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Chemoselective hydration of nitriles to amides by hydrated ionic liquid (IL) tetrabutylammonium hydroxide (TBAH) as a green catalyst

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Abstract

A transition metal–free process, catalyzed by tetrabutylammonium hydroxides (TBAH), has been developed for convenient and selective hydration of nitriles to the corresponding amides. The present process converts the aromatic, aliphatic, and heteroaromatic nitriles into wide functional group. The regioselective hydration of one nitrile moiety in the presence of an other nitrile groups makes high impact in the present protocol.

Keywords: Nitrile; amide; ionic liquid; tetrabutylammonium hydroxides; green chemistry.

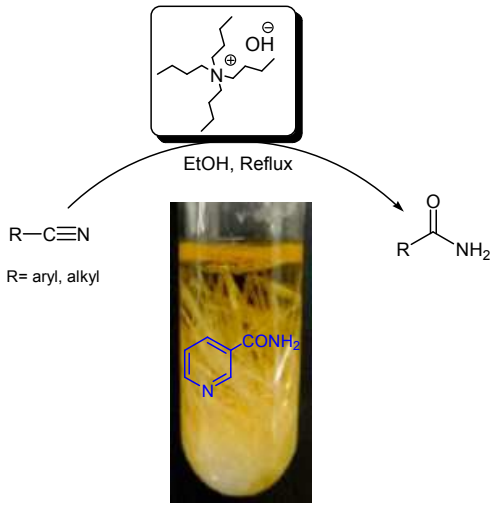
Introduction

Nitriles are one of the most important and versatile functional groups of organic compounds, which can easily be diversified into numerous important products, such as aldehydes, ketones, amines, amides, acids, and nitrogen-containing heterocycles, such as tetrazoles and oxazoles. Among them, the conversion of nitriles to amides by hydrolysis reaction has great synthetic significance in the preparation of the corresponding amides for the *isohypsic* nature of the transformation that is an important factor in redox-economy in organic synthesis.[1] These reactions have been investigated widely in organic synthesis to its broad industrial and pharmacological applications.[2] For example, hydration of acrylonitrile produces annually more than 2×10^5 tons of acrylamide and is the most important technology for the production of this chemical.[3] The reaction proceeds in a sequence of distinct steps upon treatment with strong acids or bases. Due to these harsh conditions, carboxylic acids could form as the major byproduct, and more importantly, acid or base labile functional groups and protective groups cannot be tolerated.[4] Although metals,

especially transition metal catalyzed nitrile hydrolysis reactions, have offered mild reaction conditions and selective formation of amides without the formation of carboxylic acids, functional group tolerability during the nitrile hydrolysis has not been addressed yet.[5] Several homogeneous and heterogeneous metal and metal oxide or salt catalysts, such as Ru,[6] Rd,[7] K,[8] Na,[9] Au,[10] Os,[11] Pt,[12] Pd,[13] Ir,[14] Mo,[15] Mn,[16] Fe,[17] Co,[18] Cu,[19] Ag,[20] Ce,[21] and Ni,[22] have also been reported for the hydration of nitriles. Unfortunately, each of these protocols is associated with certain debilitating disadvantages that include *(i)* formation of unwanted acids as side products, *(ii)* high reaction temperatures, and *(iii)* The presence of toxic transition metal cations within molecular structure of the reagents (*iv*) the failure, most importantly, with substrates that contain more than two nitrile groups. Thus, the development of an efficient and mild process for the synthesis of amides from nitriles even in the presence of other labile functional groups would be a valuable tool in organic synthesis.

Results and discussions

Herein, as part of our ongoing study to develop more efficient and environmentally benign methods for organic synthesis using economic and eco-friendly materials as catalysts and reagents,[23] we report a selective hydrolysis reaction of nitriles to amides under essentially aqueous media by hydrated ionic liquid (IL) tetrabutylammonium hydroxide (50% in aqueous media) conditions that allow other functional groups to remain intact (Scheme 1).



