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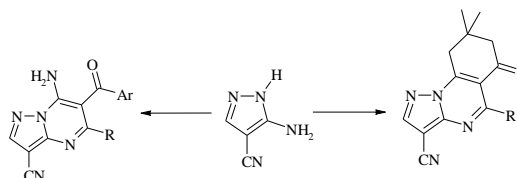
Triethylorthoesters

Pyrazolo[1,5-*a*]quinazoline

Cyclocondensation

ABSTRACT

A series of novel pyrazolopyrimidine and pyrazoloquinazoline derivatives have been synthesized in one pot, three-component synthesis method under solvent-free conditions by using 5-aminopyrazole, *p*-substituted benzoylacetonitrile/dimedone and triethylorthoesters. All new compounds were synthesized in one step without synthesizing the enol ethers or open chain intermediates by green approach without using solvent and/or catalyst. All newly synthesized compounds were characterized by spectral and analytical methods.



1. Introduction

Heterocyclic ring systems that containing the pyrazole ring fused to quinazoline rings are interesting classes of compounds both chemically and biologically. For example, pyrazolopyrimidines display significant chemical properties [1-7]. In particular pyrazolo[1,5-*a*]pyrimidines structural motif may be found in a large number of pharmaceutical agents with a diverse range of physiological activities, such as, antiepileptic agents [8], anxiolytics[9], antidepressants [10], agents for treatment of sleep disorders [11] and oncolytics [12, 13]. Whereas, several naturally occurring and synthetic compounds containing the quinazoline derivatives exhibit a wide range of biological properties [14, 15]. In recent years an increasing interest has been focused on synthesis of fluorescent compounds owing to their significant biological application in the medicinal chemistry [16, 17]. In particular these compounds have important applications in the field of dyes [18] and are used in the security papers [19]. In literature the synthesis of pyrazolo[1,5-*a*]pyrimidines have been reported [20, 21] by using Michael addition reaction of 5-aminopyrazoles with enol ether of reactive methylene compounds and triethylorthoesters. The title compounds could be synthesized in one pot in which the synthesis of enol ether is not required.

On the other hand, multi-component reactions (MCRs) are of increasing importance in organic and medicinal chemistry. MCR strategies offer significant advantages over conventional linear type synthesis [22-24]. As a part of our continued interest [25, 26] in the synthesis of novel heterocyclic compounds, we have reported the synthesis of pyrazolo[3,4-*b*]pyridines, pyrazolo[3,4-*b*]quinolines, pyrazolonaphthyridines and pyrazolopyridopyrimidines by Friedlander condensation of 5-aminopyrazole-4-carbaldehyde with various reactive methylene compounds and the synthesis of fused pyrimidines [27] by using 2-aminoheterocycles and cyclic β -formylesters in ammonium acetate at 120 °C. Also there are some reports on the study of fluorescence properties of benzo[*h*]quinolines and dipyrazolopyridines [28, 29]. Few researchers have reported the synthesis of chromenes, quinolines and pyrazolo[3,4-*b*]pyridines [30, 31]. Recently we have reported the synthesis of pyrazolo[1,5-*a*]pyrimidine and pyrazolo[1,5-*a*]quinazoline derivatives by multi-component reaction strategy using organic solvents and catalysts

[32, 33]. These literature reports and increasing importance of multicomponent reactions in organic chemistry encourage to synthesize, pyrazolo[1,5-*a*]pyrimidine and pyrazolo[1,5-*a*]quinazoline derivatives in one pot three component synthesis method by green chemistry approach under solvent and catalyst free conditions.

