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Green protocol for the synthesis of 3,4-Dihydropyrimidin-2(1*H*)-ones/thiones using TBAB as a catalyst and solvent free condition under microwave irradiation

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ABSTRACT

Simple and improved conditions have been found to carry out the Biginelli reaction for the synthesis of 3,4-dihydropyrimidin-2(1H) - one derivatives. This synthesis was performed in the presence of TBAB as catalyst. These reactions were performed under solvent free conditions with microwave irradiation as the energy source. This new method has the advantage of excellent yields (90–95%). The advantages of this novel protocol include the excellent yield, operational simplicity, short time, and the avoidance of the use of organic solvents and ecofriendly preparation.

Keywords: 3,4-Dihydropyrimidin-2(1*H*)-ones, Tetra-butyl ammonium bromide (TBAB), Solvent free, Microwave irradiation.

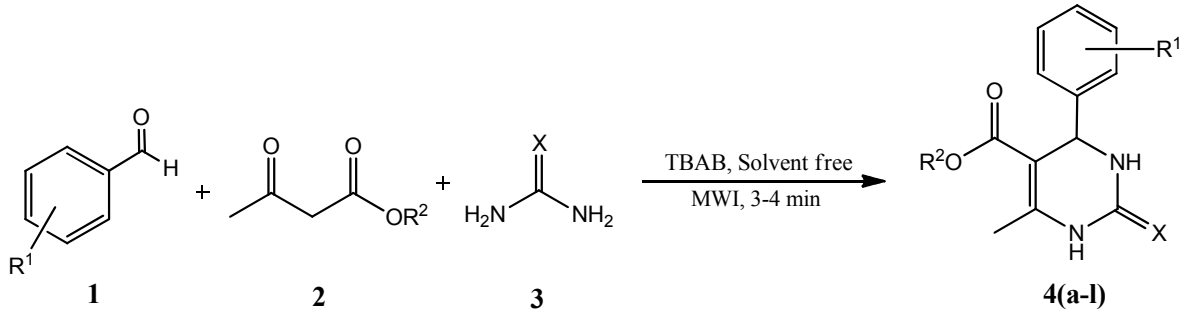
INTRODUCTION

Many 4-aryl-3,4-dihydro-2(1*H*)-pyrimidone (DHPMS) esters and 5-acetyl-4-aryl/or alkyl-6-methyl-3,4-dihydropyrimidin-2(1*H*)-ones are of pharmacological important compounds because of their promising biological effects, including antiviral, antibacterial, antitumor, anti-inflammatory activities [1]. Recently they were found to be as calcium channel modulators [2], antihypertensive agents [3] and α1a-antagonists [4]. Some alkaloids recently isolated from marine sources with interesting biological activities also possess the dihydropyrimidinone-5-carboxylate core [5]. Most notably among these are the batzelladine alkaloids which have been found to be potent HIVgp-120-CD4 inhibitors [6]. Therefore synthesis of this type of heterocyclic compounds is of much current importance. The most simple and straightforward procedure, reported by Biginelli more than 100 years ago [7], involves the three component condensation in one-pot.

Numerous synthetic methods for preparing 3,4-dihydropyrimidin-2(1*H*)-ones have been reported by using Lewis acids as well as protic acid promoters and ionic liquids; some of them include ceric ammonium nitrate (CAN) under the influence of ultrasound [8], montmorillonite KSF [9], $InCl_3$ [10], $InBr_3$ [11], $LnCl_3$ [12], $Yb(OTf)_3$ [13], $Cu(OTf)_3$ [14], H_2SO_4 [15a], conc.HCl [15b], Zirconium(IV)chloride [16], Ytterbium(III)-resin [17], 1-n-butyl-3-methyl imidazolium tetrafluoroborate ($BMImBF_4$) or hexafluorophosphorate ($BMImPF_6$) in ionic liquids [18], $Mn(OAc)_3 \cdot 2H_2O$ [19].

