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Research Paper

Highly efficient diastereoselective synthesis of novel spiro-furan derivatives catalyzed by MgO supported on periodic mesoporous organosilica based on ionic liquid

Fatemeh Ahmadi [a] , Robabeh Baharfar [b] , Seyedeh Leila Allahgholipour [c]

[a,b,c] Department of Chemistry, Faculty of Chemistry, University of Mazandaran, Babolsar, Iran

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Abstract

The synthesis of novel Spiro-furan derivatives via a three-component reaction of 1,3-dicarbonyl compounds, N-phenacyl pyridinium salts and accenaphthoquione. This reaction in the present of MgO nanoparticles on ionic liquid based periodic mesoporous organosilica (MgO@PMO- IL) were achieved in high efficiency with a simple work-up procedure and short reaction time, and the catalyst can be also recovered on efficiency reused in seven subsequent reaction conditions.

Keywords: Spiro-furans, Multi component reaction, Periodic mesoporous organosilica.

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1. Introduction

Five- membered oxygen- containing heterocycles have been referred to as privileged structural motifs owing to their wide distribution in pharmaceuticals and natural products [1]-[2]. Furans have received increasing attention because of their biological and pharmacological activities, such as antitumor, antibacterial, antimicrobial, antidepressant, antiviral, antifungal and anti-inflammatory (fig1), [3] to [7].

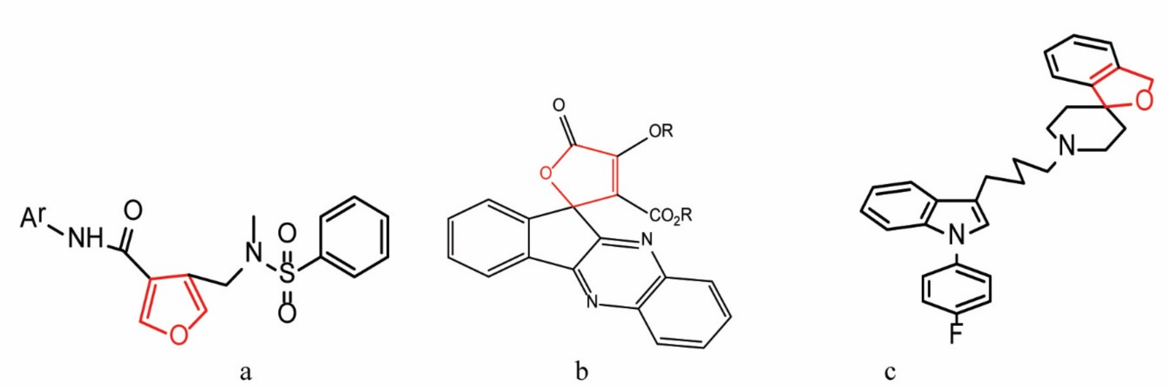


Fig 1: Antibacterial(a), antidepressant (b) and anti-inflammatory(c) properties of furan derivatives.

* Correspondence e-mail: baharfar@umz.ac.ir

Furans are also present in agrochemical bio regulator, essential, essential oils, cosmetics, dyes, photosensitizers and flavoring and fragrance compounds [8]- [9].

Spiro compounds have at least two molecular rings with only one common atom. The simplest spiro compounds are bicyclic (having only two rings), or have a bicyclic portion as part of the larger ring system, in either case with the two rings connected through the defining single common atom [10].

Multi-component reactions (MCRs) are one the best tools in combinatorial chemistry due to their productivity, conjunction simple procedures and superficial performance [11].

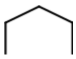
Synthesis of Spiro furan derivatives have been accomplished under homogeneous conditions in the presence of organic and inorganic base catalysts, such as DABCO, DBU and K_2CO_3 [12]. However, these methods suffer from some disadvantages, including toxicity, expensiveness difficult work up and catalyst recovery processes, long reaction time, low reaction yield, high amounts of catalyst and non-ecofriendly reaction conditions [12] to [15]. To prevent these problems, recently some recoverable heterogeneous catalysts has been developed.

In recent years, periodic mesoporous organosilica (PMO) with their uniform pore and high specific areas are received great attention from researchers because of their potential applications including catalysts, separation, adsorbents for organic molecules [15] to [17].

On the other hand, Ionic Liquids (ILs) are good solvents for catalytic reactions and have many advantages such as easy separation, high thermal stability and low toxicity.

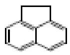
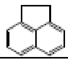
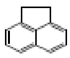
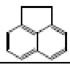
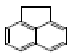
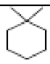
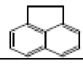
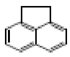
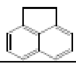
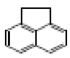
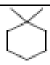
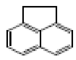
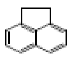
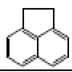
Magnesium oxide nanoparticles (MgO-NPs) have been used as heterogeneous catalyst in the synthesis because of their high surface area leading to small particle sites [18]- [19].

In the continuing of our previous work and in order to the efficiency of the nano catalysts, we used MgO@PMO-IL in the synthesis of novel spiro-furan derivatives *via* three component reaction of acenaphthoquinone, 1,3-dicarbonyl compounds, *N*-phenacyl pyridinium salts (Scheme1). The product synthesized under green reaction conditions with excellent yields, high diastereoselective, low reaction times and simple work-up in the presence of a highly efficient and recoverable nano catalyst.

