Organic Preparations and Procedures International: The New Journal for Organic Synthesis
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uopp20

A GREEN SOLVENTLESS PROTOCOL FOR THE SYNTHESIS OF N-SULFONYLIMINES IN THE PRESENCE OF SILICA SULFURIC ACID AS AN EFFICIENT, HETEROGENEOUS AND REUSABLE CATALYST

Abdolkarim Zare [a] , Alireza Hasaninejad [b] , Mohsen Shekouhy [b] & Ahmad Reza Moosavi Zare [a]
[a] Department of Chemistry , Payame Noor University (PNU) , Bushehr, 1698, IRAN
[b] Department of Chemistry, Faculty of Sciences , Persian Gulf University , Bushehr, 75169, IRAN E-mail:

To cite this article: Abdolkarim Zare , Alireza Hasaninejad , Mohsen Shekouhy & Ahmad Reza Moosavi Zare (2008) A GREEN SOLVENTLESS PROTOCOL FOR THE SYNTHESIS OF N-SULFONYLIMINES IN THE PRESENCE OF SILICA SULFURIC ACID AS AN EFFICIENT, HETEROGENEOUS AND REUSABLE CATALYST, Organic Preparations and Procedures International: The New Journal for Organic Synthesis, 40:5, 457-463, DOI: 10.1080/00304940809458106

To link to this article: http://dx.doi.org/10.1080/00304940809458106

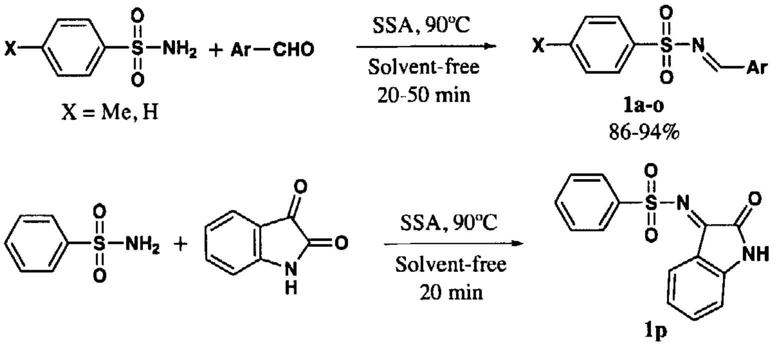
ORGANIC PREPARATIONS AND PROCEDURES INT., 40 (5), 457-463 (2008)

A GREEN SOLVENTLESS PROTOCOL FOR THE SYNTHESIS OF *N*-SULFONYLIMINES IN THE PRESENCE OF SILICA SULFURIC ACID AS AN EFFICIENT, HETEROGENEOUS AND REUSABLE CATALYST

Abdolkarim Zare*[†], Alireza Hasaninejad*[††], Mohsen Shekouhy[††]
and Ahmad Reza Moosavi Zare[†]

[†]*Department of Chemistry, Payame Noor University (PNU), Bushehr 1698, IRAN*
[††]*Department of Chemistry, Faculty of Sciences,*
Persian Gulf University, Bushehr 75169, IRAN
e-mail: abdolkarimzare@yahoo.com; ahassaninejad@yahoo.com

In recent years, the use of heterogeneous and reusable catalysts has received tremendous attention in organic synthesis.[1-3] Application of these catalysts under solvent-free conditions often leads to remarkable decreases in reaction times, increased yields, easier workup, and compliance with the green chemistry protocols. One useful example of reusable and heterogeneous catalysts is silica sulfuric acid (SSA) which has been widely used in organic transformations in recent years.[3] Because of the wide applications of the C=N bond of *N*-sulfonylimines in organic synthesis,[4-8] several synthetic routes toward this class of compounds have been developed, namely the Lewis acid-catalyzed reactions of sulfonamides with aldehydes,[9-16] rearrangement of oxime *O*-sulfinates,[17] generation of sulfonamidosulfones by three-components condensation of aldehydes, sulfonamides and sulfinic acid, and subsequently base-catalyzed elimination,[18-20] and isomerization or rearrangement of *N*-sulfonylaziridines.[21] However, there are some obvious drawbacks in these methods, such as long reaction times, unsatisfactory yields, formation of toxic by-products, the use of expensive and hazardous reagents as well as solvents, and tedious purification. Furthermore, some methods involve cumbersome and multi-step procedures. Therefore, it seems highly desirable to find an efficient, green, one-step, and inexpensive protocol for the synthesis of *N*-sulfonylimines. In continuation of our interest in using the solid acid catalysts and reagents in organic transformations[9,16,22-24] as well as in green organic syntheses,[9,16,22-36] we explored and now report the catalytic activity of SSA as a solid acid for the synthesis of *N*-sulfonylimines *via* the condensation of sulfonamides with aldehydes as well as isatin (*Scheme 1*).