Scheme 1 Selective hydrolysis reaction of nitriles to amides

Ionic liquids (ILs) have received considerable interest as eco-friendly solvents, catalysts, and reagents in the context of green synthesis because of their solvating ability, low volatility, nonflammability, ability to dissolve a wide range of materials, easy recyclability and reusability.[24]

The reaction parameters are optimized using benzonitrile as a model substrate in the presence of hydrated ionic liquid (IL) tetrabutylammonium hydroxide (TBAH). Typical reaction parameters including various solvent, time and temperature are screened and the results are summarized in Table 1. The results show that EtOH is a better solvent (Table 1, entry 7, Yield 96%). The hydrolysis on nitrile to amide in the presence of the tetrabutylammonium hydroxide may be accomplished without the use of a diluents or solvent, provided that there is sufficient miscibility between the nitrile and the water. In the event that there is not sufficient miscibility, a water miscible solvent (for example, an alcohol) may be used so as to increase miscibility. In the reaction using H_2O (entry 2) as solvent, poor solubility of benzonitrile may has contributed to the lower yield (50%).

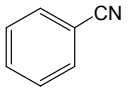
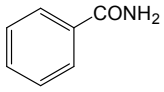
Table 1. Effect of various conditions in the hydration of benzonitrile using TBAH[a]

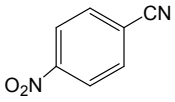
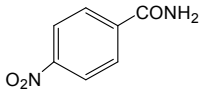
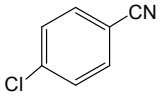
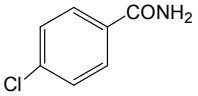
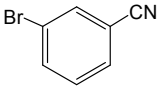
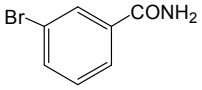
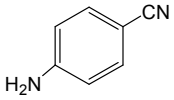
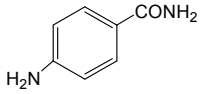
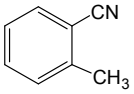
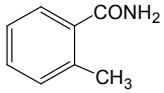
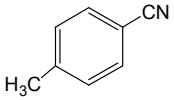
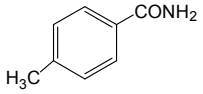
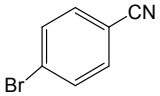
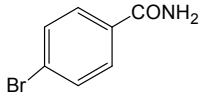
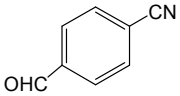
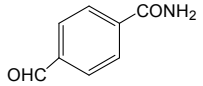
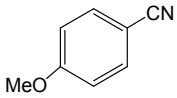
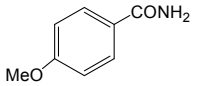
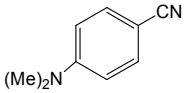
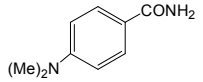
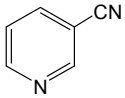
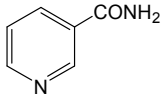
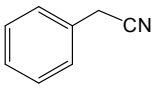
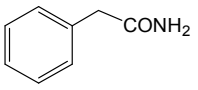
Entry	Solvent	Temp. (°C)	Time (h)	Yield[b] (%)
1	None	80	24	-[c]
2	H_2O	Reflux	24	50
3	Toluene	Reflux	12	30
4	THF	Reflux	12	35
5	CH_3CN	Reflux	10	30
6	CH_2Cl_2	Reflux	24	-[c]
7	EtOH	Reflux	3	96
8	CH_3OH	Reflux	5	80
9	n-Hexane	Reflux	12	-[c]
10	EtOH	25	10	35
11	EtOH	50	10	60

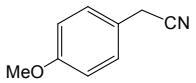
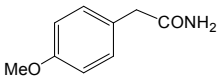
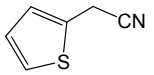
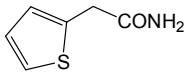
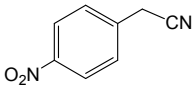
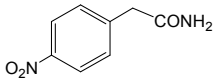
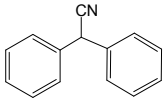
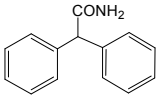
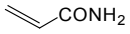
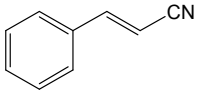
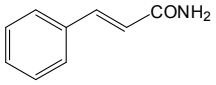
[a] Reaction conditions: benzonitrile (1 mmol), TBAH (0.5 ml, 50% in aqueous media), Solvent (5 ml). [b]Yields refers to the pure isolated products. [c]No reaction

