SOLID FLY-ASH:H_2SO_4 CATALYZED MICROWAVE ASSISTED SOLVENT-FREE CONDENSATION:SYNTHESIS OF SOME TRIFLUOROMETHYL-IMINES

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ABSTRACT

Good yield of trifluoromethyl-imines have been synthesized by Fly-ash:H_2SO_4 catalyzed condensation of anilines and phenyl trifluoromethyl ketone in microwave irradiation under solvent free conditions.

Keywords: Fly-ash:H_2SO_4, Greener synthesis, Trifluoromethylimines, Anilines.

INTRODUCTION

Chiral imine derivatives possess multipronged biological activities such as antimicrobial[1], anticancer[2], antiplasmodic-antihypoxic[3], antitubularcular[4], nematicidal, insecticidal1e[5], anti-inflammatory, and lipoxygenase[6]. The imine moieties are important intermediate and versatile starting materials for synthesis of chiral amines[7-13]pyrimidine derivatives, phenylhydrazones, azomethines, indoles, quinoxalines, imidazoles, by hydrogenation[14], nucleophilic addition with organometallics[15]and cycloaddition reaction[16]. The unique condensation of carbonyl compounds with amines is a well-known reaction. Many reagents[17] were used for synthesis of optically active imines such as Lewis acids, molecular sieves in ionic liquids, infrared[18-25] and ultrasound radiation[26]. These catalysts were applied for synthesis of chiral amines by oxidative coupling of amines[27] with carbonyl compounds[5,28,29], alcohols[30] and acid chlorides[31,32]. The use of microwave heating in synthetic methods has become popular for academic and pharmaceutical areas, due to this is a new enabling technology for new for growing of drug discovery research and developments[33]. Chemists and scientists[21, 34, 35, 21] preferred solvent free microwave synthetic method for synthesis of organics, due to shorter reaction time, operational simplicity, easy workup procedure, less hazards to environment, and better yields. There is no report on synthesis of imines with fly-ash:H_2SO_4 catalyst under microwave heating in literature in the past. Therefore the authors have taken efforts to synthesize some phenyl trifluoromethylimines from phenyl trifluoromethyl ketones and substituted anilines in the presence of Fly-ash:H_2SO_4 catalyst in microwave irradiation under solvent-free conditions. When compared to the commercially available catalyst mere Fly-ash, and laboratory made catalyst such as anhydrous sodium acetate the use of Fly-ash: H_2SO_4 catalyst in the present investigation gave more yield of imines up to 30 to 40%. The motivation and interest to select the catalyst for the present investigation is attributed to the less toxicity, lesser hazardousness, supporting pollution free environment, easy handling procedure, techniques, environmentally benign process and good percentage of yields.

EXPERIMENTAL

Materials and methods

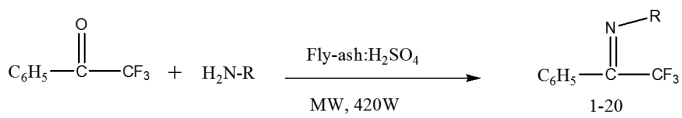
All chemicals used were procured from Sigma-Aldrich and E-Merck. The Fly-ash was collected from Thermal Unit-II, Neyveli Lignite Corporation, Neyveli, Tamilnadu, India. Infrared spectra (KBr, 4000-400 cm^{-1}) have been recorded on BRUKER (Thermo Nicolet) Fourier transform spectrophotometer. The NMR spectra of all imines have been recorded on JEOL-400 spectrometer operating at 400 MHz for recording ^1H spectra and 100 MHz for ^{13}C spectra in $CDCl_3$ solvent using TMS as internal standard. Mass spectra have been recorded on SHIMADZU spectrometer using chemical ionization technique.

Preparation of fly-ash:H_2SO_4 catalyst[36]

In a 50mL Borosil beaker, 1g of fly-ash and 0.8 mL (0.5 mol) of sulphuric acid were taken and mixed thoroughly with glass rod. This mixture was heated on a hot air oven at 85°C for 1h, cool to room temperature, stored in a borosil bottle and capped. The purities of this catalyst were confirmed by SEM analysis and infrared spectroscopic data.

