Cyanoalkyl amines: an efficient reagent to stabilize palladium nano/microparticles for Suzuki and basic media for palladium(II) catalyzed Heck cross coupling reaction†

Bandna, Dhaminder Sharma, Pralay Das

Natural Plant Products Division, CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, H.P., India
Corresponding author: pdas@ihbt.res.in, pdas_nbu@yahoo.com, Fax: +91-1894-230433

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ABSTRACT: Tris-(β-cyanoethyl) amine (TCA) and bis-(β-cyanoethyl) amine (DCA) were prepared by silica-mediated aza-Michael reaction of ammonium hydroxide and acrylonitrile in gram scale. First time TCA was used as a stabilizer of Pd(0) nano/microparticles (TCA-Pd) and efficient reagent in water mediated Suzuki cross coupling reaction. Further DCA and TCA were applied as efficient base, ligand (N,N-ligand) and reaction medium in palladium-catalyzed Heck cross coupling reaction. © Global Scientific Publishers 2013.

KEYWORDS: Bis-(β-cyanoethyl) amine (DCA), Cyanoalkyl amine, micro/nanoparticles of palladium, Suzuki and Heck cross coupling, Tris-(β-cyanoethyl) amine (TCA).

1. Introduction

The Suzuki and Heck cross coupling reactions are most important, reliable and general reaction for carbon-carbon bond formation in modern organic chemistry [1, 2]. The coupling products of both the reaction have found good applications as intermediates in preparation of natural products and bioactive compounds [3, 4]. Both the reactions can be performed in organic solvents, water and ionic liquids [5-7]. In water mediated reaction there are however problems such as solubility of substrates and stability of the metal catalysts, but these problems have to some extent been overcome by the use of phase-transfer catalysts [8, 9], additives and water soluble ligands [10, 11]. Water-cosolvent such as H$_2$O-MeOH [12], H$_2$O-CH$_3$COCH$_3$ [13], H$_2$O-TBAB [14] and H$_2$O-PEG [15] combinations have been used in Suzuki coupling reaction. Recent advances have also been made to develop new catalytic system with enhanced activity towards aryl halides in Heck cross coupling reaction which includes the use of different ligands and additives [16, 17]. Triethanolamine and task specific ionic liquids have been used as base, ligand and reaction media in Heck cross coupling reaction [18, 19]. Further approaches include heating by microwave irradiation [20, 21] or application of supported catalysts [22-24]. Through literature survey and based on our practical experience, we have observed that tris-(β-cyanoethyl) amine (TCA) and bis-(β-cyanoethyl) amine (DCA) have interesting physico-chemical properties such as low melting point, high boiling point, soluble in polar and non-polar organic solvents (like water, benzene, ethyl acetate, dichloromethane) and recoverable. But there is no report to use TCA in water mediated Suzuki cross coupling reaction and the use of DCA as base, ligand and reaction media for Heck cross coupling reaction. DCA is a valuable starting material for a number of important syntheses. It can be converted by hydrogenation into dipropylene-amine which is employed as hardener for epoxide resins. TCA is used as an additive in plasticized poly (vinyl acetate) coating to increase tensile strength, as a promoter in catalytic oxidation of alkyl aromatic hydrocarbon to aromatic carboxylic acids and hydrolyzed to nitrilotripropionic acid which is useful as boiler scale inhibitor and remover [25]. TCA has also been used as ligand in the preparation of silver macrocyclic [26]. There are several methods reported for the synthesis of TCA and DCA. In most of the cases large ratio of polar solvent, high pressure, longer time and large reaction volume are required [27, 28].

In recent years our group has been working on the development of solid-supported palladium (SS-Pd) nano/microparticles as heterogeneous catalyst and their application in different area of organic synthesis [29-33]. Herein, we report a dry media synthesis of TCA and DCA on silica surface under milder condition by aza-Michael reaction. Further TCA has used as a stabilizer for in situ formation of palladium (0) nano/microparticles. The TCA-Pd has been found efficient reagent for water mediated Suzuki cross coupling reaction. TCA and DCA have applied as efficient base, ligand (N, N-ligand) and reaction medium in palladium catalyzed Heck cross coupling reaction (Fig. 1).
coated with gold by sputter coating unit at 10 Pascal vacuum for 10 second (E1010 ion sputter Hitachi, Japan).