Many of existing methods involve expensive reagents stoichiometric amount of catalyst, strongly acidic conditions, longer reaction times, high temperatures, unsatisfactory yields, incompatibility with other functional groups, and environmental pollution. Therefore, there is a need for versatile, simple and environmentally friendly processes for the synthesis of 3,4-dihydropyrimidin-2(1*H*)-ones. The development of alternative methods would extend the scope of this useful Biginelli reaction. Currently, microwaves are applied in many fields of organic synthesis to shorten reaction times, improve reaction yields, and easier work up matching with 'green chemistry' protocols. Studies are underway to investigate the scaling up of microwave-assisted reactions from laboratory to industrial scale without changing the laboratory optimized reaction conditions. So far, only a few reports have been published describing the improvements brought about by the use of microwaves in the synthesis of 3,4-dihydropyrimidin- 2(1*H*)-ones, they are Lanthanide triflate [20], lanthanum chloride [21], indium chloride [22] and acidic clay montmorillonite KSF[23], glacial acetic acid [24] and polyphosphate ester [25].

In this report we describe a novel method of synthesis of 3,4-dihydropyrimidine-2(1*H*)-ones/-thiones (**4**) under microwave irradiation using catalytic amount of TBAB for a three-component coupling of substituted arylaldehyde (**1**), β-ketoester (**2**) and urea or thiourea (**3**) under solvent free condition. The yields are high and the reaction goes to completion within 3-4min as shown in **Scheme 1**.



1 **2** **3** **4(a-l)**

Scheme-1

MATERIALS AND METHODS

Melting points were determined on a Buchi melting point apparatus. IR, ^{1}H NMR, ^{13}C NMR and GC-MS spectra were recorded on Nicolet 400D FT-IR Spectrophotometer, 300 MHz Brucker Spectrometer and Shimadzu GC-MS QP 5050A respectively. Benzaldehydes, Ethyl acetoacetate, urea, thiourea, were all commercial products and were used without further purification. Solvents were distilled before use. Reactions were monitored on TLC with the authentic samples. For the microwave irradiation experiments a conventional (unmodified) household microwave oven was used (LG Microwave oven, Electronics India Private Limited). Yields refer to the isolated yields of the products.

General procedure for synthesis of 3,4- dihydropyrimidin-2(1H)-ones/-thiones

A mixture of β-diketone (10 mmol), aldehyde (10 mmol), urea/thiourea (10 mmol) and catalytic amount of solid tetra-butyl ammonium bromide (0.05 g, 1.5 M) was subjected to microwave irradiation for appropriate time at 40% power in 300W microwave oven for 3-4min (successive irradiation of 30-40 sec. with cooling intervals of time, the temperature being 90^{0}-100^{0}C) as indicated by TLC. The product was washed with water (3x10mL) to separate TBAB and recrystallized from ethanol to afford 3,4- dihydropyrimidin-2-one/thione **4(a-l)** in excellent yields.

5-(Ethoxycarbonyl)-6-methyl-4-(phenyl)-3,4-dihydropyrimidin-2(1*H*)-one(4a).

M.P:201–203°C; IR(KBr): υ_{max} = 3520, 3230, 3150, 1705, 1690 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.16 (br. s, 1H), 7.71 (br. s, 1H), 7.20–7.32 (m, 5H), 5.11(d, *J* = 2.7 Hz, 1H), 3.96 (q, *J* = 7.1 Hz, 2H), 2.23 (s, 3H), 1.07 (t, *J* = 7.2, 3H); ^{13}C NMR (300 MHz (d_6) DMSO: δ 163.3, 150.2, 143.1, 126.4, 125.3, 124.4, 97.4, 57.3, 52.1, 16.0, 12.2 ppm; MS: *m/z* = 261[M+].

5-(Ethoxycarbonyl)-4-(4-nitrophenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4b).

M.P: 209–210°C; IR (KBr): υ_{max} = 3243, 3011, 1710, 1687, 1626 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.32(br. s, 1H), 8.21(d, *J* = 8.3 Hz, 2H), 7.84 (br. s, 1H), 7.50 (d, *J* = 8.4 Hz, 2H), 5.22 (d, *J* = 2.7 Hz,

1H), 3.94(q, *J* = 7.2 Hz, 2H), 2.27(s, 3H), 1.10 (t, *J* = 7.2, 3H); ^{13}C NMR (300 MHz (d_6) DMSO: δ 164.7, 151.3, 149.3, 146.4, 126.8, 123.7, 59.3, 52.8,17.8, 13.7 ppm; MS: *m/z* = 276[M+].

