HETEROCYCLIC SYNTHESIS USING NITRILIMINES: PART 7. SYNTHESIS OF SOME NEW SUBSTITUTED 1,2,4,8-TETRAAZASPIRO[4.5]DEC-2-ENES

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Abstract : A series of new 1,2,4,8-tetrazaspiro[4.5]dec-2-enes 4a-r were synthesized from the reaction of corresponding hydrazonoyl halides 1 with substituted heterocyclic oximes 3. The structures of the synthesized compounds were confirmed by their elemental analysis and spectral data.

Introduction

Nitrilimines are well-explored dipoles and their reactions for the construction of heterocyclic systems are to proceed *via* 1,3-dipolar cycloaddition (1-6).

Recently, we have described a versatile and efficient one-pot synthesis of substituted 1,2,4-triazoles utilizing available keto oximes, hydrazones and hydrazonoyl halides (4,6-10). These azoles and their derivatives constitute an important class of organic compounds with diverse agricultural, industrial and biological activities (11-14).

In this work we investigated the reaction of C-substituted-N-arylnitrilimines with 1-substituted-4-piperidone oximes in an attempt to synthesize a new series of spiro-1,2,4-triazoles in anticipation of expected interesting biological activities.

Experimental

Melting points were determined using an Electrothermal melting temperature apparatus and are uncorrected. The IR spectra were measured as potassium bromide (KBr) pellets using Satellite 3000 Mid infrared spectrometer. ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker AM 300 MHz spectrometer at room temperature in $CDCl_3$ solution using tetramethylsilane (TMS) as internal reference. Electron impact (EI) mass spectra were run on Shimadzu GCMS-QP1000 EX spectrometer at 70 eV. elemental analysis were performed at Cairo University, Egypt. The hydrazonoyl halides 1 and 1-substituted-4-piperidone oximes 3 were prepared according to literature procedure (10,15,18).

Synthesis of heterocyclic spiro compounds 4a-r

General method: To a stirred solution of hydrazonoyl halides 1 (0.005 mol) and 1-substituted-4-piperidone oximes 3 (0.015 mol) in 1,4-dioxane (50 ml), triethylamine (4 ml, 0.03 mol) in 1,4-dioxane (10 ml) dropwise added at room temperature. Stirring was continued for 12 hours, then the solvent was removed under vacuum, and the residual solid was washed with water (100 ml) to get ride of the triethylamine salt. In some cases the residue was extracted with chloroform (3X25 ml) and the combined extracts were washed with water (50 ml), dried over anhydrous sodium sulfate. The solvent ($CHCl_3$) was evaporated in vacuo, and the crude product was triturated with ethanol (5-10 ml). The crude solid products were collected and recrystallized from appropriate solvents to afford the desired compounds 4a-r as yellow or red solids.

***3-Acetyl-8-isopropyl-1-phenyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4a**

Yield 65%, m.p. 158-160 °C (ethanol). Anal. Calcd for $C_{17}H_{24}N_4O$ (300.41): C 67.97%, H 8.05%, N 18.65%. Found: C 68.20%, H 7.90%, N 18.50%; MS: ($M^{+\cdot}$ = 300); IR, v/cm^{-1}: 3380 (N-H), 1680 (C=O), 1600 (C=N); ^{1}H NMR, δ/ppm:

7.30-7.20 (5H, m, Ar-H), 5.55 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.50 (3H, s, CH_3CO), 2.40 (1H, m, CH), 1.2 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 189.50 (C=O), 147.80 (C=N), 141.50-115.50 (C_{arom}), 87.80 (spiro carbon), 52.80 ($2CH_2$), 32.20 ($2CH_2$), 47.40 (CH), 27.90 ($2CH_3$).

3-Acetyl-8-benzyl-1-phenyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene **4b**

Yield 62%, m.p. 213-215 °C (ethanol). Anal. Calcd for $C_{21}H_{24}N_4O$ (348.45): C 72.39%, H 6.94%, N 16.08%. Found: C 72.50%, H 6.80%, N 15.90%; MS: ($M^{+\cdot}$ = 348); IR, ν/cm^{-1}: 3375 (N-H), 1680 (C=O), 1605 (C=N); ^1H NMR, δ/ppm: 7.30-7.7.20 (10H, m, Ar-H), 5.55 (1H, s, N-H), 3.20 (2H, s, CH_2-Ph), 2.80-1.70 (8H, m, $4CH_2$), 2.50 (3H, s, CH_3CO); ^{13}C NMR, δ/ppm: 189.50 (C=O), 147.90 (C=N), 142.30-125.50 (C_{arom}), 87.90 (spiro carbon), 52.60 ($2CH_2$), 32.10 ($2CH_2$), 50.10 (CH_2-Ph).