Scheme 1

The reaction of 4-methylbenzenesulfonamide (1 mmol) with benzaldehyde (1 mmol) proceeded efficiently at 90°C and the desired *N*-sulfonylimine **1a** was obtained in 94% yield after 20 min. To investigate the efficiency as well as the capacity of the solvent-free procedure in comparison with solution conditions, the model reaction was examined in different solvents. The results summarized in *Table 1* indicate that the solution conditions were not efficient for the preparation of *N*-sulfonylimines. Therefore, we applied SSA as catalyst in the absence of solvent to the condensation of sulfonamides with aldehydes. The scope of the present method with respect to the reported methods for the preparation of *N*-sulfonylimines was studied and compared with the results of some reported method in the synthesis of compound **1a** (*Table 2*).

Table 1. Comparative Reactions of *p*-Toluenesulfonamide (1 mmol) with Benzaldehyde (1 mmol) in the Presence of SSA (0.5 g) under Solution Conditions (5 mL of solvent) versus the Solvent-free Method

Entry	Solvent	Temperature (°C)	Time (min)	Yield (%)
1[a]	----	90	20	94
2	DMSO	90	300	56
3	EtOH	Reflux	600	58
4	CH_3CN	Reflux	600	39
5	EtOAc	Reflux	600	45
6	$CHCl_3$	Reflux	600	32
7	THF	Reflux	600	59

a) Our solvent-free conditions.

The reaction was examined with structurally diverse aldehydes as well as isatin (*Table 3*). The reactions proceeded efficiently and the desired products were obtained in high to excellent yields in relatively short reaction times. Although aromatic aldehydes containing both electron-withdrawing and electron-releasing substituents afforded the corresponding *N*-sulfonylimines in high yields, some of these substituents increased the reaction times (entries

Table 2. Comparative Synthesis of Compound **1a** using the Reported Methods versus the Present Method

Entry	Reagent and Conditions	Time (min)	Yield (%)	Ref.
1[a]	SSA, solvent-free, 90°C	20	94	----
2[b]	P_2O_5/SiO_2, solvent-free, 110°C	120	91	[16]
3	Silica chloride, solvent-free, 120°C	180	75	[9]
4	$Si(OEt)_4$/160°C	360	68	[10]
5	$CaCO_3$, K10 Clay, $CH(OMe)_3$/Microwave	6	69	[11]
6	$TiCl_4$, NEt_3/0°C (CH_2Cl_2)	25	58	[12]
7	a) PhCH=NOH b) TsCN, NEt_3/0°C (CCl_4)	30	59	[37]
8	PhCHO + Ph_3P=NTs/$RuCl_2(PPh_3)_3$ (CH_2Cl_2)	36	75	[38]

a) Our method. b) In this method, the catalyst was not reusable.

2-6, 12 and 13). This method was also successfully applied for the condensation of sulfonamides with dicarbonyl compounds, such as terephthaldehyde and isatin.

Table 3. Preparation of *N*-Sulfonylimines from Sulfonamides and Aldehydes in the Presence of SSA under Solvent-free Conditions