The present invention is applicable to the hydrolysis of a wide variety of nitriles to amides, including the hydrolysis of aliphatic nitriles, aromatic nitriles, and heterocyclic nitriles. As can be seen from Table 2, aromatic nitriles carrying either electron-donating such as *p*-methyl and *p*-methoxy or electron-withdrawing such as *p*-bromo, chloro and *p*-nitro groups exhibit comparable reactivity and react efficiently to yield the final product. In the case of 2-methyl- and 4-methyl-benzonitrile (entries 6,7) the hydration takes place within 5-6 hours, the yield is 90-92% and in the same way, 4-nitrobenzonitrile (entry 2) yields the corresponding 4-nitrobenzamide in 92% within 6 h. From this observation, it appears that electron-donating or electron-withdrawing groups do not affect significantly the rate of reaction. It was interesting to observe that the selective oxidation of 4-formylbenzonitrile to the corresponding amide could be performed without oxidation of the formyl group (entry 9). Furthermore, benzyl nitriles bearing various functionalities are also allowed to provide the corresponding amides in excellent yields irrespective of electronic effects under this newly developed protocol (entries 13–17). Similarly, aliphatic amides such as acrylonitrile and octanenitrile afforded the desired amides in excellent yields (entries 18, 20). Most importantly, when 3-cyanopyridine (entry 12) was employed as a starting substrate, a significantly excellent yield of the corresponding nicotinamide (95%) was obtained. Good yield was also obtained from the reaction of a sterically nitrile (entry 17). The nature and position of substitution on the aryl ring does not make much difference in reactivity. For example, 4-methylbenzamide (entry 7) is produced in 92% yield, and 2-methylbenzamide (entry 6) in 90% yield.

Table 2. Tetrabutylammonium hydroxide (0.5 ml, 50% in aqueous media) catalyzed hydration of nitriles to amides

Entry	Nitrile	Amide	Time (h)	Yield[a] (%)	M.p. (^{0}C)	
					Found	Lit.[b]
1			3	96	124-126	123-125

2			6	92	197-198	198-200
3			5	95	178-179	177-179
4			6	90	161-162	160-162
5			7	85	183-184	182
6			5	90	163-164	160-162
7			6	92	154-156	158-160
8			7	95	191-193	190-193
9			6	90	> 290°C dec	> 290°C dec
10			7	95	166-167	163-165
11			7	88	206-208	207-209
12			6	95	125-127	126-128
13			8	92	154-156	156-158

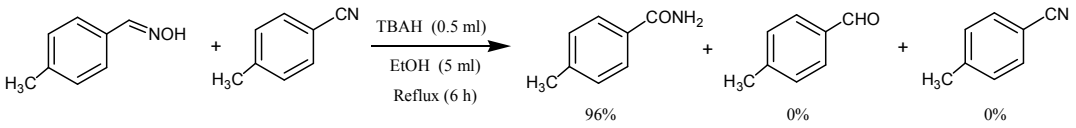
14			8	90	164-166	163-165
15			8	88	176-177	177-178
16			10	90	214-216	213-215
17			12	92	165-167	164-167
18			8	92	85-86	84-86
19			8	92	148-150	148-150
20			7	90	79-81	78-82

[a]All known products have been reported previously in the literature and were characterized by comparison of IR and NMR spectra with authentic samples. [b]www.sigmaaldrich.com.

It is notable that the nitriles were chemoselectively hydrated in the presence of the other functional groups such as C=C. For example, hydration of acrylonitrile, hydration of the double bond was not observed and only the corresponding amide was obtained in 92-95% yields (entries 18-19).

