



Synthesis of 1,2,4-Triazolo[5,1-b][1,3]-thiazin-7-ones Catalyzed by Pentafluorophenylammonium Triflate

N. MONTAZERI*, K. POURSHAMSIAN, A. DIVSALAR and M. GHOORCHI-BEIGI

Department of Chemistry, Tonekabon Branch, Islamic Azad University, Tonekabon, Iran

*Corresponding author: Fax: +98 192 4274409; Tel: +98 192 4274415, E-mail: montazer50@toniau.ac.ir

(Received: 6 August 2011;

Accepted: 17 January 2012)

AJC-11001

Pentafluorophenylammonium triflate has been found to be an outstanding catalyst for the cyclization of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)-acrylic acids into 1,2,4-triazolo[5,1-*b*][1,3]thiazin-7-ones under solvent-free microwave irradiation and conventional heating. Taking into account environmental and economical considerations, the protocol presented here has the merits of environmentally benign, simple operation, convenient work-up and good yields. Furthermore, the catalyst can be easily recovered and reused without losing its activity.

Key Words: Heterogeneous catalyst, Pentafluorophenylammonium triflate triazolothiazine, Microwave irradiation.

INTRODUCTION

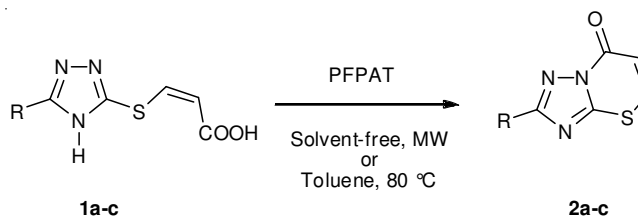
The use of homogeneous catalysts has some major limitations including no possible reuse, difficulty of products separation, air and moisture sensitivity and low product selectivity¹. As a result, one of the challenges in the field of catalysis is to replace these homogeneous catalysts by non-toxic, non-corrosive, easy to handle and environmentally friendly heterogeneous catalysts. Using solid acid catalysts have some advantages such as ease of products separation, recycling of the catalyst and environmental acceptability as compared to liquid acid catalyst². They are not corrosive but environmentally benign, presenting fewer disposal problems. Thus, the development and use of solid and green catalysts are very important in organic syntheses.

In previous paper, a new route to the synthesis of 1,2,4-triazolo[5,1-*b*][1,3]thiazin-7-ones through cyclization of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)acrylic acids using conc. H₂SO₄ at 50 °C has been reported³. Sulfuric acid is an environmentally harmful liquid acid catalyst and work-up procedures are difficult in the presence of this catalyst. These limitations prompted us towards further investigation in search of a new catalyst, which should carry out the synthesis of these compounds under simpler experimental set up and eco-friendly conditions.

Recently, Tanabe *et al.*⁴ reported the application of pentafluorophenylammonium triflate (C₆F₅NH₃OTf; PFPAT) as a novel heterogeneous catalyst in organic transformation such as esterification of carboxylic acids with alcohols, C-acylations of enol silyl ethers or ketene silyl (thio)acetals

with acid chlorides⁵ and Mukaiyama aldol and Mannich reactions using ketene silyl acetals with ketones and oxime ethers⁶.

Prompted by these findings and due to our interest on the applications of reusable catalysts in organic reactions⁷⁻⁹ and in continuation of our previous works in utilization of microwave irradiation in organic syntheses¹⁰⁻¹⁴, herein we wish to report a novel catalytic method for transformation of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)acrylic acids (**1a-c**) to 1,2,4-triazolo[5,1-*b*][1,3]thiazin-7-ones (**2a-c**) using pentafluorophenylammonium triflate (PFPAT) as an efficient and reusable catalyst under solvent-free microwave irradiation and conventional heating (**Scheme-I**).