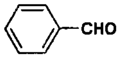
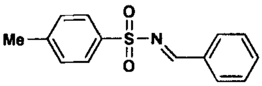
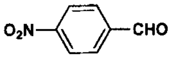
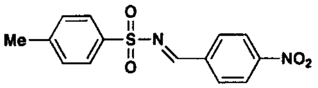
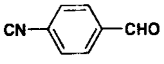
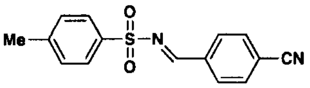
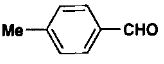
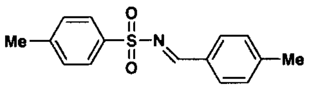
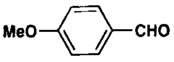
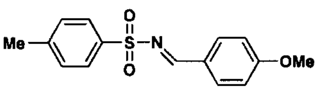
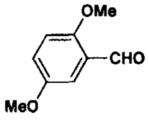
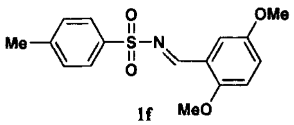
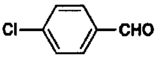
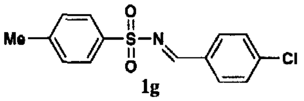
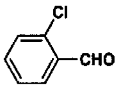
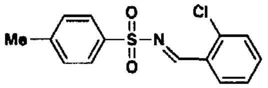
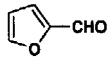
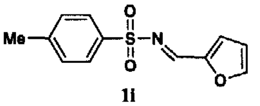
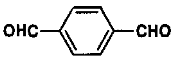
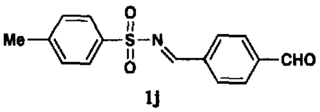
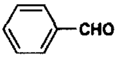
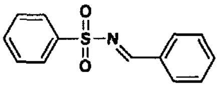
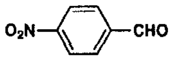
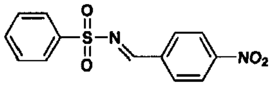
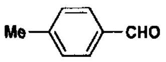
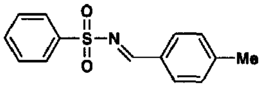
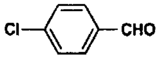
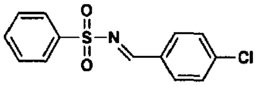
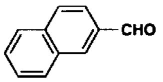
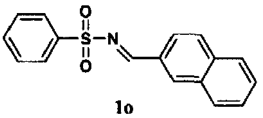
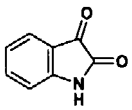
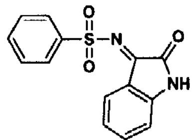
Entry	Carbonyl Compound	Product[a]	Time (min)	Yield (%)	mp. (*lit.*)
1		 1a	20	94	107-109 (108)[9]
2		 1b	45	91	164-166 (162-164)[39]
3		 1c	45	93	171-172 (172-173)[9]
4		 1d	30	92	112-114 (111-112)[40]
5		 1e	40	91	127-129 (128-129)[40]
6		 1f	50	87	125-127 (124-126)[9]

Table 3. Continued...

Entry	Carbonyl Compound	Product[a]	Time (min)	Yield (%)	mp. (*lit.*)
7		 **1g**	20	93	169-170 (172-173)[40]
8		 **1h**	25	90	126-128 (128-129)[10]
9		 **1i**	25	90	99-100 (101)[40]
10		 **1j**	35	86	98-100[b] (98-100)[16]
11		 **1k**	20	92	76-78 (77-80)[9]
12		 **1l**	45	90	165-166 (162-164)[39]
13		 **1m**	35	89	113-115 (116-118)[13]
14		 **1n**	20	91	131-133 (127-130)[13]
15		 **1o**	20	88	166-168 (172-174)[41]
16		 **1p**	20	87	143-144[c]

a) All known compounds were identified by comparison of their melting points and ^{1}H NMR data with the authentic samples. b) *Anal.* for $C_{15}H_{13}NO_3S$: C, 62.70; H, 4.56; N, 4.87. Found: C, 62.89; H, 4.40; N, 5.07. c) *Anal.* for $C_{14}H_{10}N_2O_3S$: C, 58.73; H, 3.52; N, 9.78. Found: C, 58.90; H, 3.74; N, 9.61.

Ease of recycling of the catalyst is one of the main advantages of our method. For the reaction of *p*-toluenesulfonamide with benzaldehyde no significant loss of the product yield was observed when the SSA was used after three times recycling.

In summary, we have developed an efficient new method for the synthesis of *N*-sulfonylimines *via* the condensation of sulfonamides with aldehydes as well as isatin. The advantages of this method are high yields, relatively short reaction times, low cost, simple experimental as well as isolation procedures, and agreement with the green chemistry protocols.