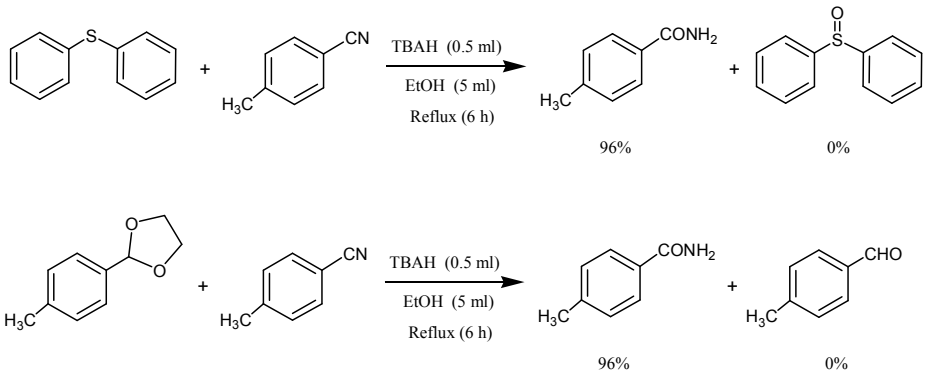
To demonstrate the validity and regioselectivity of this reagent system, we studied the hydration of nitriles in the presence of oxime, acetal and sulfide. These studies obviously show that this reagent system can be applied for the chemoselective hydration of nitriles in the presence of the above mentioned functional groups in multifunctional compounds. Therefore, to a mixture of 4-methylbenzonitrile (1 mmol) and 4-methylbenzaldehyde oxime (1 mmol) were added tetrabutylammonium hydroxide (0.5 ml, 50% in aqueous media) and ethanol (5 ml) at room temperature. The reaction vessel was allowed to stir at 80°C. The progress of the reaction was monitored by TLC analysis. After completion of the reaction (6h), the crude products were purified by column chromatography (packed with silica gel,

using n-hexane/ethyl acetate (8:2) as eluent) to achieve the desired 4-methylbenzamide in 92% yield and 4-methylbenzaldehyde oxime was recovered (Scheme 2).



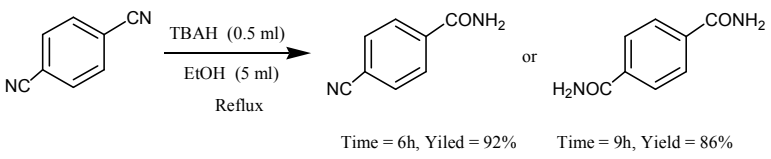
Scheme 2. Selective synthesis of 4-methylbenzamide using tetrabutylammonium hydroxide in the presence of 4-methylbenzaldehyde oxime

In two separate reactions, 4-methylbenzaldehyde oxime was replaced with 2-(4-methylphenyl)-1,3-oxazoline and diphenyl sulfide. In all cases 4-methylbenzamide was only product in the reactions (Scheme 3).



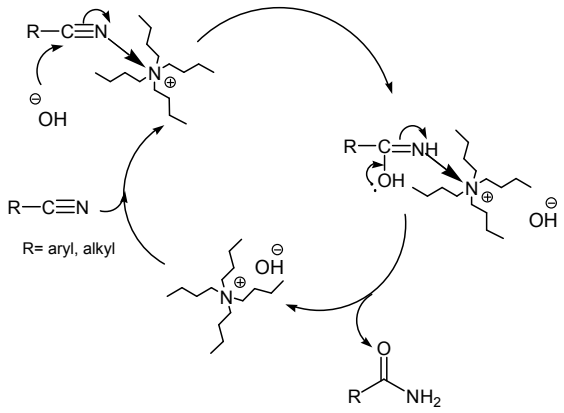
Scheme 3. Selective synthesis of 4-methylbenzamide using tetrabutylammonium hydroxide in the presence of 2-(4-methylphenyl)-1,3-oxazoline and diphenyl sulfide

Interestingly 1,4-dicyano benzene could be hydrated over longer reaction times, 6 h reaction time at refluxing EtOH leads to the selective formation of the monohydrated derivative (93%) whereas lengthened (9h) resulted in the dihydration of 1,4-dicyano benzene to terephthalamide in 86% yield (Scheme 4).



Scheme 4. Selective synthesis of 4-cyanobenzamide and terephthalamide

From the mechanistic point of view, it is well reported that bases catalyze the hydration of nitriles.[8-9,24j-k] Therefore, we propose that the nitrile group is activated by co-ordination to quaternary ammonium hydroxide and undergoes nucleophilic attack by an adjacent hydroxyl ion. It has been estimated that in this case the combination of the nucleophilic attack of hydroxyl process and activation by co-ordination to ammonium ion accelerates the rate of hydrolysis, compared with the unco-ordinated nitrile (Scheme 5).



Scheme 5. Suggested mechanism for the hydrolysis of nitriles by hydrated ionic liquid (IL) tetrabutylammonium hydroxide.