2.2 Procedure for synthesis of tris-(β-cyanoethyl) amine (1) using silica

Ammonium hydroxide (30% aq. sol.) (2.7 ml, 28.5 mmol) and acrylonitrile (6.04 g, 114.1 mmol) was added to freely flowing silica and the reaction mixture was stirred at room temperature for 1 h and then heated to 80 °C for 15 h. The progress of reaction was monitored on TLC. After completion of reaction, the mixture was extracted with ethyl acetate 2-3 times and the combined organic layer was evaporated and crystallized in ethanol at 0 °C to yield I as a white solid (5.38 g, 80.4%), mp 49-50 °C; 1H NMR (300 MHz, CDCl$_3$-$d_2$) δ 2.47-2.52 (m, 6H), 2.89-2.93 (m, 6H); 13C NMR (75 MHz, CDCl$_3$-$d_2$) δ 19.28 (3C), 44.52 (3C), 118.95 (3CN).

2.3 Procedure for TCA synthesis using alumina

Ammonium hydroxide (30% aq. sol.) (278µl, 2.8 mmol) and acrylonitrile (605.4 mg, 11.41 mmol) was added to freely flowing alumina and the reaction mixture was stirred at room temperature for 1 h and then heated to 80 °C for 15 h. The progress of reaction was monitored on TLC. After completion of reaction, the mixture was extracted with ethyl acetate 2-3 times and the combined organic layer was evaporated to yield I as a white solid (468 mg, 69.91%).

2.4 Procedure for TCA synthesis using toluene

To a solution of ammonium hydroxide (30% aq. sol.) (277.9µl, 2.8 mmol) in toluene (0.5 ml), acrylonitrile (605.4 mg, 11.41 mmol) was added and the reaction mixture was stirred at 80 °C for 15 h. The progress of reaction was monitored on TLC. After completion of reaction, the mixture was evaporated to yield I as a white solid (370 mg, 55%).

2.5 Procedure for synthesis of bis-(β-cyanoethyl) amine (2) using silica

Ammonium hydroxide (30% aq. sol.) (2.7 ml, 28.5 mmol) and acrylonitrile (1.51 g, 28.5 mmol) was added to freely flowing silica and the reaction mixture was stirred at room temperature for 1 h and then heated to 80 °C for 15 h. The progress of reaction was monitored on TLC. After completion of reaction, the mixture was extracted with ethyl acetate 2-3 times and the combined organic layer was evaporated to yield 2 as a light yellowish liquid (1.37 g, 79.5%). 1H NMR (300 MHz, CDCl$_3$-$d_2$) δ 1.88 (s, 1H), 2.40-2.44 (m, 4H), 2.79-2.83 (m, 4H); 13C NMR (75 MHz, CDCl$_3$-$d_2$) δ 18.27 (2C), 43.95 (2C), 118.54 (2CN).

HRMS (ESI) data: m/z calcd for [M+ H]$^+$ C$_8$H$_7$N$_3$ 124.1638, obsd. 124.1637.

Figure 1. TCA and DCA act as base, ligand and reaction media

2. Experiments

2.1 General

All reagents of high quality were purchased from Sigma Aldrich. Silica gel (350 mesh size) for reactions was procured from SD Fine-Chem Ltd. Aluminum oxide (basic, 70-290 mesh size) was purchased from SRL Pvt. Ltd. Toluene was freshly distilled before use and dried over 4A$^\circ$ molecular sieves. Commercial reagents and solvents were of analytical grade and were purified by standard procedures prior to use. Thin layer chromatography was performed using pre-coated silica gel plates 60F$_254$. Microwave reactions were carried out in open vessel using a CEM Discover focused microwave (2450 MHz, 300W). The temperature of reactions in microwave heating experiments was measured by an inbuilt IR temperature probe that determined the temperature on the surface of reaction flask. The sensor is attached in a feedback loop with an on-board microprocessor to control the temperature rise rate. 1H and 13C-NMR spectra were recorded using Bruker Avance 300 spectrometer operating at 300 MHz ($^1$H) and 75 MHz ($^{13}$C). Spectra were recorded at 25 °C in CDCl$_3$ (residual CHCl$_3$ ($^ss$ 7.24 ppm) or CDCl$_3$ ($^sc$ 77.00 ppm) as international standard) with TMS as internal standard. Chemical shifts were recorded in δ (ppm) relative to the TMS signal, coupling constants (J) are given in Hz and multiplicities of signals are reported as follows: s, singlet; d, doublet; t, triplet; m, multiplet; br, broad singlet. The melting points were determined on a digital Barnsted Electrothermal 9100 apparatus. Mass spectra were recorded on a Waters Q-TOF-MS with electro spray ionisation (ESI) in Waters Masslynx software. Each sample was dissolved in acetonitrile:water (50:50) and directly injected into the ESI source at a flow rate of 5µL/min. The electronic spectra were recorded on a Perkin Elmer Lambda-35 UV/Vis spectrophotometer and the $\lambda_{max}$ are expressed in cm$^{-1}$. The sample for SEM analysis was mounted on an aluminum stub using double sided tape. The completely dried sample was
2.6 Procedure for synthesis of 4-methylbiphenyl (3) from Suzuki cross coupling reaction