2. Experimental Methods

2.1 Characterization

Melting points were determined on a Gallenkamp melting point apparatus, Mod. MFB-595 in open capillary tubes and are uncorrected. The ^1H and ^{13}C NMR spectra were recorded on a Varian XL-300 spectrometer (300 MHz). Chemical shifts are reported in ppm from internal tetramethylsilane standard and are given δ -units. The solvents for NMR spectra were deuteriochloroform unless otherwise stated. Infrared spectra were taken on Shimadzu IR-408, a Shimadzu FTIR instrument in potassium bromide pellets unless otherwise stated. UV Spectra were recorded on a Shimadzu UV-1601 UV-visible Spectrophotometer. High-resolution mass spectra were obtained with a Mat 112 Varian Mat Bremen (70 eV) mass spectrometer. Compounds for UV scan was dissolved in methanol. Fluorescence spectra were recorded using RF-5301 PC Spectrofluorophotometer. Compounds for fluorescence measurements were dissolved in methanol. UV and fluorescence scans were recorded from 200 to 500 nm. Elemental analysis was performed on a Hosli CH-Analyzer and are within ± 0.3 of the theoretical percentage. Solutions were concentrated in a rotary evaporator under reduced pressure. All reactions were monitored by thin layer chromatography, carried out on 0.2 mm silica gel 60 F₂₅₄ (Merck) plates using UV light (254 and 366 nm) for detection. Common reagents-grade chemicals are either commercially available and were used without further purification or prepared by standard literature procedures.

2.2 General Procedure for the Synthesis of 7-(4-Aryl)pyrazolo[1,5-*a*]pyrimidine-3,6-dicarbonitrile (4)

A mixture of 5-aminopyrazole **1** (1.08 g, 10 mmole), aroylacetonitriles **2** (10 mmole) and triethylorthoesters **3** (10 mmole) is heated at 100-110 °C for 2-3 hours. The completion of reaction was monitored by thin layer chromatography (TLC). After completion of reaction cool the reaction mixture at room temperature and then add 10 ml of ice-cold water. The

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solid obtained was stirred, filtered, washed with cold water, dried and recrystallized from suitable solvent furnished compounds **4** in good yield.

7-(4-Chlorophenyl)pyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4a)

This compound was obtained as colorless prism (ethanol), 2.15 g (77%), mp 223–224 °C; IR: (Potassium bromide): 2237, 1654, 1606, 1590, 1525, 1486, 1264, 1065, 1012, 827, 637 cm⁻¹; ¹H NMR: (CDCl₃) δ 7.85–7.89 (m, 4H, Ar-H), 8.87 (s, 1H, Ar-H), 9.16 (s, 1H, Ar-H); ¹³C NMR: (CDCl₃) δ 66, 106, 117, 119, 128, 129, 131, 133, 134, 138, 161, 167. MS: (70 eV) m/z (%) 281 (90) (M+2), 279 (100) (M+), 271 (80), 258 (65), 244 (70), 233 (80), 207 (10), 181 (20), 153 (40), 122 (30), 93 (50), 78 (70), 63 (80), 44 (40). Anal.Calcd. for C₁₄H₆ClN₅: C, 60.12; H, 2.16; N, 25.04. Found: C, 60.29; H, 2.45; N, 25.33.

(CDCl₃) δ 66, 106, 117, 119, 128, 129, 131, 133, 134, 138, 161, 167. MS: (70 eV) m/z (%) 281 (90) (M+2), 279 (100) (M+), 271 (80), 258 (65), 244 (70), 233 (80), 207 (10), 181 (20), 153 (40), 122 (30), 93 (50), 78 (70), 63 (80), 44 (40). Anal.Calcd. for C₁₄H₆ClN₅: C, 60.12; H, 2.16; N, 25.04. Found: C, 60.29; H, 2.45; N, 25.33.

7-(4-Chlorophenyl)-5-methylpyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4b)

This compound was obtained as yellow prism (ethanol/DMF), 2.58 g (88%), mp 228–230 °C; IR: (Potassium bromide): 2246, 1615, 1596, 1489, 1464, 1381, 1098, 1018, 832, 643 cm⁻¹; ¹H NMR: (CDCl₃) δ 2.81 (s, 3H, CH₃), 7.74 (d, 2H, J = 8.7 Hz, Ar-H), 7.84 (d, 2H, J = 8.7 Hz, Ar-H), 8.89 (s, 1H, Ar-H). Anal.Calcd. for C₁₅H₈ClN₅: C, 61.34; H, 2.75; N, 23.84. Found: C, 61.13; H, 2.45; N, 23.61.

