Synthesis of Pyrroles Catalyzed by MCM-41-SO_3H as Recyclable Heterogeneous Catalyst

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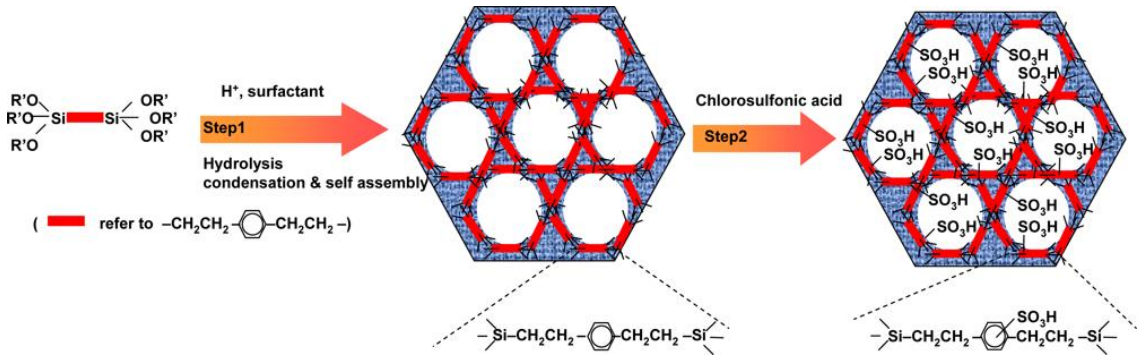
Abstract

A one-pot practical, efficient multicomponent synthesis of substituted Pyrroles has been developed using MCM-41-SO_3H as recyclable and heterogeneous Catalyst. Alternatively, Pyrroles derivatives were synthesized via a four-component reaction of aldehydes, amines, 1, 3-dicarbonyl compounds and nitromethane under microwave conditions.

Keywords: MCM-41-SO_3H, pyrroles, microwave, one-pot synthesis

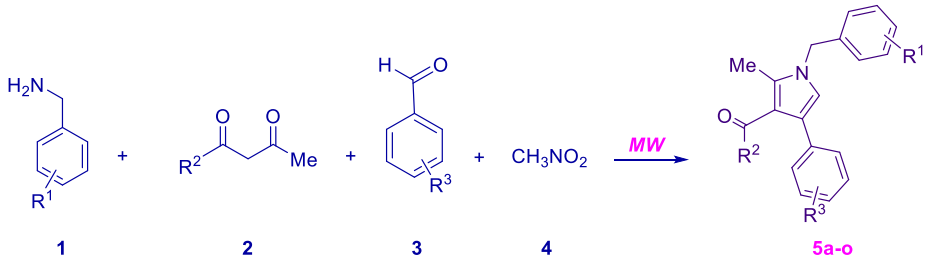
Introduction

Pyrroles and their derivatives are the most significant group of heterocyclic aromatic organic components exist in many natural things as a main building block and synthetic pharmaceutical [1]. Pyrroles have considerable biological properties such as antitumor [2], antibacterial [3], antioxidant [4] and antifungal [5]. Pyrroles have a wide application in material science, so several methods for synthesis of the construction of pyrroles have been developed. This methods include some commonly and useful reactions such as Hantzsch [6], Knorr or Paal-Knorr [7]. MCRs can give highly selective and purification products in minimization of waste, cost and time. Recently substituted pyrroles have been produced by MCRs methods using different catalysts. In this research, we used MCM-41-SO_3H as a low price, recyclable and heterogeneous catalyst for synthesis of pyrroles derivatives (Scheme 1).



Scheme 1. Schematic structure of MCM-41-SO_3H

In this study, we prepared pyrroles in short time with good yields under microwave irradiation (Scheme 2).

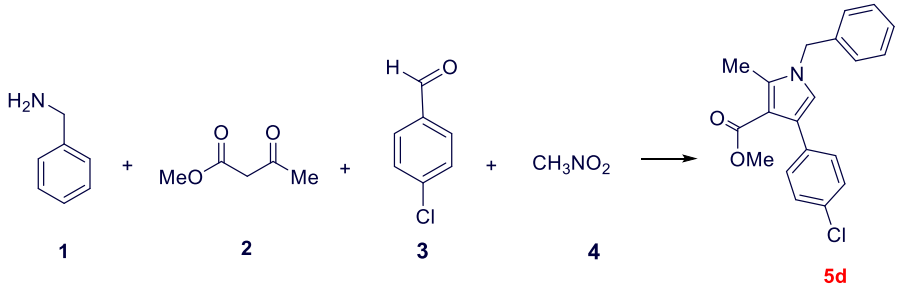


Scheme 2. Synthesis of substituted pyrroles catalyzed by MCM-41-SO_3H.

