Avrupa Bilim ve Teknoloji Dergisi
Sayı 35, S. 295-298, Nisan 2022
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Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
No. 35, pp. 295-298, April 2022
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Research Article

A Simple and Efficient Acylation Reaction over Zinc Triflate as a New Catalyst

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(First received 4 March 2022 and in final form 26 March 2022)

(**DOI:** 10.31590/ejosat.1083108)

ATIF/REFERENCE: Uludağ, N. (2022). A Simple and Efficient Acylation Reaction over Zinc Triflate as a New Catalyst. *European Journal of Science and Technology*, (35), 295-298.

Abstract

The amide containing structures are found in chemistry, and related sciences. As a consequence, methods for the *N*-acylation of amines occupies a large place in organic chemistry. In this study, Zinc triflate acylation between aniline derivatives and furan-2-carbonyl chloride was investigated under mild conditions. Also, different types of amides were obtained in very good yields at room temperature and purity after a simple workup. This newly developed method is presented as a new method in organic synthesis.

Keywords: Acylation, Zinc triflate, Heterocyclic compound, Aniline derivatives.

Yeni Katalizör Olarak Çinko Triflat Üzerinde Basit ve Etkili Açilasyon Reaksiyonu

Öz

Amit içeren yapılar kimya ve ilgili bilimlerde bulunur. Sonuç olarak, aminlerin *N*-açilasyonu için yöntemler organik kimyada büyük bir yer tutar. Bu çalışmada, anilin türevleri ile furan-2-karbonil klorür arasındaki çinko triflat asilasyonu ılımlı koşullar altında incelenmiştir. Ayrıca, basit bir çalışmadan sonra oda sıcaklığında ve saflıkta çok iyi verimlerle farklı amid türleri elde edildi. Yeni geliştirilen bu yöntem, organik sentezde yeni bir yöntem olarak sunulmaktadır.
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Anahtar Kelimeler: Açilleme, Çinko triflet, Heterosiklik bileşikler, Anilin türevleri.

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1. Introduction

N-phenylfuran-2-carboxamide and its congeners have remarkable found in many important medicinal compounds [Yogesh et al., 2022] and used in syntheses fort he raw materials of many drugs structure also acylation reactions are important transformations not only on laboratory scale but also on industrial scale [Zhang et al., 2012].

The development of effective methods have attracted much interest from synthetic organic chemistry. Amide-containing structures are synthetically important and biologically active medicinally important molecules usually used for drug synthesis, serve as component for medicinal chemistry and biologically important molecules such as peptides and amino acids [Roncalı et al., 1992; Masui et al., 2003; Kobayashi et al., 2006; Lloyd-Williams et al., 2001; Nicolauo et al., 2005; Devendar et al., 2018]. Acylation for the regenration of amine and acyl chloride is still a worthwhile area of study in different catalysts. The main acylation examples from the literature, $Bi(OTf)_3$ [Orita et al., 2001], $Gd(OTf)_3$ [Alleti et al., 2005], $LiClO_4$ [Nakae et al., 2001], $RuCl_3$ [Surya et al., 2004], as a some selected useful method for acylation reaction [Wu et al., 2021]. Even though many studies have been reported for this transformation, there is still a great demand for mild catalysts to generate amide.

Many similar zinc derivatives has been used as a mild and efficient. In this study we wish to disclose different method for acylation reactions and also acylation is a significant reaction for synthetic organic chemistry. Therefore, we have decided to seek synthesis of a new method different from the literature for the N-acyl amides using zinc triflate and also described our work to reach a successful *Zinc trifluoromethanesulfonate* (zinc triflate) calayst for acylation reactions. As shown in the Scheme 1, a series amine derivatives and furan-2-carbonyl chloride under catalysis by zinc triflate [Sarvari et al., 2004; Moreno-Fuquen et al., 2013; Cheung et al., 2013].

