Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

One-Pot, Three-Component Synthesis of 4H-Pyrans Using Cu(II) Oxymetasilicate

Majid M. Heravi [a], Yahya S. Beheshtiha [a], Zahra Pirnia [a], Samaheh Sadjadi [a] & Mina Adibi [b]
[a] Department of Chemistry, School of Sciences, Azzahra University, Vanak, Tehran, Iran
[b] Specialty Chemicals Research Department, Chemical and Petrochemical Division, Research Institute of Petroleum Industry, NIOC, Tehran, Iran
Published online: 08 Sep 2009.

To cite this article: Majid M. Heravi , Yahya S. Beheshtiha , Zahra Pirnia , Samaheh Sadjadi & Mina Adibi (2009): One-Pot, Three-Component Synthesis of 4H-Pyrans Using Cu(II) Oxymetasilicate, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 39:20, 3663-3667

To link to this article: http://dx.doi.org/10.1080/00397910902796102

Synthetic Communications®, 39: 3663–3667, 2009

ISSN: 0039-7911 print/1532-2432 online
DOI: 10.1080/00397910902796102

Taylor & Francis
Taylor & Francis Group

One-Pot, Three-Component Synthesis of 4*H*-Pyrans Using Cu(II) Oxymetasilicate

Majid M. Heravi,[1] Yahya S. Beheshtiha,[1] Zahra Pirnia,[1] Samaheh Sadjadi,[1] and Mina Adibi[2]

[1]Department of Chemistry, School of Sciences, Azzahra University, Vanak, Tehran, Iran

[2]Specialty Chemicals Research Department, Chemical and Petrochemical Division, Research Institute of Petroleum Industry, NIOC, Tehran, Iran

Abstract: 4*H*-Pyrans are synthesized through one-pot, three-component reaction of benzaldehyde, malononitrile, and ethyl acetoacetate using Cu(II) oxymetasilicate as an efficient, reusable catalyst. The procedure offers advantages in terms of better yields, short reaction times, mild reaction conditions, and reusability of the catalyst.

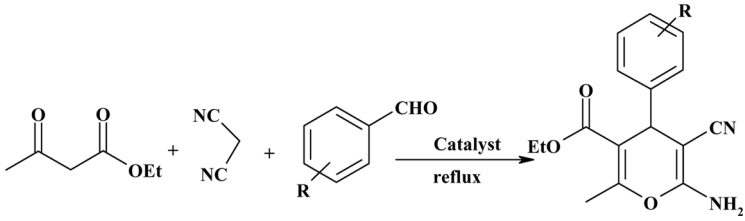
Keywords: Cu(II) oxymetasilicate, 4*H*-pyrans, recyclable catalyst

INTRODUCTION

Polyfunctionlized 4*H*-pyrans are interesting compounds because they possess biological and pharmacological activities.[1] These compounds are used as anticoagulants, anticancer agents, spasmolytics, and anti-anaphylactics.[2,3] 4*H*-Pyrans containing heterocyclic rings show more pharmacological activities.[4] These compounds can be used for the treatment of neurodegenerative diseases, including Alzheimer's disease, as well as for the treatment of schizophrenia and myoclonus. 2-Amino-4-*H*-pyran derivatives are useful as photoactive materials.[5] The 4*H*-pyran

Received January 11, 2009.

Address correspondence to Majid M. Heravi, Department of Chemistry, School of Sciences, Azzahra University, Vanak, Tehran 1234, Iran. E-mail: mmh1331@yahoo.com



Scheme 1. Synthesis of 4*H*-pyrans using Cu(II) oxymetasilicate.

unit has been synthesized using different methods, including microwave and ultrasonic irradiation.[6] In addition, the one-pot synthesis of 4*H*-pyrans has been reported using tetrabutylammonium bromide,[7] (S)-proline, rare-earth perfluorooctanoates, and hexadecyltrimethylammonium bromide.[8] All of these catalysts have limitations such as harsh reaction conditions, poor yields, tedious workups, and poor recyclability.

Herein we report the synthesis of 4*H*-pyrans from a one-pot reaction of benzaldehyde, malononitrile, and ethyl acetoacetate in the presence of catalytic amounts of Cu(II) oxymetasilicate (Scheme 1).

Cu(II) oxymetasilicate has been used successfully for the synthesis of 4*H*-pyrans through the one-pot, three-component reaction of benzaldehyde, malononitrile, and ethyl acetoacetate. The results of synthesis of 4*H*-pyrans in the presence of catalytic amounts of Cu(II) oxymetasilicate are summarized in Table 1. As shown in this table, benzaldehyde with electron-withdrawing groups led to products with slightly better yields than benzaldehyde with electron-donating groups.

To investigate the effect of catalyst amounts on the yields of reactions, two reactions were selected as model reactions. Various amounts

Table 1. Synthesis of 4*H*-pyrans using Cu(II) oxymetasilicate under refluxing condition

Entry	R	Yield (%)[a]
1	H	88
2	4-NO_2	92
3	3-NO_2	91
4	4-Cl	92
5	4-OMe	85
6	4-Me	83
7	4-OH	84

[a]Yields refer to isolated products.

Table 2. Results of using different amounts of Cu(II) oxymetasilicate on yields of two 4*H*-pyrans

Entry	R	Catalyst amount (mol%)	Yield (%)[a]
1	H	0.1	84
2	H	0.3	88
3	H	0.5	88
4	4-NO_2	0.1	89
5	4-NO_2	0.3	92
6	4-NO_2	0.5	92

[a]Yields refer to isolated products.

of catalysts (0.1, 0.3, and 0.5 mol%) were used for the synthesis of these two model reactions. The results are shown in Table 2. The results show that the optimum amount of catalyst was 0.3 mol%.