After completion of reactions, the catalyst (TBAH) can be easily removed from the reaction mixture by adding (Dowex 50WX8 hydrogen form, 50-100 mesh) as an acidic ion exchanger resin and stirring for 5 minutes at room temperature. The resin was separated by filtration and continuous removal of ammonium ion from the ion exchange resin, can be recovered the catalyst after another ion exchanging step for reuse in the hydrolysis reaction.

Experimental

List of purchased materials and used devices

Nitrile: entries 1-10, 12-14, 16-20 from Merck (Germany); entry 11 from Sigma Aldrich (United States); entry 15 from Fluka (Switzerland); Dowex 50WX8 hydrogen form, 50-100 mesh from Sigma Aldrich (United States); EtOH from Merck (China); Tetrabutylammonium hydroxide (50% in aqueous media) from Sigma Aldrich (United

States) in commercial grade. IR spectra were recorded on a Shimadzu 435-U-04 spectrophotometer (KBr pellets). ^{1}H and ^{13}C NMR spectra were obtained using Bruker DRX-300 Avance spectrometer in DMSO-d_6 or $CDCl_3$ using TMS as an internal reference. Melting points were determined in open capillary tubes in a Stuart BI Branstead Electrothermal Cat No:IA9200 apparatus and uncorrected.

General procedure for the TBAH catalyzed hydration of nitriles to amides

To a stirred solution of nitrile (1 mmol) and tetrabutylammonium hydroxide (0.5 ml, 50% in aqueous media) was added 5 ml ethanol at room temperature. The reaction mixture is vigorously stirred at 80°C in an oil bath for the specified time in Table 2. The progress of the reaction in each case was monitored by TLC analysis. After completion of the reaction, the reaction mixture is extracted with ethyl acetate, after the extraction, the catalyst is recovered by Dowex 50WX8 (hydrogen form, 50-100 mesh). The organic phase is cooled to 0°C, and white crystals are precipitated from the filtrate. The crystalline product was obtained by simple filtration and dried in vacuum at room temperature to give analytically amide product. In cases where the product not precipitated out, the reaction mixture was extracted with ethyl acetate, subsequent purification by column chromatography on silica gel provided amide product.

All products are known and compounds were characterized by melting point (mp), ^{1}HNMR, ^{13}CNMR and FT-IR. Spectroscopic data of these compounds are represented below:

Benzamide (table 2, entry 1). White solid; IR (KBr, cm^{-1}): 3369, 3177, 1661, 1592, 1498, 1334, 1192, 1112, 692, 648; ^{1}H NMR (300 MHz, DMSO-d_6, ppm) δ 7.81 (d, J = 7.2 Hz, 2H), 7.53−7.50 (m, 1H), 7.44−7.41 (m, 2H), 6.30 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 169.70, 133.40, 132.00, 128.60, 127.30.

4-Nitrobenzamide (table 2, entry 2). Brown solid; IR (KBr, cm^{-1}): 3417, 3313, 3195, 1666, 1593, 1512, 1402, 1338, 1191,1120, 885, 813, 761, 696, 655, 601; ^{1}H NMR (300 MHz, DMSO-d_6, ppm) δ 8.27-8.30 (d, 2H), 8.07-8.10 (d, 2H), 7.71 (brs, 2H); ^{13}C NMR (75 MHz, DMSO-d_6, ppm) δ 166.56, 149.41, 140.34, 129.26, 123.80.

4-Chlorobenzamide (table 2, entry 3). White solid; IR (KBr, cm^{-1}): 3371, 3181, 1662, 1592, 1409, 1348, 1210, 1192, 741, 698; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 7.66 (d, J = 8.5 Hz, 2H), 7.32 (d, J = 8.5Hz, 2H), 6.07 (brs, 1H), 5.76 (brs, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 169.32, 137.41, 131.72, 129.04, 128.94.

3-Bromobenzamide (table 2, entry 4). White solid; IR (KBr, cm^{-1}): 3394, 3279, 1691, 1494, 1391, 1281, 1099, 844, 768; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 8.13 (s, 1H), 7.82-7.65 (m, 2H), 7.40-7.27 (m, 1H), 5.77-5.75 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 160.80, 134.95, 130.57, 130.15, 129.21, 128.24, 125.80.