Scheme-I Synthesis of 1,2,4-triazolo[5,1-*b*][1,3]thiazin-7-ones catalyzed by pentafluorophenylammonium triflate

EXPERIMENTAL

Melting points were recorded on an electrothermal type 9100 melting point apparatus. The IR spectra were obtained on a 4300 Shimadzu spectrophotometer as KBr disks. The ¹H NMR (100 MHz) spectra were recorded on a Bruker AC

TABLE-1
PFPAT CATALYZED SYNTHESIS OF COMPOUNDS **2a-c** USING
MICROWAVE IRRADIATION AND CONVENTIONAL HEATING

Entry	R	Products	Microwave Irradiation (Method A)		Conventional Heating (Method B)		m.p. (°C)
			Time (min)	Yield (%) ^a	Time (h)	Yield (%) ^a	
1	H		9	76	7	78	232-234
2	Me		8	78	5	80	197-199
3	Ph		8	79	5	83	263-264

^aIsolated yields

100 spectrometer. All products were known and characterized by comparison of their physical and spectroscopic data with those of already reported³.

Preparation of the catalyst (PFPAT): This catalyst was prepared according to the literature¹⁵. To a solution of 2,3,4,5,6-pentafluoroaniline (25 mmol) in toluene (25 mL), CF₃SO₃H (25 mmol) was added at 0-5 °C. The reaction mixture was stirred at the same temperature for 0.5 h. After this time, the solvent was evaporated *in vacuo*, the crude product was collected and washed with hexane to give the pure catalyst in 92 % yield.

General procedure for the preparation of 1,2,4-triazolo[5,1-b][1,3]thiazin-7-ones (2a-c): Method A: A mixture of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)-acrylic acids **1a-c** (1 mmol) and PFPAT (0.2 mmol) as catalyst was subjected to microwave irradiation at 385 W for the indicated time. The progress of the reaction was monitored by TLC. After the completion of the reaction, the reaction mixture was cooled to room temperature and cold water was added. The precipitate was filtered off and recrystallized from ethanol/water to give compounds (**2a-c**) in 76, 78 and 79 % yields respectively (Table- 1, **Method A**).

Method B: A mixture of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)-acrylic acids **1a-c** (1 mmol) and PFPAT (0.2 mmol) as catalyst in toluene was heated on the oil bath at 80 °C for the indicated time. The reaction was monitored by TLC. After completion of the reaction, the solvent was evaporated *in vacuo* and then cold water was added. The precipitate was filtered off and recrystallized from ethanol/water to give compounds (**2a-c**) in 78, 80 and 83 % yields respectively (Table-1, **Method B**).

Recycling and reusing of the catalyst: The catalyst is soluble in water and could therefore be recycled as the filtrate. The catalyst was recovered by evaporation of the water, washed with hexane, dried at 50 °C under vacuum for 1 h and reused in another reaction without appreciable reduction in the catalytic activity.

RESULTS AND DISCUSSION

The application of microwave irradiation to organic synthesis for conducting reactions at accelerated rates is an emerging technique. In fact, in recent years, the use of microwaves has become popular among chemists both as a means to improve classical organic reactions (shortening reaction times and/or improving yields) and promote new reactions¹⁶⁻²². Availability of suitable commercial microwave equipments, domestic ovens and monomode reactors has also contributed to the development of this technique significantly. Therefore, in this paper, we decided to investigate the efficiency of PFPAT as solid acid catalyst in the synthesis of 1,2,4-triazolo[5,1-b][1,3]thiazin-7-ones under microwave irradiation conditions.

The starting materials (**1a-c**) were prepared according to the literature method³. Firstly, cyclization of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)-acrylic acids **1a-c** in the presence of a catalytic amount of PFPAT using microwave irradiation in solvent-free conditions were investigated (**Scheme-I**). Thus, the compounds (**1a-c**) and PFPAT were mixed together and then irradiated at 800 W for the indicated time, using a domestic microwave oven Model LG MS-543XD to give the cyclized products 1,2,4-triazolo[5,1-b][1,3]thiazin-7-ones (**2a-c**) in high yields (Table-1, **Method A**).

For comparison, a classical method for the above mentioned reactions was also investigated by heating the compounds (**1a-c**) in toluene as solvent on the oil bath at 80 °C and in the presence of PFPAT as catalyst (Table-1, **Method B**). It was very obvious that the classical approach for these cyclizations is a tedious method affording a relatively lower yields of **2a-c** with much longer reaction time.