2. Material and Method

2.1. Experimental Section

Proton and carbon NMR were obtained from Bruker device. FTIR spectra were measured with A Mattson 10 0 0 FTIR spectrometers. The melting points were determined with the Gallenkamp apparatus. The chemicals and solvents used in the syntheses were purified in accordance with international standards

2.1.1. General method for the synthesis of N-phenylfuran-2-carboxamide derivatives

An amine compound (1.0 mmol) was treated with zinc triflate (726 mg, 2.0 mmol) and furan-2-carbonyl chloride (392 mg, 3mmol) in 30 mL of anhydrous THF. The reaction was carried out at rt and continued by continuous TLC control (EtOAc). After the reaction was completed, it was poured into $NaHCO_3$ and rinsed with EtOAc and treated with ethyl acetate (2×10 mL). Then, the sample was dried with suitable dryer and concentrated. The sample, which could not be obtained pure, was purified according to the standard purification method.

2.1.2. Synthesis of N-phenylfuran-2-carboxamide (3)

The sample was crystallized in ether, yield: 88% (0.16 g), mp: 136–138 ^{0}C.IR (cm^{-1}): ν 3241 (NH), 3021, 2938 (C-H aliphatic), 1665, 1175. ^{1}H NMR: δ 10.09 (s ,1H, NH), 7.47 (dd, J=1.7, 0.9 Hz, 1H), 7.29 (d, J = 7.8 Hz, 2H), 7.22 (t, J = 7.8 Hz, 1H), 7.34 (d, J = 3.4 Hz, 1H) 7.16 (t, J = 7.8 Hz, 2H), 7.01 (dd, J = 3.4, 0.8 Hz, 1H). ^{13}C NMR: δ 168.8, 147.4, 144.3, 139.4, 129.1, 128.7, 127.7, 126.9, 126.4, 117.3, 111.2. Element Analysis calculated (%) for $C_{11}H_9NO_2$: C 70.58, H 4.85, N 7.48; found: C 7.49, H 4.77, N 7.56.

2.1.3. Synthesis of N-(p-tolyl)furan-2-carboxamide (4)

The sample was crystallized in petroleum ether, yield: 91% (0.18 g), mp: 146–147 ^{0}C. IR (cm^{-1}): ν 3296, 3121, 2988, 1643, 1124. ^{1}H NMR: δ 9.93 (s ,1H, NH), 7.84-7.78 (m, 2H), 7.51 (dd, J = 3.1, 1.6 Hz, 1H), 7.39-7.31 (m, 2H), 7.03 (dd, J = 3.1 and 0.8 Hz, 1H), 6.44 (dd, J = 3.1, 1.7 Hz, 1H) 2.43 (s, 3H). ^{13}C NMR: δ 178.7, 154.3, 144.2, 122.5, 122.1, 138.4, 136.3, 123.7, 122.4, 112.9, 111.8, 22.1. Element Analysis calculated (%) for $C_{12}H_{11}NO_2$: C 71.63, H 5.54, N 6.96; found: C 71.72, H 5.44, N 6.88.

2.1.4. Synthesis of *N*-(4-methoxyphenyl)furan-2-carboxamide (5)

The sample was crystallized in methanol, yield: 97% (0.21 g), mp: 148–149 ^{0}C. IR (cm^{-1}): ν 3281, 3054, 2993, 1654, 1073. ^{1}H NMR ($CDCl_3$, ppm): δ= 9.14 (s ,1H), 7.78-7.63 (m, 2H), 7.59-7.7.48 (m, 2H), 7.44 (dd, J = 3.1 and 0.8 Hz, 1H), 7.06 (dd, J = 3.1 and 0.7 Hz, 1H), 6.51 (dd, J = 3.2 and 1.4 Hz, 1H), 3.84 (s, 3H, CH_3). ^{13}C NMR ($CDCl_3$, ppm) δ 168.7, 157.8, 148.4, 142.6, 132.2, 127.7, 126.8, 114.1, 113.8, 111.5, 110.9, 61.3. Element Analysis calculated (%) for $C_{12}H_{11}NO_3$: C 66.37, H 5.14, N 6.47; found: C 66.27, H 5.04, N 6.51.