4-Aminobenzamide (table 2, entry 5). White solid; IR (KBr, cm^{-1}): 3466, 3326, 3223, 1649, 1436, 1394, 1271, 1109, 846, 698; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 7.66-7.63 (d, 2H), 6.68-6.65 (d, 2H), 6.01 (brs, 2H), 5.69 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 171.71, 149.44, 133.01, 128.02, 117.45.

2-Methylbenzamide (table 2, entry 6). White solid; IR (KBr, cm^{-1}): 3376, 3194, 1660, 1598, 1468, 1381, 1214, 112, 790, 694; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 7.45 (d, J = 7.6 Hz, 1H), 7.35−7.34 (m, 1H), 7.23 (m, 2H), 6.12 (brs, 1H), 5.79 (brs, 1H), 3.25 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 172.20, 136.30, 135.20, 131.20, 130.30, 126.90, 125.70, 20.00.

4-Methylbenzamide (table 2, entry 7). White solid; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 7.84 (d, *J* 8.2 Hz, 2H), 7.34 (d, *J* 8.3Hz, 2H), 6.02 (brs, 2H), 3.36 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 169.30, 142.50, 130.50, 129.20, 127.30, 21.40.

4-Bromobenzamide (table 2, entry 8). White solid; IR (KBr, cm^{-1}): 3339, 3158, 1672, 1601, 1413, 1302, 1210, 869, 742; ^1H NMR (300 MHz, DMSO-d_6, ppm) δ 8.34 (d, 2H), 7.74 (d, 2H), 6.97 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 168.20, 132.10, 131.90, 129.00, 126.80.

4-Formylbenzamide (table 2, entry 9). white solid; IR (KBr, cm^{-1}): 3402, 3215, 1695, 1655, 1581, 1543, 1399, 1318, 1114, 1017, 876, 733; ^1H NMR (300 MHz; DMSO-d_6, ppm) δ 7.60 (brs, 2H), 7.98 (d, 2H), 8.05 (d, 2H), 10.08 (s, 1H); ^{13}C NMR (75 MHz; $CDCl_3$, ppm): δ 191.40, 168.00, 138.60, 138.40, 129.90, 128.00.

4-Methoxybenzamide (table 2, entry 10). White solid; IR (KBr, cm^{-1}): 3389, 3163, 1617, 1602, 1594, 1423, 1387, 1292, 1112, 874, 728; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 7.94 (d, 2H), 6.98 (d, 2H), 5.98 (brs, 2H), 3.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 168.04, 161.60, 129.30, 125.60, 113.80, 55.40.

4-(Dimethylamino)benzamide (table 2, entry 11). White solid; IR (KBr, cm^{-1}): 3376, 3211, 1618, 1594, 1418, 1387, 1328, 1118, 872, 729; ^1H NMR (300 MHz, $CDCl_3$, ppm) δ 7.98-7.95 (m, 2H), 6.91- 6.64 (m, 2H), 5.38 (brs, 2H), 3.06 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 170.23, 153.81, 128.12, 115.91, 110.93, 40.07.

3-Pyridinecarboxamide (Nicotinamide) (table 2, entry 12). White solid; IR (KBr, cm^{-1}): 3412, 3210, 1612, 1598, 1414, 1392, 1318, 1128, 1091, 758; ^1H NMR (300 MHz, DMSO-

d_6, ppm) δ 9.04 (s, 1H), 8.77-8.75 (d, 1H), 8.19-8.15 (d, 1H), 7.44-7.40 (m, 3H); ^{13}C NMR (75 MHz, DMSO-d_6, ppm) δ 167.32, 151.63, 148.28, 135.42, 129.16, 123.54.

Benzylamide (table 2, entry 13). White solid; IR (KBr, cm^{-1}): 3379, 3160, 1612, 1602, 1548, 1417, 1391, 1342, 1280, 114, 1091, 841, 765; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 7.40-7.26 (m, 5H), 5.94 (brs, 1H), 5.49 (brs, 1H), 3.61 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 162.71, 144.13, 131.24, 129.63, 111.23, 51.73.

2-(4-Methoxyphenyl)acetamide (table 2, entry 14). White solid; IR (KBr, cm^{-1}): 3315, 3197, 1666, 1512, 1456, 1402, 1336, 1254, 1191, 1121, 1013, 750; ^{1}H NMR (300 MHz, $CDCl_3$/DMSO, ppm) δ 7.26-7.19 (d, 2H), 6.91-6.83 (d, 2H), 6.30 (brs, 2H), 3.80 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$/DMSO, ppm) δ 178.41, 144.81, 133.63, 132.24, 118.61, 59.76, 51.43.