General procedure for synthesis of phenyltrifluoromethylimines

An appropriate equi-molar quantities of aryl amines (2 mmol), phenyl trifloromethyl ketone (2 mmol) and fly-ash: H_2SO_4 (0.5 g) were taken in Borosil glass tube and tightly capped. The mixture was subjected to microwave irradiation for 6-8 minutes in a microwave oven (**Scheme 1**) (LG Grill, Intellowave, Microwave Oven, 160-800W) and then cooled to room temperature. The organic layer was separated with dichloromethane and the solid product was obtained on evaporation of solvent. The solid, on recrystallization with benzene-hexane mixture gave glittering solid. The insoluble catalyst was recycled by washing the solid reagent remained on the filter by ethyl acetate (8 mL) followed by drying in an oven at 100°C for 1h and it was reused for further reactions. The purities of synthesized imines were checked by their physical constants and spectral data published earlier in literature. The reactants, reaction time, percentage of yield, analytical, physical constants and mass fragments of imines have been presented in Table 1. The spectral data of unknown compounds are summarized in Table 2.



Scheme 1: Synthesis of trifluoromethyl-imines.

RESULTS AND DISCUSSION

The waste air-pollutant fly-ash has many chemical species[21, 34, 35, 36] SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO and insoluble residues. The waste fly-ash is converted into useful catalyst fly-ash: H_2SO_4 by mixing fly-ash and sulphuric acid. The fly-ash: H_2SO_4 catalyst was used for synthesis of imines. The fly ash particles are in the silt-sized range of 2-50 microns[38]. Glass, mullite-quartz, and magnetic spinel are the three major mineralogical matrices identified in fly ash. Si, Al, Fe, Ca, C, Mg, K, Na, S, Ti, P, and Mn are the major elemental constituents of fly ash. The solubility of fly ash has been extensively investigated and it is largely dependent on factors specific to the extraction procedure. Literature study reveals that the long-term leaching studies predict that fly ash will lose substantial amounts of soluble salts over time, but simulation models predict that the loss of trace elements from fly ash deposits through leaching will be very slow. Small amounts of radioisotopes are found to be the constituents of fly ash which do not appear to be hazardous.

The phenyl trifloromethylimines were synthesized by microwave irradiation of appropriate equi-molar quantities of substituted aryl amines (2 mmol), phenyl tirluoromethyl ketone(2 mmol) and fly-ash: H_2SO_4 (0.5 g) in borosil glass tube. The sulphuric acid group and chemical species present in the fly-ash have enhanced the catalytic activity. During the course of the reaction these species are involved for the promoting effects on condensation between

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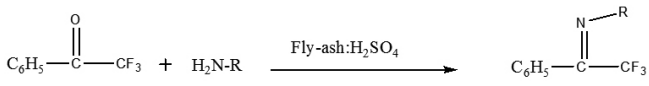
the aryl amines and trifloromethyl ketone group leading to the formation of imines by condensation of amines. The proposed general reaction mechanism is shown in Figure 1. The components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO). Hence the reaction takes place in the only in the heterogeneous phase. In these experiments the products were isolated and the catalyst was washed with ethyl acetate, heated to 100°C then reusable for further runs of reaction. There was no appreciable change in the percentage of yield of imines in further runs. In this protocol the reaction gave better yields of the imines during the condensation without any environmental discharge. The purities of synthesized imines were checked by their physical constants and spectral data published in earlier in literature. The same experiment was carried out with conventional heating method with ethanol medium. The yields of the imines were found to be 50-65% only.

Further we have investigated the catalytic effect of fly-ash: H_2SO_4 on the synthesis of imines (Entry **1**) by varying the catalyst quantity from 0.2 to 1.5g. As the catalyst quantity is increased from 0.25 to 0.5g, the percentage of yield of the product gets increased from 85 to 86%. There is no significant increase in the percentage of the product by even after increasing 0.5g of the quantity of the catalyst. This catalytic effect is shown in Figure 2. The optimum quantity of catalyst loading was found to be 0.5g for the synthesis of imines from amine with 2 mmol of ketone. The reusability of this catalyst was studied the reaction of aniline and trifluoromethyl ketone. The reusability of catalyst on condensation reaction of amines and ketones is given in Table 3. From the Table 3, first two runs gave 86% product. The third, fourth and fifth runs of reactions gave the yields 85.8%, 85.7% and 85.5 % of imines. There was no appreciable loss in its effect of catalytic activity was observed up to fifth run.

Table 1. Synthesis of trifluoromethyl-imines by microwave assisted fly-ash:H_2SO_4 catalyzed solvent free conditions from trifloromethyl ketone and various amines(R).