A mixture of 4-bromotoluene (100 mg, 0.58 mmol), phenylboronic acid (91.86 mg, 0.76 mmol) and K$_2$CO$_3$ (161.42 mg, 1.2 mmol) in H$_2$O (0.5 ml) was added to in situ prepared TCA (240 mg) stabilized Pd(0) (from Pd(OAc)$_2$; 6.55 mg, 0.03 mmol) in a round bottom flask. The mixture was stirred at 80 °C for 8 h. Upon completion, the reaction mixture was allowed to cool at room temperature and extracted with diethyl ether (3x10 ml). The combined organic phase was dried with Na$_2$SO$_4$, evaporated under reduced pressure and purified by silica gel column chromatography (hexane:EtOAc, 90:10) giving 3 as a white solid (93 mg, 95%), mp 29.30 °C; $^1$H NMR (300 MHz, CDCl$_3$-d$_j$) δ 3.70 (s, 2H), 6.74 (d, J = 7.6 Hz, 1H), 6.98 (brs, 1H), 7.10 (d, J = 7.2 Hz, 1H), 7.28-7.53 (m, 1H), 7.44 (d, J = 6.5 Hz, 1H), 7.49-7.54 (m, 2H), 7.66-7.68 (m, 2H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_j$) δ 114.38 (2C), 117.72 (2C), 127.62 (2C), 129.17 (2C), 131.10, 141.88, 142.90, 147.29.

3-Chlorobiphenyl (8): Prepared as described for 3; Starting from 3-chlorobromobenzene (100 mg, 0.52 mmol) gave, after purification with silica gel column chromatography (hexane:EtOAc, 98:2) 8 as a colourless liquid (79 mg, 80%); $^1$H NMR (300 MHz, CDCl$_3$-d$_j$) δ 7.36-7.41 (m, 3H), 7.44-7.51 (m, 3H), 7.59-7.66 (m, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_j$) δ 125.68, 127.50 (2C), 127.65 (2C), 128.25, 129.29 (2C), 130.37, 135.04, 140.19, 143.52.

4-Phenylibiphenyl (9): Prepared as described for 3; Starting from 1,4 dibromobenzene (100 mg, 0.42 mmol) gave, after purification with silica gel column chromatography (hexane:EtOAc, 98:2) 9 as a white solid (73 mg, 75%), mp 209-212 °C; $^1$H NMR (300 MHz, CDCl$_3$-d$_j$) δ 7.37-7.40 (m, 2H), 7.42-7.52 (m, 4H), 7.67-7.71 (m, 8H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_j$) δ 127.47 (4C), 127.76 (2C), 127.92 (4C), 129.23 (4C), 140.53 (2C), 141.11 (2C).

2.7 Procedure for synthesis of 4-methyl-3',4'-dichlorobiphenyl (10)

A mixture of 4-iodotoluene (100 mg, 0.45 mmol), 3,4-dichlorophenylboronic acid (111.62 mg, 0.58 mmol) and K$_2$CO$_3$ (124.38 mg, 0.90 mmol) in water (0.5 ml) was added to in situ prepared TCA (240 mg) stabilized Pd(0) (from Pd(OAc)$_2$; 5.05 mg, 0.02 mmol) in a round bottom flask. The mixture was stirred at 80 °C for 6 h. Upon completion, the reaction mixture was allowed to cool at room temperature and extracted with diethyl ether (3x10 ml). The combined organic phase was dried with Na$_2$SO$_4$, evaporated under reduced pressure and purified by silica gel column chromatography (hexane:EtOAc, 99:1) to give 10 as a white solid (95 mg, 89%), mp 70-71 °C; $^1$H NMR (300 MHz, CDCl$_3$-d$_j$) δ 2.43 (s, 3H), 7.28 (m, 2H), 7.45 (m, 4H), 7.68 (m, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_j$) δ 19.32, 126.50, 127.12 (2C), 129.06, 130.09 (2C), 130.97, 131.31, 133.11, 136.19, 138.44, 141.52.