5-(Ethoxycarbonyl)-4-(4-methylphenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4c). M.P: 214–215 °C; IR(KBr): υ_{max} = 3262, 3169, 1701, 1689, 1637 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.12(br. s, 1H), 7.65(br. s, 1H), 7.10 (m, 4H), 5.12 (d, *J* = 2.8 Hz, 1H), 3.95(q, *J* = 7.2 Hz, 2H), 2.27(s, 3H), 2.27(s, 3H), 1.13 (t, *J* = 7.2, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.2, 152.0, 148.0, 140.2, 135.0, 127.9, 126.9, 99.0, 58.9, 52.9, 20.0, 17.2, 13.9 ppm; MS: *m/z* = 274[M+].

5-(Ethoxycarbonyl)-4-(4-chlorophenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4d). M.P: 211–212°C; IR(KBr): υ_{max} = 3239, 3087, 1704, 1672, 1621 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.18 (br. s, 1H), 7.61 (br. s, 1H), 7.23-7.38 (m, 4H), 5.22 (d, *J* = 2.7 Hz, 1H), 3.95(q, *J* = 7.2 Hz, 2H), 2.19 (s, 3H), 1.02 (t, *J* = 7.2, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.0, 151.4, 148.9, 141.2, 131.7, 129.2, 128.7, 98.2, 58.9, 51.9, 17.9 ppm; MS: *m/z* = 294[M+].

5-(Ethoxycarbonyl)-4-(4-methoxyphenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4e). M.P: 200–201°C; IR (KBr): υ_{max} = 3228, 3109, 2949, 1719, 1648, 1501 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.19 (s, 1H), 7.59 (s, 1H), 7.15-6.81 (m, 4H), 5.00 (s, 1H), 3.89 (q, *J* = 6.7 Hz, 2H), 3.70(s, 3H), 2.19 (s, 3H), 1.07 (t, *J* = 6.7 Hz, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.1, 157.9, 151.8, 148.3, 137.5, 126.8, 112.7, 99.2, 58.9, 54.9, 17.9 ppm; MS: *m/z* = 261[M+].

5-(Ethoxycarbonyl)-4-(4-hydroxyphenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4f). M.P: 227–228 °C; IR (KBr): υ_{max} = 3417, 3241, 3120, 2984, 1687, 1649, 1512 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.34 (s, 1H), 9.10(s, 1H), 7.64 (s, 1H), 7.03-6.65 (m, 4H), 5.02 (s, 1H), 3.96(q, *J* = 7.0 Hz, 2H), 2.21(s, 3H), 1.08 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.4, 156.6, 152.2, 147.8, 135.5, 127.4, 115.0, 99.8, 59.1, 53.5, 17.8, 14.3 ppm; MS: *m/z* = 276[M+].

5-(Ethoxycarbonyl)-4-(4-Fluorophenyl)-6-methyl-3,4-dihydropyrimidin-2(1*H*)-one(4g). M.P: 174–176°C; IR (KBr): υ_{max} = 3243, 1698, 1638 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.25(s, 1H), 7.77(s, 1H), 7.21(m, 4H), 5.15 (s, 1H), 3.99 (q, *J* = 7.1 Hz, 2H), 2.26 (s, 3H), 1.09 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.9, 159.8, 152.0, 148.6, 141.1, 128.3, 115.1, 99.2, 59.5, 53.9, 17.7, 14.6 ppm; MS: *m/z* = 278[M+].

5-(Ethoxycarbonyl)-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1*H*)-thione(4h). M.P: 209–210°C; IR (KBr): υ_{max} = 3258, 1657, 1569 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 10.37 (s, 1H), 9.71(s, 1H), 7.38-7.21 (m, 5H), 5.21(d, *J* = 3.5 Hz, 1H) 4.05 (q, *J* = 7.0 Hz, 2H), 2.31 (s, 3H), 1.09 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 162.8, 151.0, 142.0, 125.9, 124.9, 125.0, 95.9, 57.0, 51.8, 16.3, 12.0 ppm; MS: *m/z* = 277[M+].