To study the effect of solvent on this reaction, the model reactions were performed in four solvents including CH_3CN, CH_2Cl_2, $CHCl_3$, and H_2O. The results are summarized in Table 3. As shown in this table, CH_3CN is the best solvent for this reaction.

In summary, we have developed a method using Cu(II) oxymetasilicate for the synthesis of 4-*H*-pyrans from the one-pot, three-component reaction of benzaldehyde, malononitrile, and ethyl acetoacetate. The reasonable reaction times, very good yields, simple workup procedure, and environmentally friendly conditions are the main merits of this method.

Table 3. Effect of various solvents on yield of two 4*H*-pyran derivatives

Entry	R	Solvent	Yield (%)[a]
2	H	CH_3CN	88
3	H	CH_2Cl_2	85
4	H	$CHCl_3$	82
5	H	H_2O	80
6	4-NO_2	CH_3CN	92
7	4-NO_2	CH_2Cl_2	90
8	4-NO_2	$CHCl_3$	89
9	4-NO_2	H_2O	87

[a]Yields refer to isolated products.

EXPERIMENTAL

All the chemicals were purchased from Merck Company. Cu(II) oxymetasilicate was prepared according to our previous work.[9] All compounds were known, and their physical data were compared with those of authentic compounds and found to be identical.

Synthesis of 4*H*-Pyran Derivatives: General Procedure

A catalytic amount of Cu(II) oxymetasilicate (0.3 mmol) was added to a mixture of benzaldehyde (10 mmol), malononitrile (12 mmol), and ethyl acetoacetate (10 mmol), and the mixture was refluxed in CH_3CN (10 mL) for 1 h. The progress of the reaction was monitored by thin-layer chromatography (TLC). At the end of the reaction, the catalyst was filtered off and the products were recrystallized from an ethanol mixture.

All products were identified by comparison of their physical and spectroscopic data with those reported for authentic samples.[8]

Recycling of the Catalyst

At the end of the reaction, the catalyst could be recovered by simple filtration. The recycled catalyst could be washed with dichloromethane (DCM) and subjected to a second run of the reaction process. In Table 4, the comparison of efficiency of this catalyst in synthesis of

Table 4. Comparison of efficiency of Cu(II) oxymetasilicate in synthesis of 4*H*-pyrans after three times (given in percentage of yield)

		Run[a]		
Entry	R	First	Second	Third
1	H	88	86	86
2	4-NO_2	92	90	90
3	3-NO_2	91	90	89
4	4-Cl	92	91	90
5	4-OMe	85	84	83
6	4-Me	83	82	82
7	4-OH	84	83	82

[a]Yields refer to isolated products.

4*H*-pyrans after three times is reported. As shown in Table 4, the yields of reactions after using this catalyst three times show a slight reduction.

ACKNOWLEDGEMENTS

The authors are thankful to Azzahra University Research Council for partial financial support.

REFERENCES

1. Green, G. R.; Evans, J. M.; Vong, A. K. In *Comprehensive Heterocyclic Chemistry II*; A. R. Katritzky, C. W. Rees, E. F. V. Scriven (Eds.); Pergamon Press: Oxford, 1995; vol. 5, p. 469.
2. Foye, W. O. *Prinicipi di Chemico Farmaceutica*; Piccin: Padova, Italy, 1991; p. 416.
3. Bonsignore, L.; Loy, G.; Secci, D.; Calignano, A. Synthesis and pharmacological activity of 2-oxo-(2*H*) 1-benzopyran-3-carboxamide derivatives. *Eur. J. Med. Chem.* **1993**, *28*, 517.
4. Martin, N.; Pascual, C.; Seoane, C.; Soto, J. L. The use of some activated nitriles in heterocyclic syntheses. *Heterocycles* **1987**, *26*, 2811.
5. Armesto, D.; Horspool, W. M.; Martin, N.; Ramos, A.; Seaone, C. Synthesis of cyclobutenes by the novel photochemical ring contraction of 4-substituted 2-amino-3,5-dicyano-6-phenyl-4H-pyrans. *J. Org. Chem.* **1989**, *54*, 3069.
6. (a) Zhou, J. F.; Tu, S. J.; Gao, Y.; Ji, M. One pot synthesis of pyrans and pyrano[2,3-c]pyrazole derivatives under microwave irradiation. *Chin. J. Org. Chem.* **2001**, *21*, 742; (b) Peng, Y.; Song, G. Amino-functionalized ionic liquid as catalytically active solvent for microwave-assisted synthesisof 4H-pyrans. *Catal. Commun.* **2007**, *8*, 111.
7. Fotouhi, L.; Heravi, M. M.; Fatehi, A.; Bakhtiari, K. Electrogenerated base-promoted synthesis of tetrahydrobenzo[*b*]pyran derivatives. *Tetrahedron Lett.* **2007**, *48*, 379.
8. Babu, N. S.; Pasha, N.; Rao, K. T. V.; Prasad, P. S. S.; Lingaiah, N. A heterogeneous strong basic Mg/La mixed oxide catalyst for efficient synthesis of polyfunctionalized pyrans. *Tetrahedron Lett.* **2008**, *49*, 2730.
9. Adibi, M.; Mohajeri, A. Efficient solvent-free oxidative coupling of 2-naphthols by copper(II) oxymetasilicate under microwave irradiation. *J. Chem. Res.* **2003**, 230.