1-Phenylnaphthalene (11): Prepared as described for 10; Starting from 1-iodonaphthalene (100 mg, 0.39 mmol) gave, after purification with silica gel column chromatography (hexane:EtOAc, 98:2) 11 as a colourless liquid (72 mg, 90%); $^1$H NMR (300 MHz, CDCl$_3$-d$_j$) δ 7.55-7.62 (m, 9H), 7.97-8.08 (m, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_j$) δ 125.11, 125.76 (2C), 126.66, 126.96, 127.37, 129.99 (4C), 129.81 (2C), 131.37, 133.54, 140.00, 140.50.

4-Hydroxybiphenyl (12): Prepared as described for 10; Starting from 4-iodophenol (100 mg, 0.45 mmol) gave,
after purification with silica gel column chromatography (hexane:EtOAc, 92:8) 12 as a white solid (58 mg, 75%); mp 162-164 °C; 1H NMR (300 MHz, CDCl₃-d₅) δ 5.00 (s, 1H), 6.93 (m, 2H), 7.34-7.45 (m, 2H), 7.51-7.56 (m, 5H); 13C NMR (75 MHz, CDCl₃-d₅) δ 116.06 (2C), 127.13 (3C), 128.80 (2C), 129.13 (2C), 134.45, 141.16, 155.47.

2.8 Procedure for Suzuki cross coupling reaction under microwave condition

A mixture of 4-nitrobenzobenzene (100 mg, 0.49 mmol), phenylboronic acid (77.65 mg, 0.63 mmol), K₂CO₃ (155.44 mg, 0.98 mmol) in water (0.5 ml) was added to in situ prepared TCA (240 mg) stabilized Pd(0) (from Pd(OAc)₃; 5.50 mg, 0.02 mmol) in a round bottom flask. The mixture was irradiated under microwave system at 80 °C for 5 min. Upon completion, the reaction mixture was allowed to cool at room temperature and extracted with diethyl ether (3x10 ml). The combined organic phase was dried with Na₂SO₄, evaporated under reduced pressure and purified by silica gel column chromatography (hexane:EtOAc, 95:5) yielded 5 as a white solid (87 mg, 89%). Melting point and NMR data are same as described for 5 above.

Compounds 3-12 were also prepared under microwave conditions following the same method as described for 5.

2.9 Procedure for synthesis of Ethyl-3-p-tolylacrylate (13) from Heck cross coupling

A mixture of palladium acetate (5.05 mg, 0.02 mmol), 4-iodotoluene (100 mg, 0.45 mmol), ethyl acrylate (135.14 mg, 1.37 mmol) and TCA (322.43 mg, 1.83 mmol) was stirred at 110 °C for 12 h and the progress of the reaction was monitored by TLC. After completion of the reaction, the crude reaction mixture was diluted with diethyl ether. The organic layer was evaporated under reduced pressure. The obtained residue was purified by silica gel column chromatography (hexane:EtOAc, 99:1) yielded 13 as a colourless liquid (83 mg, 95%); 1H NMR (300 MHz, CDCl₃-d₅) δ 1.37-1.46 (m, 3H), 2.44 (s, 3H), 4.30-4.39 (m, 2H), 6.48 (dd, J = 15.9, 7.5 Hz, 1H), 7.27-7.29 (m, 2H), 7.48-7.52 (m, 2H), 7.75 (dd, J = 15.9, 7.5 Hz, 1H); 13C NMR (75MHz, CDCl₃-d₅) δ 14.44, 21.52, 60.48, 117.33, 128.15 (2C), 129.71 (2C), 131.89, 140.69, 144.68, 167.26; HRMS (ESI) data: m/z calcd for [M+H]⁺ C₁₅H₁₄O₂ 227.2784, obsd. 227.2749.