Results and discussion

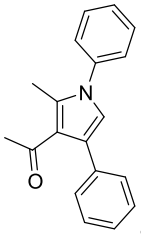
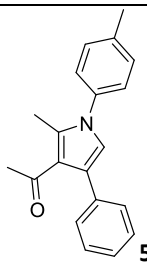
We tried to obtain optimal conditions with varying amounts of catalyst in reaction of benzyl amine (0.1 mmol), 4-Chlorobenzaldehyde (0.1 mmol), methyl acetoacetate (0.1 mmol) and nitro methane (1 mL) as model substrates. The reaction did not proceed in the absence of catalyst at ambient temperature, reflux and microwave (Table 1, entries 1, 2). The yield of the model reaction and its completion time were similar using 0.01, 0.02 and 0.03 g of the catalyst (Table 1, entries 3, 4) but it is more affordable to use 0.01 g of catalyst as the optimum amount. The model reaction proceeded well under 2 min microwave irradiation and afforded high yields of the corresponding product. Some different substituted pyrroles were prepared under similar conditions (Table 2).

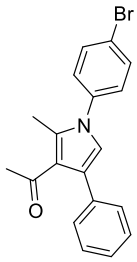
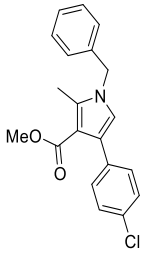
Table 1. The optimal amount of catalyst



Entry	MCM-41-SO_3H (g)	conditions	Isolated Yield (%)	Time
1	-	RT-Reflux	N. R.	48 h
2	-	MW	N. R.	60 min
3	0.01	MW	86	2 min
4	0.02-0.03	MW	85	2 min

Table 2. Synthesis of different substituted pyrroles.

Entry	R^1	R^2	R^3	Time/ min	Product	Yield* (%)	Mp (◦C)	Mp (◦C)/Ref
1	C_6H_5	Me	C_6H_5	4	 **5a**	87	(105-107)	(106–107)[12]
2	4-Me-C_6H_4	Me	C_6H_5	3	 **5b**	90	(110-113)	(109-111)[12]

3	4-Br-C_6H_4	Me	C_6H_5	5	 **5c**	85	(140-143)	(141-143)[12]
4	$C_6H_5CH_2$	OMe	4-Cl-C_6H_4	2	 **5d**	86	Oil	[14]

*Isolated yield.

Experimental

Materials and instrumentation

All chemical and solvents were purchased from commercially available sources such as Sigma–Aldrich and Merck. Melting points were determined by Electro thermal 9100 apparatus. Industrial microwave (SN134962) was used for reactions progress.

General procedure for synthesis of pyrroles

A mixture of aldehyde (0.1 mmol), amine (0.1 mmol), dicarbonyl compounds (0.1 mmol) and nitro methane (1 mL) In the presence of MCM-41-SO_3H (0.01 g) were reacted in a 25 mL flask under microwave irradiation. The reaction progress was monitored by TLC. After completion of the reaction obtained products were purified by plate chromatography. Products were achieved in excellent yields.

Conclusion

In summary, an efficient and simple method has been developed for the synthesis of tetra-substituted pyrroles via a four component and one-pot reaction of amines, aldehydes, active methylene compounds and nitro alkanes using MCM-41-SO_3H as heterogeneous catalyst.

Acknowledgements

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References

1. Pinna, G.A., et al., *Synthesis and dopamine D 2-like receptor binding affinity of substituted 5-phenyl-pyrrole-3-carboxamides.* Il Farmaco, 1999. **54** (8): p. 542-550.
2. Denny, W.A., G.W. Rewcastle, and B.C. Baguley, *Potential antitumor agents. 59. Structure-activity relationships for 2-phenylbenzimidazole-4-carboxamides, a new class of minimal DNA-intercalating agents which may not act via topoisomerase II.* Journal of medicinal chemistry, 1990. **33** (2): p. 814-819.
3. Murineddu, G., et al., *Synthesis and analgesic-antiinflammatory activities of novel acylarylhydrazones with a 5-phenyl-4-R-3-pyrrolyl-acyl moiety.* Archiv der Pharmazie, 2001. **334** (12): p. 393-398.
4. Bürli, R.W., et al., *DNA binding ligands targeting drug-resistant Gram-positive bacteria. Part 1: Internal benzimidazole derivatives.* Bioorganic & medicinal chemistry letters, 2004. **14** (5): p. 1253-1257.
5. Meshram, H., B. Prasad, and D.A. Kumar, *A green approach for efficient synthesis of N-substituted pyrroles in ionic liquid under microwave irradiation.* Tetrahedron Letters, 2010. **51** (27): p. 3477-3480.
6. Koukabi, N., et al., *A Magnetic Particle-Supported Sulfonic Acid Catalyst: Tuning Catalytic Activity between Homogeneous and Heterogeneous Catalysis.* Advanced Synthesis & Catalysis, 2012. **354** (10): p. 2001-2008.
7. Chen, J., et al., *An approach to the Paal–Knorr pyrroles synthesis catalyzed by Sc (OTf) 3 under solvent-free conditions.* Tetrahedron letters, 2006. **47** (30): p. 5383-5387.