5-(Ethoxycarbonyl)-6-methyl-4-(4-methoxyphenyl)-3,4-dihydropyrimidin-2(1*H*)-thione (4i). M.P: 151–152°C; IR–(KBr): υ_{max} = 3256, 1659, 1595, 1569 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.87 (br. s, 1H), 9.33 (br. s, 1H), 7.19 (d, *J* = 8.1 Hz, 2H), 6.69 (d, *J* = 8.1 Hz, 2H), 5.16 (s, 1H), 4.06 (q, *J* = 7.1 Hz, 2H), 2.28 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (300 MHz) (d_6) DMSO: δ 173.9, 174.3, 165.9, 126.8, 158.5, 145.2, 135.9, 128.0, 114.0, 101.5, 59.8, 55.3, 53.6, 17.4, 14.3 ppm; MS: *m/z* = 306[M+].

5-(Ethoxycarbonyl)-6-methyl-4-(4-chlorophenyl)-3,4-dihydropyrimidin-2(1*H*)-thione (4j). M.P: 192–194°C; IR–(KBr): υ_{max} =3258, 1661, 1566 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 10.0(br. s, 1H), 9.33(br. s, 1H), 7.17 (m, 4H), 5.28 (s, 1H) 4.12 (q, *J* = 7.1 Hz, 2H), 2.46(s, 3H), 1.15(t, *J* = 7.1 Hz, 3H) ppm; ^{13}C NMR (300 MHz) (d_6) DMSO: δ 174.8, 165.3, 145.5, 142.7, 132.0, 127.9, 128.9, 100.4, 59.3, 53.4, 17.2, 14.2 ppm; MS: *m/z* = 310[M+].

5-(Ethoxycarbonyl)-6-methyl-4-(2-Furyl)-3,4-dihydropyrimidin-2(1*H*)-one (4k). M.P: 204–205°C; IR–(KBr): υ_{max} = 3334, 3238, 3129, 2987, 1698, 1657, 1460, 1082, 876 cm^{-1}; ^{1}H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 9.33 (s, 1H), 7.7 (s, 1H), 7.56 (s, 1H), 6.36 (d, *J* = 3.5 Hz, 1H) 4.27 (q, *J* = 6.5 Hz, 2H), 2.40 (s, 3H), 1.29 (t, *J* = 6.5 Hz, 3H) ppm; ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.5, 157.0, 152.8, 149.5, 142.6, 110.2, 105.3, 96.0, 60.3, 47.5, 18.1, 14.2 ppm; MS: *m/z* = 250[M+].

5-(Ethoxycarbonyl)-6-methyl-4-(4-styryl)-3,4-dihydropyrimidin-2(1*H*)-one (4l). M.P: 232–233°C; IR–(KBr): υ_{max} = 3245,1711, 1658 cm^{-1}; ^1H NMR (300 MHz), $CDCl_3$/DMSO–d_6 solution: δ 8.93 (br. s, 1H), 7.87 (br. s, 1H), 7.29 (m, 5H), 6.49 (d, *J* = 14.3 Hz, 1H) 6.18(dd, *J* = 14.5, 4.1 Hz, 1H), 5.30(d, *J* = 4.1 Hz, 1H), 4.12 (q, *J* = 7.1 Hz, 2H), 2.26 (s, 3H), 1.16 (t, *J* = 7.1 Hz, 3H) ppm; ^{13}C NMR (300 MHz) (d_6) DMSO: δ 165.7, 152.9, 148.3, 137.0, 130.1, 127.2, 126.2, 97.5, 59.1, 52.0, 17.9, 14.2 ppm; MS: *m/z* = 286[M+].

RESULTS AND DISCUSSION

The efficiency of the reaction is affected mainly by the amount of TBAB (Table **1**). No product was obtained in the absence of the catalyst even after 15 min (entry 1) indicating that the catalyst is necessary for the reaction. Increasing the amount of the catalyst increased the yield of the product **4a**. The optimal amount of TBAB was 0.05 g (entry 4); increasing the amount of the catalyst beyond this value did not increase the yield noticeably (entries 5, 6).