Ethyl-3-(naphthalene-5-yl) acrylates (15): Prepared as described for 13; Starting from 1-iodonaphthalene (100 mg, 0.39 mmol) gave, after purification with silica gel column chromatography (hexane:EtOAc, 98:2) 15 as a colourless liquid (85 mg, 96%); 1H NMR (300 MHz, CDCl₃-d₅) δ 1.40-1.43 (m, 3H), 4.31-4.38 (m, 2H), 6.56 (d, J = 15.7 Hz, 1H), 7.48-7.63 (m, 3H), 7.80 (d, J = 7.1, 1H), 7.88-7.92 (m, 2H), 8.22 (d, J = 8.0 Hz, 1H), 8.56 (d, J = 15.7 Hz, 1H); 13C NMR (75 MHz, CDCl₃-d₅) δ 14.80, 61.04, 121.33, 123.82, 125.40, 125.88, 126.63, 127.26, 129.13, 130.31, 131.81, 132.23, 134.07, 142.03, 167.33; HRMS (ESI) data: m/z calcd for [M+H]⁺ C₁₅H₁₁O₂ 227.2784, obsd. 227.2749.

2.10 Procedure for synthesis of Ethyl-3-(3-chlorophenyl)acrylates (16) from Heck cross coupling

A mixture of palladium acetate (11.6 mg, 0.05 mmol), 1-bromo-3-chlorobenzene (100 mg, 0.52 mmol), ethyl acrylate (156.18 mg, 1.56 mmol) and TCA (732.1 mg, 4.16 mmol) was stirred at 110 °C for 15 h and monitored on TLC. After completion of reaction, the crude reaction mixture was diluted with ethyl acetate. The organic layer was evaporated under vacuum. The obtained residue was purified by silica gel column chromatography (hexane:EtOAc, 98:2) yielded 16 as a colourless liquid (77

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*Isolated Yield, acrylonitrile (ACN)
mg, 70%); $^1$H NMR (300 MHz, CDCl$_3$-d$_4$) δ 1.31-1.36 (m, 3H), 4.23-4.30 (m, 2H), 6.43 (d, $J = 16.0$ Hz, 1H), 7.31-7.37 (m, 2H), 7.39-7.50 (m, 2H), 7.60 (d, $J = 16.0$ Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$-d$_4$) δ 14.41, 60.78, 118.25, 126.32, 127.90, 130.19 (2C), 135.04, 136.46, 143.03, 166.64; HRMS (ESI) data: m/z calcd for [M+ H]$^+$ C$_{11}$H$_{11}$ClO$_2$ 211.6645, obsd. 211.6631.

**Ethyl-3-p-tolylacrylate (13):** Prepared as described for 16. Starting from 4-bromotoluene (100 mg, 0.53 mmol) gave, after purification with silica gel column chromatography (hexane:EtOAc, 99:1) 13 as a colourless liquid (66 mg, 65%). NMR data is same as described for 13 above. Compound 13 (Tab. 4, entry 6) was also prepared by using DCA (4 eq.) following the same methods described for TCA.

Figure 2. *In situ* formation of palladium(0) nano/microparticle stabilized by TCA

Figure 3. UV-Vis absorption spectrometric study for *in situ* conversion of Pd(II) to Pd(0). Reagents and conditions: (a) TCA in DMF; (b) Pd(OAc)$_2$ in DMF at initial stage; (c) TCA+ Pd(OAc)$_2$ after 1-2 min at rt (recorded in DMF); (d) after heated at 80 °C for 30 min TCA+ Pd(0) (recorded in DMF).
Figure 4. (a) FT-IR spectra of TCA, (b) FT-IR spectra of TCA-Pd.
3. Results and Discussion

Initially, silica surface was chosen to investigate aza-Michael reaction [34] of ammonium hydroxide (30% aq. sol.) with acrylonitrile. 1:4 Molar ratios of ammonium hydroxide and acrylonitrile gave highest yield of 1. When ammonium hydroxide and acrylonitrile were added in 1:2 and 1:3 molar ratios, mixture of products 1 and 2 were obtained. Interestingly equimolar (1:1) mixture of ammonium hydroxide and acrylonitrile gave highest yield of 2. Moderate yield of 1 was observed under acidic alumina and toluene condition (Tab. 1).

Previously nitrile functionalized ionic liquid has been used for the formation of palladium nanoparticles [35]. It has been demonstrated that nitrile group enhance the catalytic stability and prevent aggregation. When TCA was treated with Pd(OAc)$_2$ at 80 °C for 30 min. the brown colour of solution changed to blackish (Fig. 2).

The in situ conversion of Pd(II) to Pd(0) was monitored by UV-Visible absorption spectrophotometer (Fig. 3).