1-(4-Chlorophenyl)-8-isopropyl-3-methoxycarbonyl-1,2,4,8-tetraazaspiro[4.5]-dec-2-ene **4c**

Yield 55%, m.p. 126-128 °C (ethanol). Anal. Calcd for $C_{17}H_{23}ClN_4O_2$ (350.85): C 58.20%, H 6.61%, N 15.97%. Found: C 58.30%, H 6.70%, N 16.20%; MS: ($M^{+\cdot}$ = 350/352); IR, ν/cm^{-1}: 3380 (N-H), 1730 (O-C=O), 1600 (C=N); ^1H NMR, δ/ppm: 7.30-7.10 (4H, m, Ar-H), 5.50 (1H, s, N-H), 3.80 (3H, s, OCH_3) 2.80-1.80 (8H, m, $4CH_2$), 2.40 (1H, m, CH), 1.2 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 158.40 (O-C=O), 147.70 (C=N), 141.10-120.60 (C_{arom}), 88.30 (spiro carbon), 52.80 ($2CH_2$), 33.10 ($2CH_2$), 47.60 (CH), 27.80 ($2CH_3$).

8-Benzyl-1-(4-chlorophenyl)-3-methoxycarbonyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene **4d**

Yield 52%, m.p. 120-122 °C (ethanol). Anal. Calcd for $C_{21}H_{23}ClN_4O_2$ (398.90): C 63.23%, H 5.81%, N 14.05%. Found: C 63.00%, H 6.00, N 13.90%; MS: ($M^{+\cdot}$ = 398/400); IR, ν/cm^{-1}: 3380 (N-H), 1725 (O-C=O), 1595 (C=N); ^1H NMR, δ/ppm: 7.30-7.10 (9H, m, aromatic), 5.50 (1H, s, N-H), 3.80 (3H, s, OCH_3) 3.20 (2H, s, CH_2-Ph), 2.80-1.70 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 158.50 (O-C=O), 147.80 (C=N), 141.10-120.50 (C_{arom}), 88.20 (spiro carbon), 52.70 ($2CH_2$), 33.30 ($2CH_2$), 50.30 (CH_2-Ph).

1-(4-Chlorophenyl)-3-benzoyl-8-methyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene **4e**

Yield 57%, m.p. 132-134 °C (methanol). Anal. Calcd for $C_{20}H_{21}ClN_4O$ (368.87): C 65.12%, H 5.74%, N 15.19%. Found: C 65.30%, H 5.60, N 15.30%; MS: ($M^{+\cdot}$ = 368/ 370); IR, ν/cm^{-1}: 3365 (NH), 1635 (C=O), 1590 (C=N); ^1H NMR, δ/ppm: 8.30-7.20 (9H, m, Ar-H), 5.65 (1H, s, N-H), 3.00-1.80 (8H, m, $4CH_2$), 2.40 (3H, s, CH_3); ^{13}C NMR, δ/ppm: 183.10 (C=O), 147.60 (C=N), 141.00-120.40 (C_{arom}), 85.90 (spiro carbon), 53.10 ($2CH_2$), 31.00 ($2CH_2$), 46.70 (CH_3).

1-(4-Chlorophenyl)-3-benzoyl-8-isopropyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene **4f**

Yield 55%, m.p. 166-168 °C (methanol). Anal. Calcd for $C_{22}H_{25}ClN_4O$ (396.92): C 66.57%, H 6.35%, N 14.12%. Found: C 66.30%, H 6.20%, N 14.30%; MS: ($M^{+\cdot}$ = 396/ 398); IR, ν/cm^{-1}: 3365 (N-H), 1635 (C=O), 1595 (C=N); ^1H NMR, δ/ppm: 8.20-7.20 (9H, m, Ar-H), 5.70 (1H, s, N-H), 2.90-1.60 (8H, m, $4CH_2$), 2.40 (1H, m, CH), 1.3 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 182.90 (C=O), 147.60 (C=N), 141.00-120.50 (C_{arom}), 86.00 (spiro carbon), 53.10 ($2CH_2$), 30.90 ($2CH_2$), 47.30 (CH), 27.60 ($2CH_3$).