7-(4-Chlorophenyl)-5-ethylpyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4c)

This compound was obtained as colorless prism (ethanol/DMF), 2.43 g (79%), mp 174–175 °C; IR: (Potassium bromide): 2233, 1622, 1587, 1492, 1463, 1385, 1094, 1021, 838, 642 cm⁻¹; ¹H NMR: (CDCl₃) δ 1.41 (t, 3H, J = 7.2 Hz, CH₃), 3.19 (q, 2H, J = 7.2 Hz, CH₂), 7.83 (d, 2H, J = 8.7 Hz, Ar-H), 7.95 (d, 2H, J = 8.4 Hz, Ar-H), 8.91 (s, 1H, Ar-H); MS: (70 eV) m/z (%) 309 (40) (M+2), 307 (100) (M+), 280 (40), 272 (80), 252 (20), 245 (30), 229 (10), 218 (10), 187 (30), 179 (20), 161 (50), 152 (30), 126 (30), 113 (10), 111 (40), 88 (10), 75 (60), 63 (50), 51 (55), 40 (40). Anal.Calcd. for C₁₆H₁₀ClN₅: C, 62.45; H, 3.28; N, 22.76. Found: C, 62.67; H, 3.53; N, 22.55.

7-(4-Bromophenyl)pyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4d)

This compound was obtained as colorless prism (ethanol), 2.78 g (86%), mp 246–248 °C; IR: (Potassium bromide): 2239, 1656, 1610, 1587, 1521, 1482, 1262, 1068, 1018, 828, 639 cm⁻¹; ¹H NMR: (CDCl₃) δ 7.85 (d, 2H, J = 8.5 Hz, Ar-H), 7.89 (d, 2H, J = 8.4 Hz, Ar-H), 8.85 (s, 1H, Ar-H), 9.12 (s, 1H, Ar-H); ¹³C NMR: (CDCl₃) δ 67, 108, 118, 121, 125, 127, 131, 134, 136, 140, 163, 168. MS: (70 eV) m/z (%) 326 (90) (M+2), 324 (100) (M+), 323 (80), 322 (60), 298 (10), 271 (10), 258 (10), 244 (20), 233 (10), 207 (10), 183 (20), 181 (10), 153 (40), 122 (60), 102 (70), 91 (60), 75 (80), 63 (70), 44 (60). Anal.Calcd. for C₁₄H₆BrN₅: C, 51.88; H, 1.87; N, 21.61. Found: C, 51.54; H, 1.62; N, 21.41.

7-(4-Bromophenyl)-5-methylpyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4e)

This compound was obtained as yellow prism (ethanol/DMF), 2.77 g (82%), mp 142–143 °C; IR: (Potassium bromide): 2243, 1611, 1592, 1485, 1460, 1383, 1097, 1016, 830, 641 cm⁻¹; ¹H NMR: (CDCl₃) δ 2.83 (s, 3H, CH₃), 7.76 (d, 2H, J = 8.7 Hz, Ar-H), 7.86 (d, 2H, J = 8.7 Hz, Ar-H), 8.85 (s, 1H, Ar-H). Anal.Calcd. for C₁₅H₈BrN₅: C, 53.28; H, 2.38; N, 20.71. Found: C, 53.51; H, 2.49; N, 20.39.

7-(4-Bromophenyl)-5-ethylpyrazolo[1,5-a]pyrimidine-3,6-dicarbonitrile (4f)

This compound was obtained as yellow prism (ethanol/DMF), 2.67 g (76%), mp 194–196 °C; IR: (Potassium bromide): 2234, 1622, 1587, 1491, 1461, 1382, 1093, 1016, 836, 646 cm⁻¹; ¹H NMR: (CDCl₃) δ 1.40 (t, 3H, J = 7.2 Hz, CH₃), 3.18 (q, 2H, J = 7.2 Hz, CH₂), 7.83 (d, 2H, J = 8.7 Hz, Ar-H), 7.94 (d, 2H, J = 8.4 Hz, Ar-H), 8.91 (s, 1H, Ar-H); Anal.Calcd. for C₁₆H₁₀BrN₅: C, 54.56; H, 2.86; N, 19.89. Found: C, 54.29; H, 2.66; N, 19.65.