Entry	R	Yield(%)			M. F.	M.W.	Mass (m/z)
		MW	SOL.	NaOAc			
1	C_6H_5	88	62	48	$C_{14}H_{10}F_3N$	249	$^{15}249M^+$, $251M^{+2}$, $253M^{+4}$, $258M^{+6}$
2	3-BrC_6H_4	84	58	43	$C_{14}H_9BrF_3N$	328	$^{37}328M^+$, $330M^{+2}$, $332M^{+4}$, $334M^{+6}$, $338M^{+8}$
3	4-BrC_6H_4	84	62	44	$C_{14}H_9BrF_3N$	328	$^{37}328M^+$, $330M^{+2}$, $332M^{+4}$, $334M^{+6}$, $338M^{+8}$
4	2-ClC_6H_4	80	64	43	$C_{14}H_9ClF_3N$	284	$^{37}284M^+$, $286M^{+2}$, $288M^{+4}$, $290M^{+6}$, $292M^{+8}$
5	3-ClC_6H_4	82	59	45	$C_{14}H_9ClF_3N$	284	$^{37}284M^+$, $286M^{+2}$, $288M^{+4}$, $290M^{+6}$, $292M^{+8}$
6	4-ClC_6H_4	85	58	44	$C_{14}H_9ClF_3N$	284	$^{15}284M^+$, $286M^{+2}$, $288M^{+4}$, $290M^{+6}$, $292M^{+8}$
7	3-FC_6H_4	80	63	45	$C_{14}H_9F_4N$	248	$^{37}248M^+$, $250M^{+2}$, $252M^{+4}$, $254M^{+6}$, $256M^{+8}$
8	4-FC_6H_4	82	59	44	$C_{14}H_9F_4N$	248	$^{15}248M^+$, $250M^{+2}$, $252M^{+4}$, $254M^{+6}$, $256M^{+8}$
9	3-$OCH_3C_6H_4$	85	60	54	$C_{15}H_{12}F_3NO$	279	$^{37}279M^+$, $281M^{+2}$, $283M^{+4}$, $285M^{+6}$
10	4-$OCH_3C_6H_4$	85	58	55	$C_{15}H_{12}F_3NO$	279	$^{15}279M^+$, $281M^{+2}$, $283M^{+4}$, $285M^{+6}$
11	2-$CH_3C_6H_4$	83	62	53	$C_{15}H_{12}F_3N$	263	$^{15}263M^+$, $265M^{+2}$, $267M^{+4}$, $269M^{+6}$
12	3-$CH_3C_6H_4$	85	64	50	$C_{15}H_{12}F_3N$	263	$^{37}263M^+$, $265M^{+2}$, $267M^{+4}$, $269M^{+6}$
13	4-$CH_3C_6H_4$	85	60	53	$C_{15}H_{12}F_3N$	263	$^{15}263M^+$, $265M^{+2}$, $267M^{+4}$, $269M^{+6}$
14	3-$CF_3C_6H_4$	80	58	40	$C_{15}H_9F_6N$	317	$^{15}317M^+$, $319M^{+2}$, $321M^{+4}$, $323M^{+6}$, $325M^{+8}$
15	-$CH_2C_6H_4$	83	61	40	$C_{15}H_{12}F_3N$	263	$^{15}263M^+$, $265M^{+2}$, $267M^{+4}$, $269M^{+6}$
16	-$CH(CH_3)C_6H_4$	80	59	40	$C_{15}H_{12}F_3N$	277	$^{15}277M^+$, $279M^{+2}$, $281M^{+4}$, $283M^{+6}$
17	$C_{10}H7$(1-Naph)	81	63	43	$C_{18}H_{12}F_3N$	299	$299M^+$, $301M^{+2}$, $303M^{+4}$, $305M^{+6}$
18	$C_{10}H_7$(2-Naph)	86	65	42	$C_{18}H_{12}F_3N$	299	$^{15}299M^+$, $301M^{+2}$, $303M^{+4}$, $305M^{+6}$
19	$C_{13}H_9$(2-Fluorene)	81	64	41	$C_{21}H_{14}F_3N$	337	$337M^+$, $339M^{+2}$, $341M^{+4}$, $343M^{+6}$
20	C_8H_8(4-Biphenyl)	81	63	48	$C_{20}H_{13}F_3N$	321	$321M^+$, $323M^{+2}$, $325M^{+4}$, $327M^{+6}$

Table 2. The spectral data of selective trifloromethyl-imines.