1-(4-Chlorophenyl)-3-benzoyl-8-benzyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene **4g**

Yield 72%, m.p. 134-136 °C (methanol). Anal. Calcd for $C_{26}H_{25}ClN_4O$ (444.97): C 70.18%, H 5.66%, N 12.59%. Found: C 70.50%, H 5.80%, N 12.50%; MS: ($M^{+\cdot}$ = 444/446); IR, ν/cm^{-1}: 3360 (N-H), 1635 (C=O), 1590 (C=N); ^1H NMR, δ/ppm: 8.20-7.20 (14H, m, Ar-H), 5.60 (1H, s, N-H), 3.30 (2H, s, CH_2-Ph), 3.00-1.70 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 183.00 (C=O), 147.50 (C=N), 142.30-125.80 (C_{arom}), 85.80 (spiro carbon), 53.20 ($2CH_2$), 31.10 ($2CH_2$), 50.00 (CH_2-Ph).

***1-(4-Chlorophenyl)-8-methyl-3-phenylaminocarbonyl-1,2,4,8-tetraazaspiro[4.5]-dec-2-ene* 4h**

Yield 65%, m.p. 185-187 °C (ethanol). Anal. Calcd for $C_{20}H_{22}ClN_5O$ (383.88): C 62.58%, H 5.78%, N 18.24%. Found: C 62.70%, H 5.90%, N 18.10%; MS: ($M^{+\cdot}$ = 383/385); IR, ν/cm^{-1}: 3365 (N-H), 3350 (PhN-H), 1660 (C=O), 1605 (C=N); ^{1}H NMR, δ/ppm: 8.80 (1H, s, Ph-NH), 7.70-7.20 (9H, m, Ar-H), 5.65 (1H, s, N-H), 2.80-1.60 (8H, m, $4CH_2$), 2.30 (3H, s, CH_3); ^{13}C NMR, δ/ppm: 159.80 (C=O), 147.90 (C=N), 141.30-115.90 (C_{arom}), 87.40 (spiro carbon), 53.20 ($2CH_2$), 31.10 ($2CH_2$), 46.40 (CH_3).

***8-Isopropyl-1-phenyl-3-phenylaminocarbonyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4i**

Yield 58%, m.p. 173-175 °C (ethanol). Anal. Calcd for $C_{22}H_{27}N_5O$ (377.49): C 70.00%, H 7.21%, N 18.55%. Found: C 69.90%, H 7.30%, N 18.70%; MS: ($M^{+\cdot}$ = 377); IR, ν/cm^{-1}: 3370 (N-H), 3355 (PhN-H), 1665 (C=O), 1600 (C=N); ^{1}H NMR, δ/ppm: 8.70 (1H, s, Ph-NH), 7.60-7.20 (10H, m, Ar-H), 5.70 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.40 (1H, m, CH), 1.2 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 159.75 (C=O), 147.80 (C=N), 141.50-115.80 (C_{arom}), 87.40 (spiro carbon), 53.10 ($2CH_2$), 31.00 ($2CH_2$), 46.90 (CH), 27.50 ($2CH_3$).

***8-Benzyl-1-phenyl-3-phenylaminocarbonyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4j**

Yield 62%, m.p. 168-170 °C (ethanol). Anal. Calcd for $C_{26}H_{27}N_5O$ (425.54): C 73.39%, H 6.40%, N 16.46%. Found: C 73.50%, H 6.30%, N 16.50%; MS: ($M^{+\cdot}$ = 425); IR, ν/cm^{-1}: 3360 (N-H), 3350 (PhN-H), 1660 (C=O), 1595 (C=N); ^{1}H NMR, δ/ppm: 8.80 (1H, s, Ph-NH), 7.80-7.20 (15H, m, Ar-H), 5.60 (1H, s, N-H), 3.10 (2H, s, CH_2-Ph), 2.90-1.70 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 159.90 (C=O), 147.70 (C=N), 141.00-115.60 (C_{arom}), 87.50 (spiro carbon), 53.30 ($2CH_2$), 31.20 ($2CH_2$), 50.00 (CH_2-Ph).