2.3 General Procedure for the Synthesis of 8,8-Dimethyl-6-oxo-6,7,8,9-tetrahydropyrazolo[1,5-a]quinazoline-3-carbonitrile (6)

A mixture of 5-aminopyrazole **1** (1.08 g, 10 mmole), dimedone **5** (10 mmole) and triethylorthoesters **3** (10 mmole) is heated at 90–100 °C for 1–2 hours. The completion of reaction was monitored by thin layer chromatography (TLC). After completion of reaction cool the reaction mass at room temperature and then add 10 mL of ice-cold water. The solid obtained was stirred, filtered, washed with cold water, dried and recrystallized from suitable solvent furnished compounds **6** in good yield.

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8,8-Dimethyl-6-oxo-6,7,8,9-tetrahydropyrazolo[1,5-a]quinazoline-3-carbonitrile (6a)

This compound was obtained as colorless prism (ethanol), 1.96 g (82%), mp 162–163 °C; IR: (Potassium bromide): 2215, 1687, 1609, 1537, 1367, 1310, 1261, 1175, 1096, 801, 683 cm⁻¹; ¹H NMR: (CDCl₃) δ 1.25 (s, 6H, 2CH₃), 2.65 (s, 2H, CH₂), 3.40 (s, 2H, CH₂), 8.49 (s, 1H, Ar-H), 9.18 (s, 1H, Ar-H); ¹³C NMR: 28, 32, 37, 50, 85, 111, 115, 149, 150, 151, 153, 193. Anal.Calcd. for C₁₃H₁₂N₄O: C, 64.99; H, 5.03; N, 23.32. Found: C, 65.29; H, 5.16; N, 23.56.

5,8,8-Trimethyl-6-oxo-6,7,8,9-tetrahydropyrazolo[1,5-a]quinazoline-3-carbonitrile (6b)

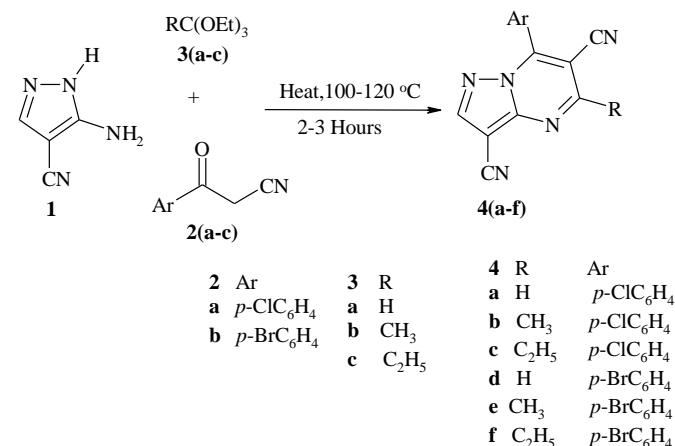
This compound was obtained as colorless prism (ethanol), 2.13 g (84%), mp 186–187 °C; IR: (Potassium bromide): 2217, 1689, 1610, 1539, 1369, 1312, 1264, 1177, 1098, 802, 684 cm⁻¹; ¹H NMR: (CDCl₃) δ 1.23 (s, 6H, 2CH₃), 2.63 (s, 2H, CH₂), 2.79 (s, 3H, CH₃), 3.38 (s, 2H, CH₂), 8.47 (s, 1H, Ar-H), 9.17 (s, 1H, Ar-H); Anal.Calcd. for C₁₄H₁₄N₄O: C, 66.13; H, 5.55; N, 22.03. Found: C, 65.97; H, 5.31; N, 22.41.