Table-1: Effect of the amounts of TBAB on the model reaction [a]

Entry	Catalyst (g)	Reaction Time (min)	Yield [b] (%)
1	None	15	None
2	0.03	7	75
3	0.04	6	87
4	0.05	4	95
5	0.06	5	95
6	0.07	5	93

[a] *Reaction condotins: Benzaldehyde (10 mmol), Ethyl acetoacetate (10 mmol), and Urea/thiourea (10 mmol), in MWI.* [b] *Isolated yields.*

The use of TBAB preserved the classical simplicity of Biginelli one-pot synthesis and remarkably improved the yield profile and time to complete the reaction (Table 1) in shorter span (3-4 min) than the reported longer times.

Our work has also been extended to observe the effect of solvent on the reaction (Table **2**, entries 1-6) and solvent free condition was found to be the best condition when considering the reaction yields and environmental damage.

Table-2: Synthesis of compound 4a in the presence of TBAB (0.05 g) in different solvents[a]

Entry	Catalyst	Solvent	Time (min)	Yield (%)
1	TBAB	EtOH	4	85
2	TBAB	CH_3CN	5	78
3	TBAB	Solvent free	3	95
4	TBAB	THF	7	75
5	TBAB	Benzene	10	Trace
6	TBAB	Toluene	10	Trace

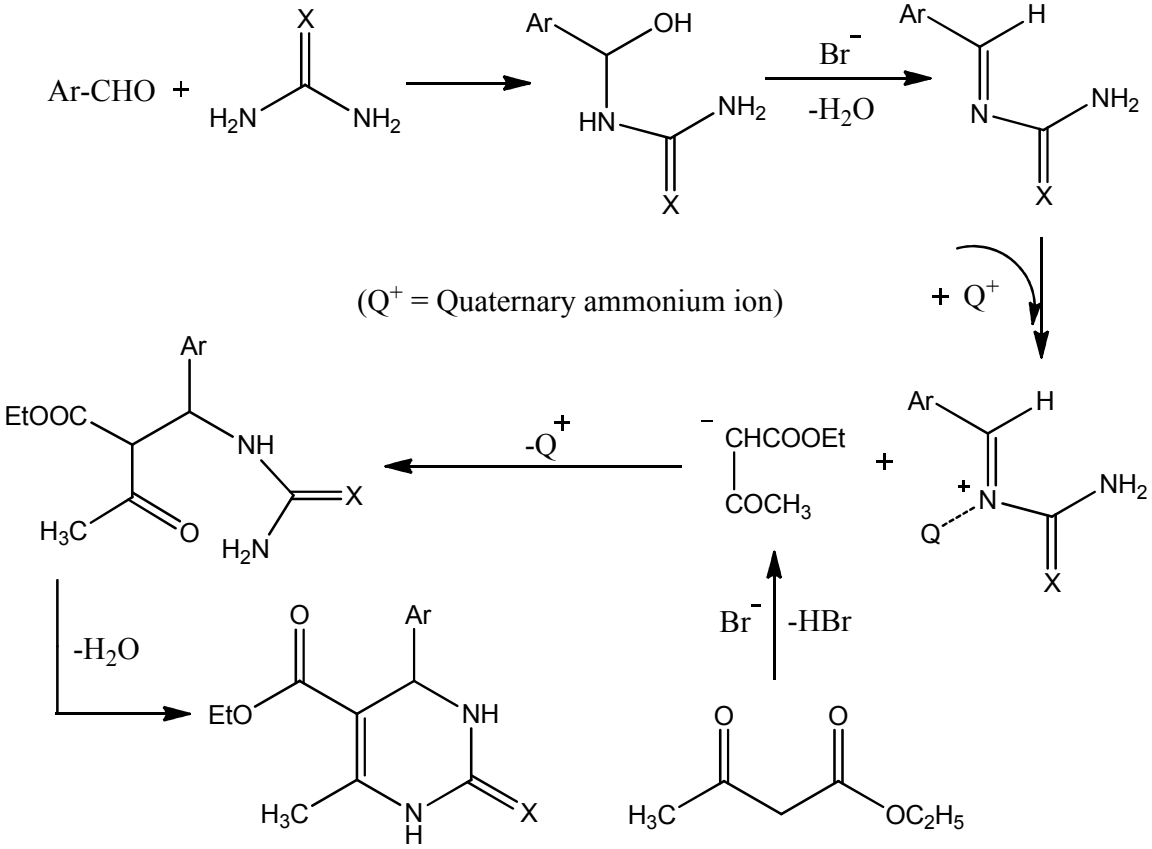
[a] *All reactions were carried out in microwave irradiation*