***8-Methyl-3-(2-naphthoyl)-1-phenyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4k**

Yield 60%, m.p. 173-175 °C (ethanol). Anal. Calcd for $C_{24}H_{24}N_4O$ (384.49): C 74.97%, H 6.29%, N 14.57%. Found: C 75.10%, H 6.40%, N 14.50%; MS: ($M^{+\cdot}$ = 384); IR, ν/cm^{-1}: 3375 (N-H), 1640 (C=O), 1595 (C=N); ^{1}H NMR, δ/ppm: 8.90-7.26 (12H, m, Ar-H), 5.75 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.36 (3H, s, CH_3); ^{13}C NMR, δ/ppm: 182.30 (C=O), 147.80 (C=N), 141.70-115.30 (C_{arom}), 85.60 (spiro carbon), 53.10 ($2CH_2$), 31.00 ($2CH_2$), 46.30 (CH_3).

***8-Isopropyl-3-(2-naphthoyl)-1-phenyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4l**

Yield 55%, m.p. 186-188 °C (methanol). Anal. Calcd for $C_{26}H_{28}N_4O$ (412.54): C 75.70%, H 6.84%, N 13.58%. Found: C 75.80%, H 6.70%, N 13.50%; MS: ($M^{+\cdot}$ = 412); IR, ν/cm^{-1}: 3370 (N-H), 1645 (C=O), 1590 (C=N); ^{1}H NMR, δ/ppm: 8.85-7.25 (12H, m, Ar-H), 5.70 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.40 (1H, m, CH), 1.2 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 182.30 (Ar-C=O), 147.80 (C=N), 141.60-115.50 (C_{arom}), 85.70 (spiro carbon), 52.90 ($2CH_2$), 31.00 ($2CH_2$), 47.50 (CH), 27.30 ($2CH_3$).

***4-Benzyl-3-(2-naphthoyl)-1-phenyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4m**

Yield 64%, m.p. 146-148 °C (ethanol). Anal. Calcd for $C_{30}H_{28}N_4O$ (460.58): C 78.23%, H 6.13%, N 12.16%. Found: C 78.10%, H 6.00%, N 12.30%; MS: ($M^{+\cdot}$ = 460); IR, ν/cm^{-1}: 3375 (N-H), 1640 (C=O), 1590 (C=N); ^{1}H NMR, δ/ppm: 9.00-7.26 (17H, m, Ar-H), 5.70 (1H, s, N-H), 3.20 (2H, s, CH_2-Ph), 2.80-1.70 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 182.40 (C=O), 146.85 (C=N), 142.10-122.30 (C_{arom}), 85.60 (spiro carbon), 53.10 ($2CH_2$), 31.10 ($2CH_2$), 49.60 (CH_2-Ph).

***8-Methyl-3-(2-naphthoyl)-1-tolyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene* 4n**

Yield 60%), m.p. 173-175 °C (methanol). Anal. Calcd for $C_{25}H_{26}N_4O$ (398.51): C 75.35%, H 6.58%, N 14.06%. Found: C 75.20%, H 6.70%, N 13.90%. MS: ($M^{+\cdot}$ = 398); IR, ν/cm^{-1}: 3375 (N-H), 1640 (C=O), 1595 (C=N); ^{1}H NMR, δ/ppm: 8.90-7.26 (11H, m, Ar-H), 5.70 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.36 (3H, s, CH_3); ^{13}C NMR, δ/ppm: 183.60 (C=O), 147.70 (C=N), 141.50-115.50 (C_{arom}), 85.70 (spiro carbon), 53.00 ($2CH_2$), 31.00 ($2CH_2$), 46.70 (NCH_3), 20.70 (CH_3).