5-Ethyl-8,8-dimethyl-6-oxo-6,7,8,9-tetrahydropyrazolo[1,5-a]quinazoline-3-carbonitrile (6c)

This compound was obtained as colorless prism (ethanol), 2.38 g (89%), mp 205–206 °C; IR: (Potassium bromide): 2216, 1688, 1610, 1538, 1366, 1310, 1266, 1176, 1098, 801, 685 cm⁻¹; ¹H NMR: (CDCl₃) δ 1.27 (s, 6H, 2CH₃), 1.43 (t, 3H, J = 7.2 Hz, CH₃), 2.66 (s, 2H, CH₂), 3.19 (q, 2H, J = 7.1 Hz, CH₂), 3.41 (s, 2H, CH₂), 8.50 (s, 1H, Ar-H), 9.19 (s, 1H, Ar-H); Anal.Calcd. for C₁₅H₁₆N₄O: C, 67.15; H, 6.01; N, 20.88. Found: C, 67.29; H, 6.16; N, 20.56.

3. Results and Discussion

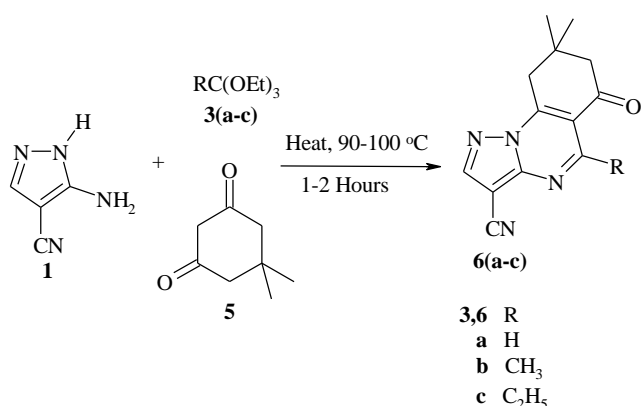
The cyclocondensation of 5-amino-1H-pyrazole-4-carbonitrile **1**, *p*-substituted benzoylacetonitriles **2** and triethylorthoesters **3** by heating at 100–110 °C for 2–3 hours, afforded compounds **4** in good yield (Scheme 1). The structure of **4a** was confirmed by IR, ¹H NMR, ¹³C NMR, mass spectroscopy and elemental analysis for example the IR spectrum of **4a** showed bands at 2237 cm⁻¹ for CN stretching. The ¹H NMR of compound **4a** showed a multiplets at δ 7.85 to 7.89 for four aromatic protons and the two singlets at δ 8.87 and δ 9.16 corresponding to C₂H and C₅H aromatic protons. The ¹³C NMR spectrum of this compound exhibits a peak of tertiary carbons at δ 128, 129, 138, 161 and of quaternary carbons at δ 66, 106, 117, 167, 131, 133, 134. Mass Spectrum of **4a** showed characteristic peaks for M⁺ and M+2 at 279 and 281 m/z, due to presence of chlorine. The elemental analysis obtained is in agreement with molecular formula.



Scheme 1 Synthesis of Pyrazolo[1,5-a]pyrimidine derivatives

The synthesis of pyrazolo[1,5-a]quinazolines **6** were also achieved in one step, three component synthesis by the cyclocondensation of 5-aminopyrazole **1**, dimedone **5** and triethylorthoesters **3** by heating at 100–110 °C for 1–2 hours, furnished the compound **6** in 85–90 % yield (Scheme 2). The structure of **6a** was confirmed by IR, ¹H NMR, ¹³C NMR and elemental analysis for example the IR spectrum of **6a** showed bands at 2215, 1687 cm⁻¹ for CN and carbonyl groups. The ¹H NMR of compound **6a** showed a singlet at δ 1.25 for six methyl protons, singlet at δ 2.65 and δ 3.40 for four methylene protons, a singlet at 8.49 and 9.18 corresponding

to C₂H and C₅H protons respectively. Further this structure was confirmed by ¹³C NMR which is in agreement with the structure proposed. Similarly, the structures of compound **6b** and **6c** were confirmed.



