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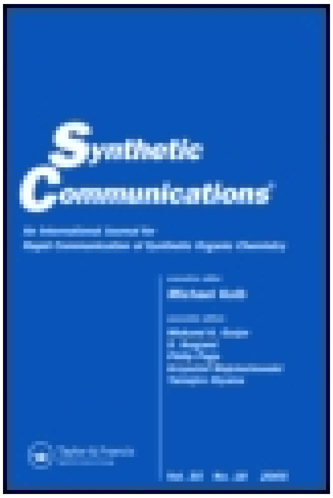

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$K_5CoW_{12}O_{40} \cdot 3H_2O$: Heterogeneous Catalyst for the Strecker-Type Aminative Cyanation of Aldehydes and Ketones

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$K_5CoW_{12}O_{40} \cdot 3H_2O$: Heterogeneous Catalyst for the Strecker-Type Aminative Cyanation of Aldehydes and Ketones

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Abstract: One-step synthesis of α-aminonitriles was successfully carried out by a three-component condensation of aldehydes or ketones, amines, and potassium cyanide in the presence of a catalytic amount of $K_5CoW_{12}O_{40} \cdot 3H_2O$ as an efficient, reusable, and nontoxic catalyst.

Keywords: α-aminonitriles, polyoxometalates, potassium cyanide, Strecker reactions

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Applications of polyoxometalates (POMs) have been demonstrated in different areas, and some of the most relevant properties for technological applications rely on solubility, acidity, and redox potential.[1] Heteropoly compounds with Keggin structure are the most studied class within POMs,[2] and those containing tungsten as addenda atoms exhibit strong acidity, high thermal stability, and low oxidation potential,[3] which allow them to be used as catalysts in various reactions at moderate temperatures.[4] In continuation of our research on the application of POMs[5] in organic synthesis, herein the applicability of $K_5CoW_{12}O_{40} \cdot 3H_2O$ as an efficient

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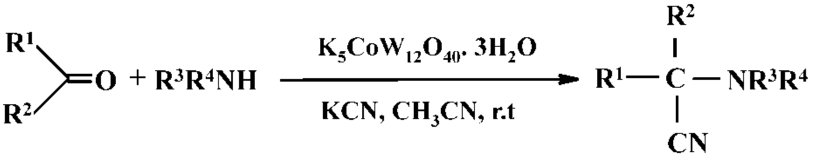
catalyst for the synthesis of α-aminonitriles is reported. There are no examples of the use of POMs as catalyst for the synthesis of α-aminonitriles in the literature.

α-Aminonitriles are useful intermediates for the synthesis of amino acids[6] and nitrogen-containing heterocycles such as thiadiazoles and imidazole derivatives.[7] The synthetic route to α-aminonitriles, known the Strecker reaction, involves the treatment of an aldehyde or a ketone with alkaline cyanides and salts of amines.[8] The reaction is usually carried out in aqueous solution, and the workup procedure is also tedious. If the usual solvent used (water) could be changed for typical organic solvents (toluene, dichloromethane, acetonitrile, etc.), the solubility of the organic reagents as well as the reaction conditions will be improved. This new protocol involves the use of an efficient catalyst, $K_5CoW_{12}O_{40} \cdot 3H_2O$, budding many of the catalysts reported in the literature (Scheme 1).[9–12]

After some experimentation with respect to the molar ratio of reactants and catalyst, the best results were obtained with a 1:1.1:1.5:0.1 molar ratio of aldehyde (or ketone), amine, KCN, and catalyst. It seems that acetonitrile is much better solvent than all others tested (such as dichloromethane, tetrahydrofuran, and toluene). It is remarkable to note that no improvements in the reaction rates and yields were observed by increasing the amount of the catalyst from 10 mol% to 20 mol%, and lesser amount (5 mol%) also worked with longer reaction times. A series of aliphatic, heterocyclic, and aromatic aldehydes carrying either electron-donating or electron-withdrawing substitutions are reacted with aromatic, benzylic, aliphatic (both primary and secondary) amines, giving α-aminonitriles in high to excellent yields under these optimum conditions (Table 1). Acid-sensitive aldehydes such as furfural and cinnamaldehyde worked well without the formation of any side products (Table 1, entries 11–13). Furthermore, the reaction conditions are mild enough to perform the reaction in the presence of enolizable aldehydes such as decanal (Table 1, entry 15). To our knowledge, only a few reports of Strecker reactions with ketones are reported,[9,10] but as evidenced in Table 1, entries 17–20, ketones gave moderate yields in short reaction times. These three-component coupling reactions proceeded efficiently at ambient temperature with high selectivity. In addition, $K_5CoW_{12}O_{40} \cdot 3H_2O$ can be reused several times with only a



Scheme 1.