8-Isopropyl-3-(2-naphthoyl)-1-tolyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene 4o

Yield 57%, m.p. 220-222 °C (methanol). Anal. Calcd for $C_{27}H_{30}N_4O$ (426.57): C 76.03%, H 7.09%, N 13.13%. Found: C 75.90%, H 6.90%, N 13.20%; MS: (M^+ = 426); IR, v/cm^{-1}: 3370 (N-H), 1645 (C=O), 1590 (C=N); ^{1}H NMR, δ/ppm: 8.85-7.25 (11H, m, Ar-H), 5.65 (1H, s, N-H), 2.80-1.80 (8H, m, $4CH_2$), 2.40 (1H, m, CH), 1.2 (6H, d, $2CH_3$); ^{13}C NMR, δ/ppm: 182.45 (Ar-C=O), 147.75 (C=N), 141.50-116.20 (C_{arom}), 85.80 (spiro carbon), 52.90 ($2CH_2$), 30.90 ($2CH_2$), 47.20 (CH), 27.40 ($2CH_3$), 20.70 (CH_3).

8-Bezyl-3-(2-naphthoyl)-1-tolyl-1,2,4,8-tetraazaspiro[4.5]dec-2-ene 4p

Yield 62%, m.p. 164-166 °C (ethanol). Anal. Calcd for $C_{31}H_{30}N_4O$ (474.61): C 78.45%, H 6.37%, N 11.80%. Found: C 78.60%, H 6.20%, N 11.90%; MS: (M^+ = 474); IR, v/cm^{-1}: 3370 (N-H), 1640 (C=O), 1595 (C=N); ^{1}H NMR, δ/ppm: 9.00-7.26 (16H, m, Ar-H), 5.70 (1H, s, N-H), 3.20 (2H, s, CH_2-Ph), 2.80-1.70 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 182.65 (C=O), 146.80 (C=N), 142.30-122.50 (C_{arom}), 85.90 (spiro carbon), 53.00 ($2CH_2$), 31.20 ($2CH_2$), 49.75 (CH_2-Ph), 20.70 (CH_3).

8-Benzyl-1-(4-chlorophenyl)-3-(2-furoyl)-1,2,4,8-tetraazaspiro[4.5]dec-2-ene 4q

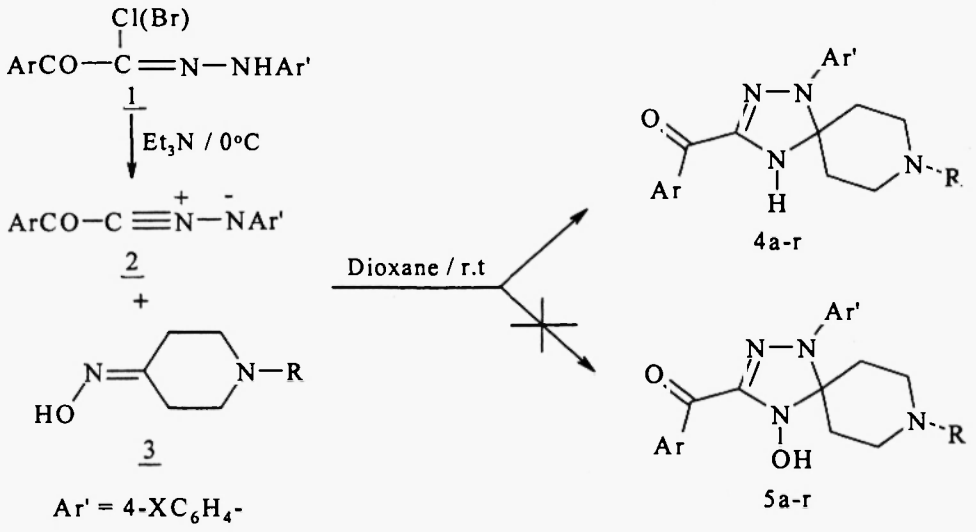
(1.33 g, 61%), m.p. 153-155 °C (ethanol). Anal. Calcd for $C_{24}H_{23}ClN_4O_2$ (434.93): C 66.28%, H 5.33%, N 12.88%. Found: C 66.40%, H 5.20%, N 13.00%; MS: (M^+ = 434/ 436); IR, v/cm^{-1}: 3370 (N-H), 1660 (C=O), 1610 (C=N); ^{1}H NMR, δ/ppm: 8.20-7.2 (12H, m, Ar-H), 5.65 (1H, s, N-H), 3.20 (2H, s, CH_2-Ph), 2.90-1.80 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 172.80 (C=O), 147.40 (C=N), 142.20-120.50 (C_{arom}), 87.50 (spiro carbon), 52.70 ($2CH_2$), 31.00 ($2CH_2$), 49.85 (CH_2-Ph).