It is clear from Table 3 that, a wide range of structurally varied β-ketoester, substituted arylaldehyde and urea are coupled together by this procedure to produce the corresponding 3,4-dihydropyrimidin-2(1*H*)-ones. It is also clear that, aromatic aldehydes, carrying either electron-withdrawing or electron-donating substituents afford high yields of products with high purity, and another important feature of this procedure is that of the survival of a variety of functional groups such as halides, nitro, hydroxy, ether. Acid sensitive aldehyde like 2-furaldehyde also worked well without formation of side products (Table-3, entries 11, 12) and α,β-unsaturated aldehydes produced good yield of the product and there is no decomposition or polymerization under our reaction conditions. Thiourea has been used with similar success to provide the corresponding thioderivatives of 3,4-dihydropyrimidin-2(1*H*)-ones (Table 3, entries 8–10), which are also of much interest with respect to their biological activities. This method utilizes readily available low cost reagents affords high yields of different substituted 3,4-dihydropyrimidin-2(1*H*)-ones /thiones, in short reaction times.

Table-3: TBAB catalyzed Synthesis of 3,4-Dihydropyrimidine-2-(1*H*)-Ones/thiones

Entry	R^1	R^2	X	Product [a]	Yield [b] (%)	M.P (°C)
1	H	Et	O	**4a**	95	201–203
2	4-NO_2	Et	O	**4b**	92	209–210
3	4-CH_3	Et	O	**4c**	90	214–215
4	4-Cl	Et	O	**4d**	93	211–212
5	4-OCH_3	Et	O	**4e**	94	200–201
6	4-OH	Et	O	**4f**	90	227–228
7	4-F	Et	O	**4g**	93	174–176
8	4-F	Et	S	**4h**	95	209–210
9	4-OCH_3	Et	S	**4i**	94	151–152
10	4-Cl	Et	S	**4j**	92	193–195
11	2-furyl	Et	O	**4k**	91	204–205
12	C_6H_4-CH=CH	Et	O	**4l**	90	232–233

[a] *All compounds thus obtained were characterized by comparison of physical and spectral data with authentic samples.* [b] *Isolated Yields.*



Scheme-2: The proposed mechanism for the formation of pyrimidine derivative

CONCLUSSION

The present protocol of the synthesis of 3,4-dihydropyrimidin-2(1*H*)-ones/-thiones under microwave irradiation using catalytic amount of TBAB for a three-component coupling of substituted arylaldehyde, β-ketoester and urea or thiourea works in the absence of a solvent, the yields are high and the reaction goes to completion within 3-4 minutes. This method has the ability to tolerate a wide variety of substitutions in all three components which is lacking in existing reported procedures. Thus, this procedure will offer an easy access to substituted 3,4-

dihydropyrimidin-2(1*H*)-ones/-thiones with varied substitution pattern in very high yields. We conclude our procedure will find important applications in the synthesis of dihydropyrimidinones.