FT-IR spectra of TCA and TCA-Pd (Fig. 4) also showed the binding of nitrile moiety with palladium. The two $\nu_{CN}$ stretching vibration bands at 2243 cm$^{-1}$ and 2360 cm$^{-1}$ in infrared spectra of TCA-Pd demonstrated the presence of uncoordinated (or weakly binding) and metal bound cyano group. Surface studies of TCA (Fig. 5(a)) and TCA-Pd (Fig. 5(b)) were also performed to see the formation of nano/microparticles of Pd(0) stabilized by TCA.

First time TCA was used as stabilizer of Pd(0) nano/microparticles in water mediated Suzuki cross coupling reaction. Due to interesting physicochemical properties of TCA, it behaves as interface reagent to bring the substrates (such as Pd(0), hydrophobic compounds and water) in a common surface to interact with each other to give high performance of the reaction. The Suzuki cross coupling reaction of 4-bromotoluene and phenyl boronic acid in water with in situ prepared TCA-Pd under microwave irradiation for 5 minute gave corresponding product 3 in 81% yield (Tab. 2, entry 1). Similar reaction under conventional condition gave 3 in 80% yield after 8 h. Different aryl bromides substituted with hydroxy, nitro, methoxy and amino groups were found suitable under conventional and microwave heating conditions (Tab. 2, entries 2-5). Selective bromo coupled product of 3-chlorobromobenzene was observed under both the conditions (Tab. 2, entry 6). 1,4-Dibromobenzene under same conditions gave major disubstituted product (Tab. 2, entry 7). The reaction was further extended for the cross coupling reaction of aryl bromides with different arylboronic acids. The result indicated that the electron deficient 3,4-dichlorophenyl boronic acid afforded the corresponding product with moderate yield (Tab. 2, entry 8). Different aryl iodides also gave corresponding cross coupled products in good yield (Tab. 2, entries 9-12).

Figure 5 (a) Scanning Electron Micrograph (SEM) of TCA surface, (b) Scanning Electron Micrograph (SEM) of TCA-Pd(0) surface and (c) histogram illustrating the particle size distribution of Pd(0) nano/microparticles
Table 2. Suzuki cross coupling of different aryl halides in water with TCA-Pd(0)

\[
X + B(OH)_2 \xrightarrow{TCA-Pd(0), K_2CO_3, 80\degree C, 6-8\ h} R \quad R' \quad 80\degree C, 6-8\ h, \\
MW, 5-7\ min. \\
H_2O
\]

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<th>Entry</th>
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<sup>a</sup> Isolated Yield
Table 3. Optimization study for Heck cross coupling reaction

Through these studies 4 equivalent of TCA was found suitable as a media and base for Heck cross coupling reaction of 4-iodotoluene (Tab. 3). Under similar reaction condition, 4 equivalent of DCA gave low yield of corresponding product as compare to TCA (Tab. 3).

Table 4. TCA or DCA promoted Heck cross coupling reaction of different aryl halides

Through these studies 4 equivalent of TCA was found suitable as a media and base for Heck cross coupling reaction of 4-iodotoluene (Tab. 3). Under similar reaction condition, 4 equivalent of DCA gave low yield of corresponding product as compare to TCA (Tab. 3).

1-iodonaphthalene and 4-iodophenol underwent Heck cross coupling reaction under same condition and afforded corresponding coupled products 14 and 15 (Tab. 4, entries 2 and 3). Heck cross coupling reaction of different aryl bromides were also investigated to examine the scope of the procedures. For 4-bromotoluene, corresponding coupling products 13 was obtained in 65% yield (Tab. 4, entry 4).

Reaction of 1-bromo-3-chlorobenzene with ethyl acrylate gave the corresponding Heck cross coupling product 16 in 70% yield (Tab. 4, entry 5). DCA was not found to be suitable reaction media for Heck cross coupling reaction of aryl bromides and the probable reason might be due to its less basic nature than TCA. But Heck cross coupling reaction of 4-iodotoluene in DCA (4 eq.) gave 13 in 70% yield which could be considered as a good conversion under this mild basic condition (Tab. 4, entry 6).
4. Conclusions

In summary, a silica mediated aza-Michael reaction of ammonium hydroxide and acrylonitrile was carried out to produce TCA and DCA. First time TCA was applied in water mediated Suzuki cross coupling reaction and could be referred as interface reagent. Further TCA and DCA act as a reaction media, ligand and base in Heck cross coupling reaction. The solubility and high boiling point were found to be very interesting properties to use TCA in water mediated and microwave assisted reactions. Simultaneously, due to property of TCA as a stabilizer of nano/microparticles in reaction media, it could be used in different metal catalyzed organic transformations.

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