Scheme 2 Synthesis of Pyrazolo[1,5-a]quinazoline derivatives

4. Conclusion

The reactions reported here represent the ecofriendly, green and cost-effective route towards the synthesis of novel pyrazolopyrimidine and pyrazoloquinazoline derivatives under solvent free conditions with simple work up. All compounds were synthesized by simply heating the precursors at about 90-120 °C without using solvent and/or catalyst and thus hazardous, harmful and toxic effects of solvents and/or catalyst have been minimized.

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References

- [1] E. Taylor, A. McKillop, *The Chemistry of Cyclic Enaminonitriles and o-Aminonitriles*, Advanced Organic Chemistry, J. Wiley-Inter Science, New York, 1970.
- [2] E. Taylor, R. Loeffler, *Studies in purine chemistry IX pyrimidine synthesis of o-aminonitrile*, J. Am. Chem. Soc. 82 (1960) 3147–3151.
- [3] P. Baraldi, B. Cacciarri, R. Romagnoli, G. Spalluto, K. Klotz et al., *Pyrazolo[4,3-e]-1,2,4-triazolo[1,5-c]pyrimidine derivatives as highly potent and selective human A3 adenosine receptor antagonists*, J. Med. Chem. 42 (1999) 4473–4478.
- [4] R. Robins, F. Furcht, A. Grauer, J. Jones, *Potential purine antagonists. II. synthesis of some 7- and 5,7-substituted pyrazolo[4,3-d]pyrimidines*, J. Am. Chem. Soc. 78 (1956) 2418–2422.
- [5] C. Cheng, R. Robins, *Potential purine antagonists. VI. synthesis of 1-alkyl- and 1-aryl-4-substituted pyrazolo[3,4-d]pyrimidines*, J. Org. Chem. 21 (1956) 1240–1256.
- [6] C. Cheng, R. Robins, *Potential purine antagonists VII. synthesis of 6-alkylpyrazolo-[3,4-d]pyrimidines*, J. Org. Chem. 23 (1958) 191–200.
- [7] C. Cheng, R. Robins, *Total synthesis of pseudoionone and an isomeric ketone*, J. Org. Chem. 23 (1958) 852–861.
- [8] A. Tomeufcik, J. Albright, J. Dusza, U.S. Patent 4,654,347, 1987.
- [9] Y. Chen, JP Patent 2000502723, 1998.
- [10] J. Dusza, J. Albright, A. Tomcufcik, U.S. Patent 5,538,977, 1996.
- [11] M. Boes, H. Stadler, C. Riemer, U.S. Patent 6,194,410, 2001.
- [12] P. O'Donnell, W. Thiele, U.S. Patent 6,384,221, 2002.
- [13] M. Fraley, W. Hoffman, R. Rubino, R. Hungate, A. Tebben et al., *Synthesis and initial SAR studies of 3,6-disubstituted pyrazolo[1,5-a]pyrimidines: A new class of KDR kinase inhibitors*, Bioorg. Med. Chem. Lett. 12 (2002) 2767–2770.
- [14] I. Dalinger, I. Vatsade, S. Shevelev, A. Ivachtchenko, *Liquid-phase synthesis of combinatorial libraries based on 7-trifluoromethyl-substituted pyrazolo[1,5-a]pyrimidine scaffold*, J. Comb. Chem. 7 (2005) 236–245.
- [15] M. Kessler, M. Baudry, G. Lynch, *Quinoxaline derivatives are high-affinity antagonists of the NMDA receptor-associated glycine sites*, Brain Res. 489 (1989) 377–382.
- [16] L. McQuaid, E. Smith, K. South, D. Lodge, E. Pralong et al., *3-Phenyl-4-hydroxyquinolin-2(1H)-ones: potent and selective antagonists at the strychnine-insensitive glycine site on the N-methyl-D-aspartate receptor complex*, J. Med. Chem. 35 (1992) 3323–3325.