2.1.5. Synthesis of *N*-(4-(trifluoromethyl)phenyl)furan-2-carboxamide (6)

The sample was crystallized in ether ether, yield: 67 % (0.17 g), mp: 185-187 ^{0}C. IR cm^{-1}):ν 3301 (NH), 3011, 2877, 1668, 1270 (C-F), 1011. ^{1}H NMR: δ 8.97 (s ,1H), 7.78-7.69 (m, 2H), 7.57-7.53 (m, 2H, H_{Ar}), 7.44 (dd, J=1.6 and 0.7 Hz, 1H), 7.11 (dd, J=3.4 and 0.8 Hz, 1H), 6.56 (dd, J=3.4 and 1.6 Hz, 1H, H_{Ar}). ^{13}C NMR: δ 163.9, 157.8, 147.5, 143.4, 143.6, 131.5, 128.3, 126.8, 122.6, 117.2, 116.1, 113.5, 110.5. Element Analysis calculated (%) for $C_{12}H_8F_3NO_2$: C 56.48, H 3.16, N 5.49; found: C 56.41, H 3.09, N 5.38.

2.1.6. Synthesis of *N*-(4-nitrophenyl)furan-2-carboxamide (7)

The sample was crystallized in ether, yield: 73% (0.17 g), mp: 386-388 ^{0}C [15]. IR (cm^{-1}): ν 342, 3024, 2965, 1693, 1356 (NO_2). 1093. ^{1}H NMR ($CDCl_3$, ppm): δ= 9.91 (s ,1H, NH), 8. 21 (d, J = 7.7 Hz, 1H), 7.52 (d, J = 8.4 Hz, 1H), 7.39 (dd, J=1.3 and 0.7 Hz, 1H), 7.27-7.11 (m, 2H), 6.98 (dd, J=3.7 and 0.9 Hz, 1H), 6.40 (dd, J=3.7 and 1.4 Hz, 1H, H_{Ar}). ^{13}C NMR ($CDCl_3$, ppm) δ 169.4, 147.2, 144.5, 143.8, 143.1, 125.2, 124.8, 118.6,

117.3, 114.2, 111.0. Element Analysis calculated (%) for $C_{11}H_8N_2O_4$: C 56.93, H 3.45, N 12.05; found: C 56.79, H 3.56, N 12.19.

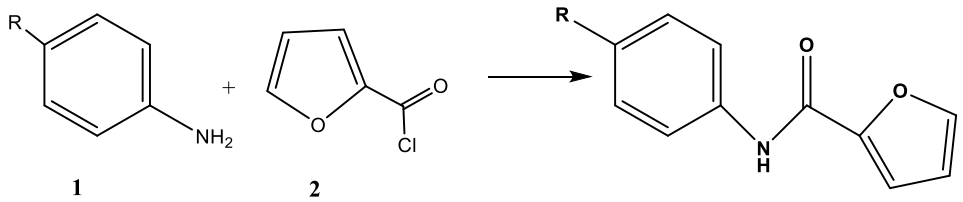
2.1.7. Synthesis of *N*-(4-cyanophenyl)furan-2-carboxamide (8)

The sample was crystallized in ether- ethyl acetate (2:1), yield: 88% (0.18 g), mp.: 164–165 ^{0}C. IR (cm^{-1}): ν 3433, 3034, 2978, 1644, 1093, 2244 (CN). ^{1}H NMR (400 MHz, $CDCl_3$, ppm): δ= 8.17 (s, 1H), 7.63 (dd, *J*=8.8 , 4.7 Hz, 2H, H_{Ar}), 7.54 (s, 1H, H_{Ar}), 7.27 (d, *J* = 3.2 Hz, 1H, H_{Ar}), 7.03 (dd, *J* = 8.8, 8.6 Hz, 2H, H_{Ar}), 6.55 (d, *J* = 1.4 Hz, 1 H). ^{13}C NMR (100 MHz, $CDCl_3$, ppm) δ 159.3, 156.4, 148.8, 143.4, 134.5, 121.9, 118.6, 115.5, 116.9, 115.2, 112.8. 107.9. Element Analysis calculated (%) for $C_{12}H_8N_2O_2$: C 67.94, H 3.81, N 13.22; found: C 67.83, H 3.93, N 13.11.