Conclusion

In summary, we have reported a quick, clean and simple method for cyclization of 3-(4*H*-1,2,4-triazol-3-ylsulfanyl)-acrylic acids into 1,2,4-triazolo[5,1-b][1,3]thiazin-7-ones catalyzed by pentafluorophenylammonium triflate as catalyst

under solvent-free microwave irradiation and also by conventional heating. In comparison, the reactions carried out with the assistance of microwave technique are faster than conventional method. The catalyst can be reused after a simple work-up, with only slight reduction in the catalytic activity. Good to excellent yields, short reaction times, simple operation and easy work-up are some advantages of this protocol. It is believed that this applicability of pentafluorophenylammonium triflate with mentioned advantages makes present method superior over previous reported method for the synthesis of 1,2,4-triazolo[5,1-b][1,3]thiazin-7-ones.

ACKNOWLEDGEMENTS

The authors are thankful to Islamic Azad University, Tonekabon Branch for financial support.

REFERENCES

1. S.K. Jana, *Catal. Surv. Asia*, **9**, 25 (2005).
2. T. Okuhara, *Chem. Rev.*, **102**, 3641 (2002).
3. M.M. Heravi, N. Montazeri, M. Rahimizadeh, M. Bakavoli and M. Ghassemzadeh, *Monatsh. Chem.*, **132**, 1225 (2001).
4. T. Funatomi, K. Wakasugi, T. Misaki and Y. Tanabe, *Green Chem.*, **8**, 1022 (2006).
5. A. Iida, J. Osada, R. Nagase, T. Misaki and Y. Tanabe, *Org. Lett.*, **9**, 1859 (2007).
6. R. Nagase, J. Osada, H. Tamagaki and Y. Tanabe, *Adv. Synth. Catal.*, **352**, 1128 (2010).
7. N. Montazeri, S. Khaksar, A. Nazari, S.S. Alavi, S.M. Vahdat and M. Tajbakhsh, *J. Fluorine Chem.*, **132**, 450 (2011).
8. N. Montazeri, *Asian J. Chem.*, **22**, 7432 (2010).
9. K. Rad-Moghadam and N. Montazeri, *Asian J. Chem.*, **21**, 499 (2009).
10. N. Montazeri and K. Rad-Moghadam, *Phosphorus Sulfur Silicon Rel. Elem.*, **179**, 2533 (2004).
11. N. Montazeri and K. Rad-Moghadam, *Asian J. Chem.*, **18**, 1557 (2006).
12. K. Rad-Moghadam and N. Montazeri, *Asian J. Chem.*, **19**, 2467 (2007).
13. N. Montazeri and K. Rad-Moghadam, *Chin. Chem. Lett.*, **19**, 1143 (2008).
14. F. Hatamjafari and N. Montazeri, *Turkish J. Chem.*, **33**, 797 (2009).
15. T. Funatomi, K. Wakasugi, T. Misaki and Y. Tanabe, *Green Chem.*, **8**, 1022 (2006).
16. M. Rahimizadeh, A. Davoodnia, M.M. Heravi and M. Bakavoli, *Phosphorus Sulfur Silicon Rel. Elem.*, **177**, 2923 (2002).
17. A. Davoodnia, M. Bakavoli, F. Khorramdelan and M. Roshani, *Indian J. Heterocycl. Chem.*, **16**, 147 (2006).
18. A. Davoodnia, M. Rahimizadeh, Sh. Rivadeh, M. Bakavoli and M. Roshani, *Indian J. Heterocycl. Chem.*, **16**, 151 (2006).
19. A. Davoodnia, M. Roshani, E. Saleh-Nadim, M. Bakavoli and N. Tavakoli-Hoseini, *Chin. Chem. Lett.*, **18**, 1327 (2007).
20. A. Davoodnia, M. Roshani, S.H. Malaek and M. Bakavoli, *Chin. Chem. Lett.*, **19**, 525 (2008).
21. A. Davoodnia, M. Rahimizadeh, H. Atapour-Mashhad, N. Tavakoli-Hoseini, *Heteroatom Chem.*, **20**, 346 (2009).
22. A. Davoodnia, A. Zare-Bidaki and H. Eshghi, *Phosphorus, Sulfur Silicon Rel. Elem.*, **183**, 2968 (2008).