2-(Thiophen-2-yl)acetamide (table 2, entry 15). Yellow solid; IR (KBr, cm^{-1}): 3334, 3168, 1622, 1568, 1449, 1412, 1326, 1246, 1182, 1110, 1091, 844, 768; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 7.26-7.24 (m, 1H), 7.01-6.96 (m, 2H), 5.66 (brs, 2H), 3.97 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 172.31, 136.03, 127.36, 125.55, 37.07.

2-(4-Nitrophenyl)acetamide (table 2, entry 16). White solid; IR (KBr, cm^{-1}): 3409, 3323, 1656, 1539, 1454, 1393, 1352, 1284, 1193, 1122, 852, 813, 746, 659; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 8.17-8.41 (d, 2H), 7.69-7.52 (m, 2H), 6.50 (brs, 2H), 4.18 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 175.92, 148.51, 135.12, 129.31, 128.14, 39.43.

Bis phenyl acetamide (table 2, entry 17). White solid; IR (KBr, cm^{-1}): 3421, 3328, 1646, 1514, 1434, 1392, 1351, 1274, 1183, 1132, 842, 812, 746; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 7.82 (d, 4H), 7.53−7.51 (m, 2H), 7.42−7.32 (m, 4H), 6.44 (brs, 2H), 4.56 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 173.11, 134.54, 133.16, 129.72, 127.52, 46.71.

Acrylamide (table 2, entry 18). White solid; IR (KBr, cm^{-1}): 3353, 3191, 1672, 1612, 1429, 1402, 1352, 1280, 1193, 1135, 989, 960, 817, 655; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 6.21 (m, 1H), 6.42 (m, 1H), 5.84(m, 1H), 5.74 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 167.50, 130.10, 127.70.

Cinnamamide (table 2, entry 19). White solid; IR (KBr, cm^{-1}): 3383, 3198, 1674, 1612, 1442, 1391, , 1352,1285, 1197, 1131, 987, 812; ^{1}H NMR (300 MHz, $CDCl_3$, ppm) δ 7.52 (d, J = 15.7 Hz, 1H), 7.52−7.50 (m, 2H), 7.38−7.36 (m, 3H), 6.47 (d, *J* = 15.7 Hz, 1H), 5.79 (brs, 2H); ^{13}C NMR (75 MHz, $CDCl_3$, ppm) δ 169.12, 141.74, 133.61, 131.14, 129.01, 128.14, 119.61.

Acetamide (table 2, entry 20). White solid; IR (KBr, cm^{-1}): 3369, 3191, 2924, 2912, 2674, 1673, 1464, 1378, 1150, 1087, 1046, 1005, 773, 720; ^{1}H NMR (300 MHz, DMSO- d_6, ppm) δ 1.69 (s, 3H), 6.62 (brs, 1H), 7.27 (brs, 1H); ^{13}C NMR (75 MHz; $CDCl_3$, ppm) δ 22.94, 171.90.

Conclusion

In conclusion, tetrabutylammonium hydroxide (TBAH) has a high synthetic utility, because it is reusable and shows high activity for selective hydration of aliphatic, aromatic, and heterocyclic nitriles to amides without the formation of carboxylic acids. The simplicity and convenience of this oxidation procedure are attractive, the fact that the reaction proceeds in excellent yields, reusable catalyst, and its use in ethanol as solvent hold promise as the basis for this process, which is environmentally safe, and economical. The high reactivity combined with inexpensive, easily available reagents, and no side products in the reaction makes it a suitable practical alternative.

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Graphical Abstract

Chemoselective hydration of nitriles to amides by hydrated ionic liquid (IL) tetrabutylammonium hydroxide (TBAH) as a green catalyst

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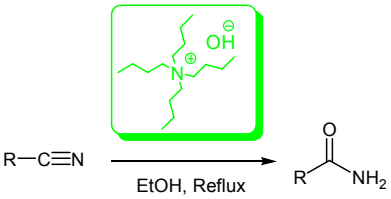

- ✓ Chemoselective synthesis of amides
- ✓ Avoiding of any base, metal, or Lewis acid catalysts
- ✓ Green chemistry