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REFERENCES

[1] C. O. Kappe, *Tetrahedron*, **1993**, 49, 6937.
[2] (a) G. C. Rovnyak, S. D. Kimball, B. Bever, *J. Med. Chem*., **1995**, 38, 119. (b) K. S. Atwal, C. G. Rovnyak, S. D. Kimball, *J. Med. Chem*., **1990**, 33, 2629. (c) H. Cho, M. Ueda, K. Shima, *J. Med. Chem*., **1989**, 32, 2399.
[3] (a) G. C. Rovnyak, K. S. Atwal, S. D. Kimball, *J. Med. Chem*., **1992**, 35, 3254. (b) K. S. Atwal, B. N. Swanson, S. E. Unger, *J. Med. Chem*., **1991**, 34, 806.
[4] (a) D. R. Sidler, R. D. Larsen, M. Chartrain, *et al*., PCT Int. Appl. WO 99 07695. (b) D. Nagarathnam, W. C. Wong, S. W. Miao, *et al*., PCT Int. Appl. WO 97 17969.
[5] B. B. Snider, Z. Shi, *J. Org. Chem*., **1993**, 58, 3828.
[6] (a) A. D. Patil, N. V. Kumar, W. C. Kokke, *J. Org. Chem*., **1995**, 60, 1182. (b)B. B. Snider, J. Chen, A. D. Patil, *Tetrahedron Lett*., **1996**, 37, 6977. (c) A. V. Rama Rao, M. K. Gujar, J. Vasudevan, *J. Chem. Soc., Chem. Commun*., **1995**, 1369.
[7] P. Biginelli, *Gazz. Chim. Ital*. **1893**, 23, 360.
[8] J.S. Yadav, B.V.S. Reddy, K.B. Reddy, K.S. Raj, A.R. Prasad, *J. Chem. Soc. Perkin Trans. 1*, **2001**, 42, 7975.
[9] F. Bigi, S. Carloni, B. Frullanti, R. Maggi, G. Sartori, *Tetrahedron Lett.*, **1999**, 40, 3465.
[10] B.C. Ranu, A. Hajra, U. Jana, *J. Org.Chem.*, **2000**, 65, 6270.
[11] N.Y. Fu, Y.F. Yuan, Z. Cao, S.W. Wang, J.T. Wang, C. Peppe, *Tetrahedron.*,**2002**, 58, 4801.
[12] J. Lu, Y. Bai, Z. Wang, B. Yang, H. Ma, *Tetrahedron Lett.*, **2000**, 41, 9075.
[13] Y. Ma, C. Qian, L. Wang, M. Yang, *J. Org. Chem.*, **2000**, 65, 3864.
[14] A.S. Paraskar, G.K. Dewkar, A. Sudalai, *Tetrahedron Lett.*, **2003**, 44, 3305.
[15] (a) J.C. Bussolari, P.A. McDonnell, *J. Org. Chem.*, **2000**, 65, 6777; (b) K.S. Atwal, B.CO'Reilly, J.Z. Gougoutas, M.F. Malley, *Heterocycles.*, **1987**, 26, 1189; K.S. Atwal, B.C. O'Reilly, J. Schwartz, *J. Org. Chem.*, **1985**, 54, 5898.
[16] C.V. Reddy, M. Mahesh, P.V.K. Raju, T.R. Babu, V.V.N. Reddy, *Tetrahedron Lett.*, **2002**, 43, 2657.
[17] A. Dondoni, A. Massi, *Tetrahedron Lett.*, **2001**, 42, 7975.
[18] J. Peng, Y. Deng, *Tetrahedron Lett.*, **2001**, 42, 5917.
[19] K.A. Kumar, M. Kasthuraiah, C.S. Reddy, C.D. Reddy, *Tetrahedron Lett.*, **2001**, 42, 7873.
[20] Y. Ma, C. Qian, L. Wang, M.Yang, *J. Org. Chem*., **2000**, 65, 3864.
[21] J. Lu, Y. Bai, Z. Wang, *Tetrahedron Lett*., **2000**, 41, 9075.
[22] B.C. Ranu, A. Hajra, U. Jana, *J. Org. Chem*., **2000**, 65, 6270.
[23] F. Bigi, S. Carloni, B. Frullanti, *Tetrahedron Lett*., **1999**, 40, 3465.
[24] J. S. Yadav, B.V. Subba Reddy, E. Jagan Reddy, T. Ramalingam, *J. Chem. Res*., **2000**, 354.
[25] C. O. Kappe, D. Kumar, R. S.Varma, *Synthesis*, **1999**, 1799.