sampling and HPLC-analysis. When conversion is complete, the resulting mixture, a suspension, is cooled to room temperature. Water (100 g) is added and the suspension is filtered. The filter-cake, the desired product, is washed with water (2 x 50g) and dried under vacuum. Crude 2-(4-chloro-2,6-dimethyl-phenyl)acetic acid is obtained.

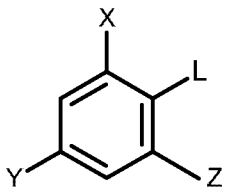
Claims:

1. A process for the preparation of a compound of Formula (I):




(I)

the process comprising the reaction of a compound of Formula (II) with malononitrile in the presence of a base and a palladium catalyst,




(II)

wherein

X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl; and

L is a leaving group;

with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro.

2. The process according to claim 1, comprising steps (i) and (ii), wherein:

(i) malononitrile is reacted with base to form a malononitrile anion ($[NCCHCN]^-$); and

(ii) the compound of Formula (II) is reacted with the malononitrile anion of step (i) in the presence of palladium catalyst to form a compound of Formula (I).

3. The process according to claim 1 or claim 2, wherein X is methyl, Y is chloro and Z is methyl.

4. The process according to any one of claims 1 to 3, wherein L is bromo.

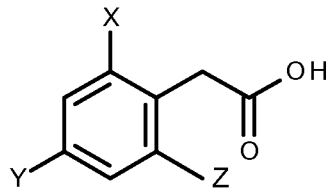
5. The process according to any one of claims 1 to 4, wherein the base is an alkali metal hydroxide, preferably sodium hydroxide.

6. The process according to any one of claims 1 to 5, wherein the palladium catalyst is prepared *in situ* from palladium (II) or palladium (0) compounds by complexing with phosphine ligands.

7. The process according to any one of claims 1 to 6, wherein the process is carried out in the presence of a dipolar aprotic solvent, preferably N-methyl-2-pyrrolidone.

8. The process according to any one of claims 1 to 7, wherein the process is carried out at 110 to 150 °C.

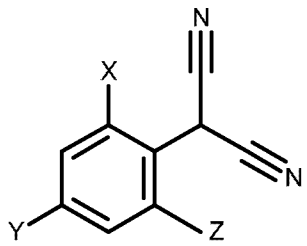
9. The process according to any one of claims 1 to 8, further comprising the step of reacting the compound of Formula (I) with an acid in the presence of water, and optionally a further diluent, to form a compound of Formula (III),




(III)

wherein X, Y and Z are as defined in claim 1 or claim 3.

10. A compound of Formula (I):




(I)

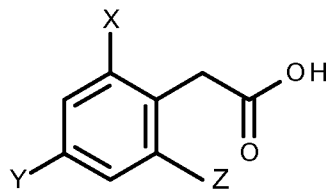
wherein

X, Y and Z, independently of each other, represent fluoro, chloro or $C_{1-4}$alkyl;

with the proviso that 1 or 2 of X and Y are, independently of each other, fluoro or chloro.

11. The compound according to claim 10, which is 2-(4-chloro-2,6-dimethyl-phenyl)propanedinitrile.

12. A process for the preparation of a compound of Formula (III):




(III)

the process comprising the reaction of a compound of Formula (I) according to claim 10 or 11 with an acid in the presence of water, and optionally a further diluent.

13. The process according to claim 9 or claim 12, wherein the acid is sulphuric acid.

14. The process according to claim 12 or claim 13, wherein the process is further carried out in the presence of toluene or xylene.

15. The process according to any one of claims 12 to 14, wherein the process is carried out at 120 to 155 °C.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068345

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07C253/30 C07C255/33 C07C51/08 C07C53/134
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| A | page 1, compound of general formula (I); page 9, Reaction Scheme 1; page 9, line 9 from the bottom to page 14, line 2; examples, e.g. Examples P6, P7 and P8; claims, e.g. Claim 1, Claims 10-23 | 9,12-15 |
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 25 August 2017 | 31/08/2017 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Sen, Alina |

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| A | page 589, "Reaction Scheme"; page 590, Table 1, entry 4 wherein R1, R3 and R5 are Me; page 590, last full paragraph | 1-9, 12-15 |
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Information on patent family members

International application No
PCT/EP2017/068345

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