EXPERIMENTAL SECTION

All chemicals were purchased from Merck or Fluka Chemical Companies. SSA was prepared according to the reported method in the literature.[3] The progress of the reactions was followed by TLC using silica gel SILG/UV 254 plates. The ^{1}H NMR (250 MHz) and ^{13}C NMR (62.5 MHz) were run on a Brucker Avanced DPX-250, FT-NMR spectrometer (δ in ppm). Mass spectra were recorded on a Shimadzu GC MS-QP 1000 EX apparatus. Microanalyses were performed on a Perkin-Elmer 240-B microanalyzer. Melting points were recorded on a Büchi B-545 apparatus in open capillary tubes.

General Procedure for the Synthesis of *N*-Sulfonylimines.- To a well ground mixture of the sulfonamide (1 mmol) and SSA (0.5 g) in a 10 mL round-bottomed flask connected to a reflux condenser was added the carbonyl compound (1 mmol). The mixture was stirred in an oil bath (90°C) for the times indicated in *Table 3*. Afterward, the reaction mixture was cooled to room temperature and the solid mixture was transferred to a sintered glass funnel and washed with acetone (20 mL). The solvent was evaporated from the filtrate and the crude product was dissolved in warm ethyl acetate (2 mL), *n*-hexane (6 mL) was added, and allowed to stand at room temperature for 5-6 h. During this time, crystals of the product which had formed were collected on a sintered glass funnel, washed with *n*-hexane, and dried. The catalyst that remained on the funnel[42] was dried and used for next run under identical reaction conditions.

Acknowledgements.- We appreciate Payame Noor University (PNU) and Persian Gulf University Research Councils for financial support of this work.

REFERENCES

1. K. Tanaka, "*Solvent-free Organic Synthesis*", Wiley-VCH, GmbH and KGaA, Weinheim, 2004.
2. A. Loupy, "*Microwave in Organic Synthesis*", Wiley-VCH, Weinheim, 2006.
3. P. Salehi, M. A. Zolfigol, F. Shirini and M. Baghbanzadeh, *Curr. Org. Chem.*, **10**, 2171 (2006).
4. M. Gohain, *Synlett*, 2097 (**2003**).

5. H.-K. Yim and H. N. C. Wong, *J. Org. Chem.*, **69**, 2892 (2004).

6. L. G. Arini, A. Sinclair, P. Szeto and R. A. Stockan, *Tetrahedron Lett.*, **45**, 1589 (2004).

7. M. J. Melnick, S. M. Weinreb and A. Freyer, *Tetrahedron Lett.*, **29**, 3891 (1988).

8. X.-T. Zhou, Y.-R. Lin, L.-X. Dai, J. Sun, L.-J. Xia and M.-H. Tang, *J. Org. Chem.*, **64**, 1331 (1999).

9. A. Hasaninejad and H. Sharghi, *Phosphorus, Sulfur, and Silicon*, **182**, 873 (2007).

10. B. E. Love, P. S. Raje and T. C. Williams, *Synlett*, 493 (**1994**).

11. A. Vass, J. Dudas and R. S. Varma, *Tetrahedron Lett.*, **40**, 4951 (1999).

12. W. B. Jennings and C. J. Lovely, *Tetrahedron*, **47**, 5561 (1991).

13. T Jin, G. Feng, M. Yang and T. Li, *Synth. Commun.*, **34**, 1277 (2004).

14. F. A. Davis, U. Nadir, E. W. Kluger, T. C. Sedergran, T. W. Panunto, R. Billmers, R. Jenkins, I. J. Turchi, W. H. Watson, J. S. Chen and M. Kimura, *J. Am. Chem. Soc.*, **102**, 2000 (1980).

15. F. A. Davis, J. M. Kaminski, E. W. Kluger and H. S. Freilich, *J. Am. Chem. Soc.*, **97**, 7085 (1975).

16. A. Hasaninejad, A. Zare, H. Sharghi and M. Shekouhy, *ARKIVOC*, **(xi)**, 64 (2008).

17. D. L. Borger and W. L. Corbett, *J. Org. Chem.*, **57**, 4777 (1992).

18. Z. Li, X. Ren, P. Wei, H. Wan, Y. Shi and P. Ouyang, *Green Chem.*, 433 (**2006**).

19. J. Sisko, M. Mellinger, P. W. Sheldrake and N. H. Baine, *Tetrahedron Lett.*, **37**, 8113 (1996).

20. F. Chemla, V. Hebbe and J.-F. Normant, *Synthesis*, 75 (**2000**).

21. J. P. Wolfe and J. E. Ney, *Org. Lett.*, **5**, 4607 (2003).

22. A. Hasaninejad, A. Zare, H. Sharghi, M. Shekouhy, R. Khalifeh, A. Salimi Beni and A. R. Moosavi Zare, *Can. J. Chem.*, **85**, 416 (2007).