- [17] R. Shan, C. Velazquez, E. Knaus, *Syntheses, calcium channel agonist-antagonist modulation activities, and nitric oxide release studies of nitrooxyalkyl derivatives*, J. Med. Chem. 47 (2004) 254–261.
- [18] G. Uray, K. S. Niederreiter, F. Belaj, W. Fabin, *Long-wavelength-absorbing and -emitting carbostyrils with high fluorescence quantum yields*, Helv. Chim. Acta 82 (1999) 1408–1417.
- [19] G. Strohmeier, W. Fabin, G. Uray, *New low-molecular-mass gelators based on L-lysine: amphiphilic gelators and water-soluble organogelators*, Helv. Chim. Acta 87 (2004) 1–10.
- [20] A. Basta, A. Girgis, H. Saied, *Fluorescence behavior of new 3-pyridinecarbonitrile containing compounds and their application in security paper*, Dyes Pigm. 54 (2002) 1–10.
- [21] W. Ried, S. Aboul-Fetouh, *Synthesis of new substituted pyrazolo[1,5-a]pyrimidines and pyrazolo[1,5-a]1,3,5-triazines*, Tetrahedron 44 (1988) 7155–7162.
- [22] M. Elnagdi, B. Kandeel, M. Elmoghayar, Z. Naturforsch. B 30 (1977) 307–320.
- [23] I. Zhu, H. Bienayme (Eds.), *Multicomponent reactions*, Wiley-VCH, Weinheim, 2004.
- [24] I. Ugi, *Recent progress in the chemistry of multicomponent reactions*, Pure Appl. Chem. 73 (2001) 187–191.
- [25] C. Blackburn, B. Guan, P. Fleming, K. Shiosaki, S. Tsai, *Parallel synthesis of 3-aminoimidazo[1,2-a]pyridines and pyrazines by a new three-component condensation*, Tetrahedron Lett. 39 (1998) 3635–3638.
- [26] M. Jachak, A. Avhale, V. Medhane, R. Toche, *A convenient route for the synthesis of pyrazolo[3,4-d]pyrimidine derivatives*, J. Heterocycl. Chem. 43 (2006) 1169–1175.
- [27] M. Jachak, A. Avhale, R. Toche, R. Sabnis, *Synthesis of pyrazolo-annulated heterocyclic compounds*, J. Heterocycl. Chem. 44 (2007) 343–347.
- [28] R. Toche, B. Ghotekar, M. Kazi, D. Kendre, M. Jachak, *Synthesis of fused pyrimidines from amines and cyclic β-formylesters*, Tetrahedron 63 (2007) 8157–8163.
- [29] M. Jachak, D. Kendre, A. Avhale, R. Toche, R. Sabnis, *A novel synthesis of benzo[h]quinolines and study of their fluorescence properties*, J. Heterocycl. Chem. 44 (2007) 1525–1528.
- [30] D. Kendre, R. Toche, M. Jachak, *Synthesis of novel dipyrazolo derivatives and study of their fluorescence behavior*, Tetrahedron 63 (2007) 11000–11004.
- [31] D. Kendre, R. Toche, M. Jachak, *Synthesis of pyrazolo[3,4-b]pyridines and attachment of amino acids and carbohydrate as linkers*, J. Heterocycl. Chem. 45 (2008) 667–671.
- [32] M. Jachak, A. Avhale, B. Ghotekar, D. Kendre, R. Toche, *Synthesis of pyrazole [3,4-b]pyridines using ammonium acetate as green reagent in multicomponent reactions*, J. Heterocycl. Chem. 45 (2008) 1221–1224.
- [33] B. Ghotekar, M. Jachak, R. Toche, *New one-step synthesis of pyrazolo[1,5-a]pyrimidine and pyrazolo[1,5-a]quinazoline derivatives via multicomponent reactions*, J. Heterocycl. Chem. 46 (2009) 708–713.

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