2.1.8. Synthesis of *N*-(4-chlorophenyl)furan-2-carboxamide (9)

The sample was crystallized in ether ether, yield: 84% (0.18 g), mp: 181-183 ^{0}C, IR (cm^{-1}): ν 3316, 3029, 2978, 1654, 1023, 670. ^{1}H NMR ($CDCl_3$, ppm): δ= 8.78 (s, 1H), 7.58 (dd, *J*=8.7, 4.5 Hz, 2H), 7.46 (s, 1H), 7.25 (d, *J* = 3.1 Hz, 1H), 7.11 (dd, *J* = 8.8, 8.6 Hz, 2H), 6.61 (d, *J* = 1.3 Hz, 1H). ^{13}C NMR ($CDCl_3$, ppm) δ 164.3, 152.4, 146.8, 144.4, 131.5 125.9, 117.6, 117.1.5, 116.4, 115.1, 111.8. 110.9. Element Analysis calculated (%) for $C_{11}H_8ClNO_2$: C 59.31, H 3.61, N 6.32; found: C 57.55, H 3.75, N 6.44.

Scheme 1. Synthesis of N-phenylfuran-2-carboxamide derivatives



1 **2**

R: -H (**3**), -CH_3 (**4**), -OCH_3 (**5**), -NO_2 (**6**), -Cl (**7**), -CF_3 (**8**), -NO_2 (**9**)

3. Results and Discussion

It has been reported that aniline derivatives can be converted to furan-2- carboxamide using furan-2-carbonyl chloride at 25 ^{0}C condition (Scheme 1). Herein, we report the successful results of the acylation reactions to produce N-phenylfuran-2-carboxamide derivatives in the presence of THF.

The formation acylation is of significant value compared to the existing methods [Scmidt et al., 2017]. In this study, an alternative method for acylation reactions was developed to the existing methods in synthetic organic chemistry. Hence, during the course of these studies, we have achieved the synthesis of furan-2-carboxamide analog series. For this aim, we used aniline as a starting material.

Then electron withdrawing or donor groups which are derivatives of aniline. Aniline **1** was trearted with furan-2-carbonyl chloride in 30 mL of THF gave *N*-phenylfuran-2-carboxamide **3**. After several attempts, we used this method as a one-step procedure in a short and efficient synthesis of compound **1** as amodel substrate to establish the optimal reaction conditions and tetrahydrofuran are also suitable solvent. the reaction did proceed cleanly using substances. At this point, we assessed that the generalization of this transformation was subject to a variety of aniline derivatives as the starting material.

The reaction with furan-2-carbonyl chloride **2** proceeded smoothly. This makes the reaction more useful for the development of acylation chemistry [Bejblova et al., 2009].
The present method applicable to both organic chemistry and industrial processes was developed as a new catalyst as a new catalyst (zinc triflate) system for N-phenylfuran-2-carboxamide.

4. Conclusions

N-phenylfuran-2-carboxamide derivatives was successfully synthesized for the first time using zinc triflate, and its reactivity toward electron withdrawing and electron donating reagents was studied in comparison to the furan-2-carboxamide analog.

5. Acknowledge

I would like to thank Namik Kemal University research center laboratory

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Lloyd-Williams P, Giralt E. (2001). Atropisomerism, biphenyls And the Suzuki coupling: peptide Antibiotics Abbreviations: Bn = benzyl; Boc = *tert*-butoxycarbonyl; dba = dibenzylideneacetone; Ddm = 4,4′-imethoxydiphenylmethyl; DMSO = dimethylsulfoxide; FDPP = pentafluorophenyl diphenylphosphinate; MEM = methoxyethoxymethyl; Ms = methylsulfonyl; Piv = pivaloyl; TBS = *tert*-butyldimethylsilyl; Tf = trifluoromethanesulfonyl; Tfa = trifluoroacetyl; TFA = trifluoroacetic acid; Z = benzoxycarbonyl. *Chemical Society Reviews,* 30, 145-157. Doi: 10.1039/B001971M

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