23. A. Khalafi-Nezhad, A. Parhami, M. N. Soltani Rad, M. A. Zolfigol and A. Zare, *Tetrahedron Lett.*, **48**, 5219 (2007).

24. A. Hasaninejad, A. Zare, H. Sharghi, K. Niknam and M. Shekouhy, *ARKIVOC*, **(xiv)**, 39 (2007).

25. A. Hasaninejad, A. Parhami, A. Zare, A. Khalafi-Nezhad, A. Nasrolahi Shirazi and A.R. Moosavi Zare, *Polish J. Chem.*, **82**, 565 (2008); *Chem. Abstr.*, AN 453098 (2008).

26. A. Zare, A. Hasaninejad, M.H. Beyzavi, A. Parhami, A.R. Moosavi Zare, A. Khalafi-Nezhad and H. Sharghi, *Can. J. Chem.*, **86**, 317 (2008).

27. A. Khalafi-Nezhad, A. Parhami, A. Zare, A.R. Moosavi Zare, A. Hasaninejad and F. Panahi, *Synthesis*, 617 (**2008**).

28. A. Zare, A. Hasaninejad, A. Khalafi-Nezhad, A. Parhami and A.R. Moosavi Zare, *J. Iran. Chem. Soc.*, **5**, 100 (2008); *Chem. Abstr.*, AN 402126 (2008).

29. A. Zare, A. Hasaninejad, A. Parhami, A.R. Moosavi Zare and A. Khalafi-Nezhad, *Polish J. Chem.*, **82**, 1059 (2008); *Chem. Abstr.*, AN 645731 (2008).

30. A. Zare, A. Hasaninejad, A. Khalafi-Nezhad, A. R. Moosavi Zare, A. Parhami and G. R. Nejabat, *ARKIVOC*, **(i)**, 58 (2007).

31. A. Zare, A. Hasaninejad, A. Khalafi-Nezhad, A. R. Moosavi Zare and A. Parhami, *ARKIVOC*, **(xiii)**, 105 (2007).

32. G. H. Imanzadeh, A. Zare, A. Khalafi-Nezhad, A. Hasaninejad, A. R. Moosavi Zare and A. Parhami, *J. Iran. Chem. Soc.*, **4**, 467 (2007); *Chem. Abstr.*, AN 1483174 (2007).

33. A. Khalafi-Nezhad, A. Zare, A. Parhami, M. N. Soltani Rad and G. R. Nejabat, *J. Iran. Chem. Soc.*, **4**, 271 (2007); *Chem. Abstr.*, AN 1049047 (2007).

34. A. Zare, A. Hasaninejad, A. R. Moosavi Zare, A. Parhami, H. Sharghi and A. Khalafi-Nezhad, *Can. J. Chem.*, **85**, 438 (2007).

35. G. H. Imanzadeh, A. Khalafi-Nezhad, A. Zare, A. Hasaninejad, A. R. Moosavi Zare, A. Parhami, *J. Iran. Chem. Soc.*, **4**, 229 (2007); *Chem. Abstr.*, AN 708227 (2007); CAN **148**, 471915 (2007).

36. A. Khalafi-Nezhad, A. Zare, A. Parhami, M. N. Soltani Rad and G. R. Nejabat, *Phosphorus, Sulfur, and Silicon*, **182**, 657 (2007).

37. S. M. Weinreb, *Top. Curr. Chem.*, **190**, 131 (1997).

38. S. L. Jain, V. B. Sharma and B. Sain, *J. Mol. Cat. A.: Chem.*, **239**, 92 (2005).

39. F. A. Davis and S. G. La, *J. Org. Chem.*, **53**, 5004 (1988).

40. B. M. Trost and C. Marrs, *J. Org. Chem.*, **56**, 6468 (1991).

41. J. L. G. Ruano, J. Aleman, M. B. Cid and A. Perra, *Org. Lett.*, **7**, 179 (2005).

42. A regular Buchner funnel containing a thin layer of Celite on top of which a thin layer of cotton is pressed, may be used instead of the glass funnel.

(Received May 22, 2008; in final form September 5, 2008)