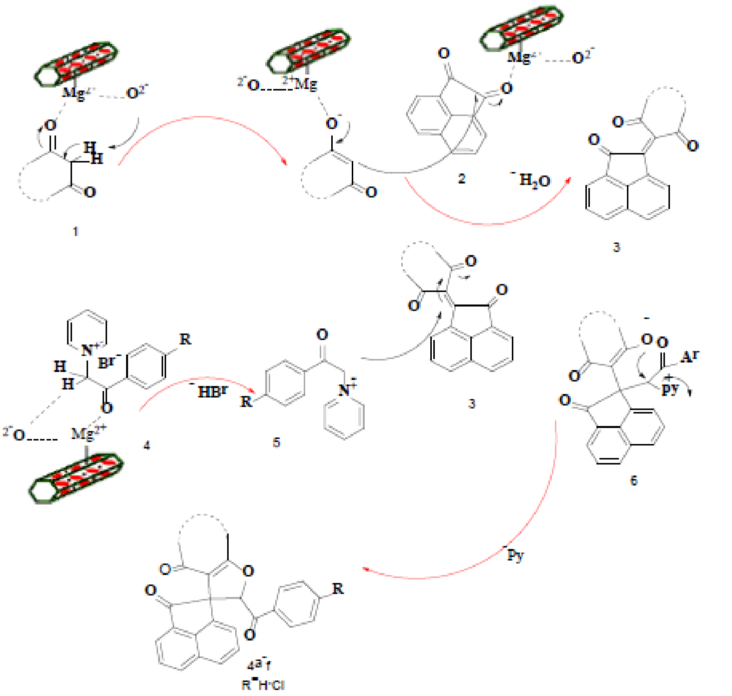


Scheme 1: Preparation of spiro-furan derivatives

Table 1: synthesis of the novel spiro-furan derivatives in the presence of MgO@(PMO-IL)

Entry	A	B	C	Product	Time(min)	Yield
4a					١٠٥	٨٥
4b					٢٠	٩٥
4c					٥٠	٩٠
4d					٣٥	٩٥
4e					٤٥	٤٥
4f					١٢٠	٨٥

A proposed mechanism for this reaction is presented in Scheme **3.** Initially, α, β-unsaturated carbonyl compound **3** is formed by the Knoevenagel condensation between acenaphthoquinone and active 1,3-dicarbonyl compounds, and *N*-phenacyl pyridinium salt is converted to pyridinium ylide **4** in the presence of MgO@PMO-IL. Then, Michael addition of **5** to Knoevenagel product forms intermediate **6**, which *via* intramolecular substitution and Keto– enol tautomerism leads to spiro- furans **4a-f** (Scheme2).



Scheme 2: Proposed mechanism for the preparation of Spiro-furan derivatives

General procedure for the synthesis of compounds 4a-f: A mixture of acenaphthoquinone (1.0 mmol),
active 1,3-dicarbonyl compound (1.0 mmol), and *N*-phenacyl pyridinium salts (1.0 mmol) in the presence of 1% mole MgO@PMO-IL was magnetically stirred in 5-7 ml of ethanol at 50 °C or reflux conditions in some cases. After completion of the reaction (monitored by TLC on SiO_2), the solvent was removed under reduced pressure and the product was obtained by recrystallization from methanol and diethyl ether.
The structure of products was confirmed with FT-IR, ^{13}C-NMR, ^{1}H NMR and mass spectroscopy:
2'-benzoyl-6',6'-dimethyl-4',5',6',7'-tetrahydro-2H,2'H-spiro[acenaphthylene-1,3'-benzofuran]-2-one (F6):
White powder, mp: 2۲۰-2۲۲ °C; yield (90%); IR (KBr) (ν_{max}, cm^{-1}) 2927(C_{sp3}-H), 1639 and 1709 (C=O), 1425 (C=C), 1227 (C_{sp2} -O), 1062 (C_{sp3}-O); ^{1}H NMR (400 MHz, $CDCl_3$), δ_H (ppm): 1.17 and 1.22 (2s, 6H, $2CH_3$), 2.16 (2d, 2H, $^{2}J_{HH}$ = 16 Hz, AB-system, CH_2), 2.72 (2d, 2H, $^{2}J_{HH}$ = 18.4 Hz, AB-system, CH_2), 6.54 (s, 1H, CH_{furan}), 6.85 (t, 2H, $^{3}J_{HH}$ =8 Hz, $2CH_{Ar}$), 7.09 (t, 1H, $^{3}J_{HH}$ =7.6 Hz, CH_{Ar}), 7.10 (d, 2H, $^{2}J_{HH}$ =7.6 Hz, CH_{Ar}), 7.18 (d, 1H, J_{HH} = 7.2, CH_{Ar}), 7.43 (t, 1H, J_{HH} =7.6, CH_{Ar}), 7.61 (d, 1H, J_{HH} =8, CH_{Ar}), 7.88 (d, 1H, J_{HH} =8, CH_{Ar}), 7.92 (d, 1H, J_{HH} =6.8, CH_{Ar}); ^{13}C NMR (100 MHz, $CDCl_3$), δ_C (ppm): 28.0 and 29.2 ($2CH_3$), 34.5 (CMe_2), 37.8 and 50.7 ($2CH_2$), 63.5 (C_{spiro}), 91.7 (CH_{furan}), 115.9 and 177.7(Cq_{furan}), 122,1, 122.2, 125.1, 126.9, 127.9, 128.2, 129.9, 131.9, 132.4, 133.0, 134.3, 136.0 and 141.1 (C_{Ar} and Cq_{Ar}), 192.0, 193.1, 203.4 (CO); MS, m/z: 422 (M^{+}•).

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