Entry	Infrared spectra, ν(cm^{-1})			^{1}H NMR δ(ppm)		^{13}C NMR δ(ppm)			
	CN	CF	Subst.	H-Ar	Subst.	CN	CF	C-Ar	Substt.
2	1664.22	885.57	557.24 (C-Br)	7.436-7.721	---	165.38	113.58	121.35-158.47	---
3	1662.71	865.21	558.09 (C-Br)	7.452-7.734	---	165.08	112.99	121.65-154.09	---
4	1662.38	825.34	554.68 (C-Cl)	7.453-7.825	---	166.05	114.89	122.35-157.36	---
5	1664.69	836.49	561.23 (C-Cl)	7.632-7.827	---	165.81	113.58	121.83-158.68	---
7	1665.32	851.36	824.36 (C-F)	7.025-7.156	---	164.29	112.57	123.65-156.47	---
9	1661.39	823.31	1265.32 (C-O-C)	7.010-7.120	4.221 (OCH_3)	162.35	112.09	121.98-155.98	56.23 (OCH_3)
12	1663.85	845.67	---	7.102-7.205	2.985 (CH_3)	163.87	112.65	122.35-158.47	26.87 (CH_3)
17	1667.25	842.19	---	7.258-7.648	---	165.34	112.87	123.58-159.67	---
19	1663.27	857.12	---	7.538-7.974	---	166.32	113.36	123.98 -156.37	---
20	1665.36	852.36	---	7.266-7.528	---	166.38	113.48	123.65-158.68	---

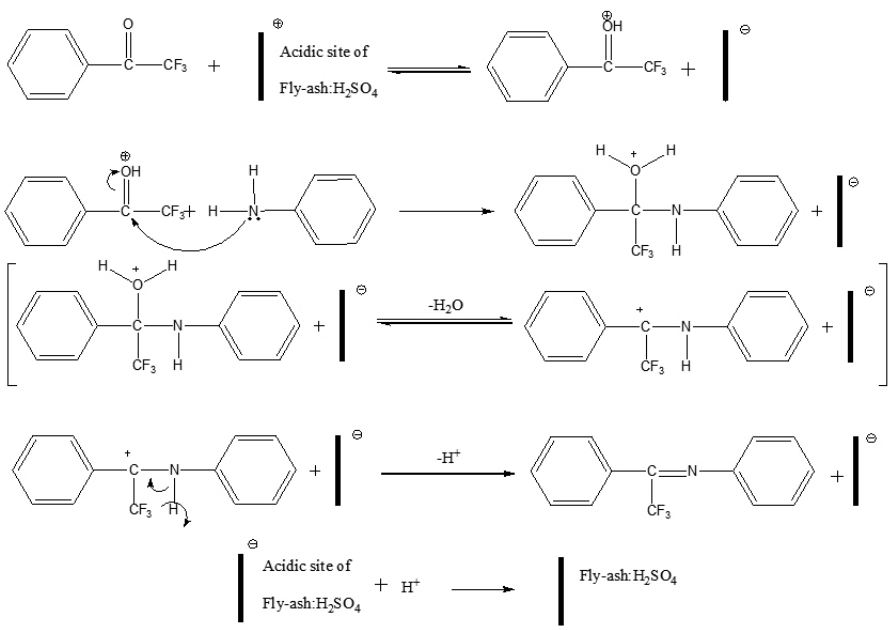


Figure 1. Proposed mechanism for synthesis of trifluoromethane–imines by condensation of amines in presence Fly-ash:H_2SO_4 catalyst.

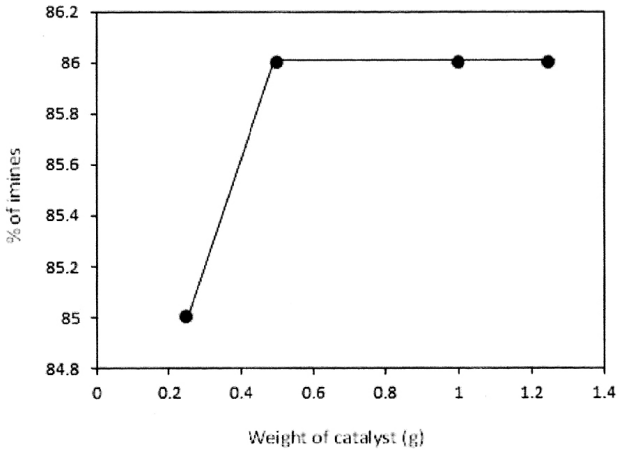


Figure 2. Effect of loading of catalyst fly-ash: H_2SO_4 versus percentage of trifluoromethyl-imines.

Table 3. Reusability of catalyst on condensation of trifluoromethyl-imine (2 mmol) and benzaldehydes (2 mmol) under microwave irradiation.

Run	1	2	3	4	5
Yield	86	86	85.8	85.5	85.5

CONCLUSION

In conclusion, we have developed an efficient method for synthesis of triflоromethyl-imines by condensation of amines, using solvent free environmentally greener catalyst fly-ash: H_2SO_4 under microwave irradiation between phenyl triflоromethyl ketone and amines. This reaction protocol offers a simple, economical, environmentally friendly, non-hazards, easier work-up procedure and good yields.

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