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Table 1. $K_5CoW_{12}O_{40} \cdot 3H_2O$-catalyzed synthesis of α-aminonitriles

Entry	Aldehyde/ketone	Amine	Time (min)	Yield[a] (%)	Ref.[b]
1	Benzaldehyde	Aniline	50	95	[4g]
2	Benzaldehyde	Benzylamine	65	95	[4d]
3	Benzaldehyde	Butylamine	80	90	[4g]
4	Benzaldehyde	Isobutylamine	60	86	[3b]
5	*m*-Methoxybenzaldehyde	Aniline	60	85	[3b]
6	*m*-Methoxybenzaldehyde	Benzylamine	40	98	[3b]
7	*m*-Methoxybenzaldehyde	Butylamine	55	91	[3b]
8	*p*-Chlorobenzaldehyde	Aniline	15	92	[4g]
9	*p*-Nitrobenzaldehyde	Aniline	60	87	[4d]
10	*p*-Methylbenzaldehyde	Aniline	20	88	[4g]
11	Furfural	Aniline	45	74	[4a]
12	Furfural	Benzylamine	50	97	[4g]
13	Cinamaldehyde	Aniline	90	80	[4g]
14	Thiophene-2-carboxaldehyde	Benzylamine	30	94	[4d]
15	Decanal	Aniline	45	77	[4d]
16	Benzaldehyde	Morpholine	110	90	[3b]
17	Cyclohexanone	Benzylamine	30	51	[3b]
18	Cyclohexanone	Butylamine	140	67	[3b]
19	*m*-Methyl cyclohexanone	Benzylamine	100	46	[3b]
20	*m*-Methyl cyclohexanone	Morpholine	300	70	[3b]
21	Benzaldehyde	Aniline	50	80[c]	[4g]

[a] Isolated yield.

[b] Products were characterized by comparison of their spectroscopic data with those reported in the literature.

[c] After ten successive runs.

slight decrease in the activity, simply by filtering the catalyst, washing with acetone, and drying (Table 1, entry 21). We believe that because of the protection of the central cobalt ion with inert oxygen atoms, amines, even those with strong complexation ability, could not attach the cobalt ion and deactivate it. However, such deactivation has been previously reported for metal triflate and $CeCl_3$ as catalysts. In another experiment, when the filtered solution containing the catalyst was used after 6 months of storage, it was observed that the catalyst was quite active, demonstrating that $K_5CoW_{12}O_{40} \cdot 3H_2O$ is stable and does not undergo any deterioration.

In summary $K_5CoW_{12}O_{40} \cdot 3H_2O$ can be regarded as an efficient, environmentally friendly, cheap, nontoxic, and reusable catalyst. Also this method is clean, practical, simple, mild, and applicable to a wide scope of structural types for synthesis of α-aminonitriles in short reaction times and high to excellent yields with very easy workup.

EXPERIMENTAL

$K_5CoW_{12}O_{40} \cdot 3H_2O$ was prepared according to the previously reported procedure.[5a] All products were identified by comparison of their physical and spectroscopic data with authentic samples prepared in according with the procedures in the literature.[9]

General Procedure for the Preparation of α-Aminonitriles

A mixture of aldehyde (1 mmol), amin (1.1 mmol), KCN (1.5 mmol), and $K_5CoW_{12}O_{40} \cdot 3H_2O$ (0.1 mmol) in acetonitrile (3 mL) was stirred at room temperature for an appropriate time (Table 1). After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered and washed with acetonitrile (2 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, concentrated in vacuum, and purified by column chromatography on silica gel (ethyl acetate–hexane, 1:9) to afford pure α-aminonitrile.

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