8-Benzyl-1-(4-chlorophenyl)-3-(2-thenoyl)-1,2,4,8-tetraazaspiro[4.5]dec-2-ene 4r

Yield 63%, m.p. 163-165 °C (ethanol). Anal. Calcd for $C_{24}H_{23}ClN_4OS$ (450.99): C 63.92%, H 5.14%, N 12.42%. Found: C 64.10%, H 5.00%, N 12.50%; MS: (M^+ = 450/ 452);. IR, v/cm^{-1}: 3375 (N-H), 1665 (C=O), 1605 (C=N); ^{1}H NMR, δ/ppm: 8.30-7.16 (12H, m, Ar-H), 5.70 (1H, s, N-H), 3.40 (2H, s, CH_2-Ph), 3.00-1.80 (8H, m, $4CH_2$); ^{13}C NMR, δ/ppm: 174.30 (C=O), 147.30 (C=N), 142.10-120.30 (C_{arom}), 87.60 (spiro carbon), 53.00 ($2CH_2$), 31.10 ($2CH_2$), 49.90 (CH_2-Ph).

Results and Discussions

The treatment of hydrazonoyl halides 1 –precursors of nitrilimines 2- with appropriate 1-substituted-4-piperidone oximes 3 in 1,4-dioxane or tetrahydrofuran in presence of triethylamine as a base, did not produce the expected 4-hydroxytriazoles 5, instead, spirotriazoles 4a-r formed as reaction products (Scheme-1). It was thought that the formation of compounds 4a-r is assumed to involve cycloaddition products 5 which tautomerize to amine oxide-type intermediates that are deoxygenated by triethylamine (19). It is worth mentioning that, the nitrile oxides 7 generated in *situ* from respective hydroxamoyl chlorides 6 upon action of triethylamine as a base are found to react with oximes to give the 4-hydroxy-4,5-dihydro-1,2,4-oxadiazoles 8 (Scheme-2) (20).



Entery	Ar	R	X
a	CH_3-	-$CHMe_2$	H
b	CH_3-	-CH_2Ph	H
c	CH_3O-	-$CHMe_2$	Cl
d	CH_3O-	-CH_2Ph	Cl
e	Ph	-CH_3	Cl
f	Ph	-$CHMe_2$	Cl
g	Ph	-CH_2Ph	Cl
h	PhNH-	-CH_3	Cl
i	PhNH-	-$CHMe_2$	H

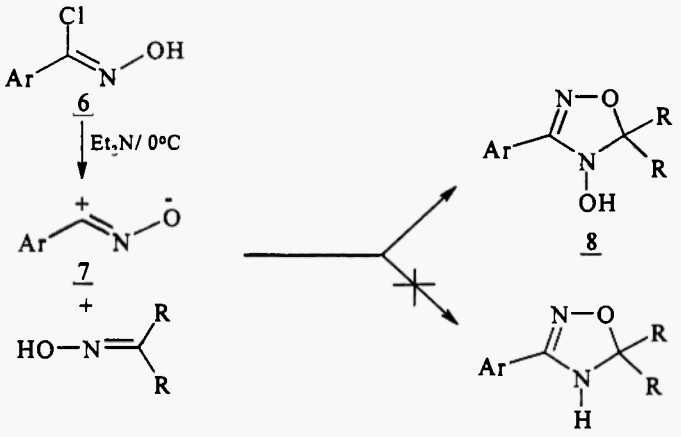
Entery	Ar	R	X
j	PhNH-	-CH_2Ph	H
k	2-Naphthyl	-CH_3	H
l	2-Naphthyl	-$CHMe_2$	H
m	2-Naphthyl	-CH_2Ph	H
n	2-Naphthyl	-CH_3	CH_3
o	2-Naphthyl	-$CHMe_2$	CH_3
p	2-Naphthyl	-CH_2Ph	CH_3
q	2-Furyl	-CH_2Ph	Cl
r	2-Thienyl	-CH_2Ph	Cl

Scheme-1: Synthetic pathway for the preparation of compound 4a-r

Spectral Data Analysis

The characterization data of synthesized compounds 4a-r are given in the experimental section. These compounds 4a-r gave satisfactory analysis for the proposed structures which are confirmed on the bases of their spectroscopic data. The electron impact (EI) mass spectra displayed the correct molecular ions (M^+) in accordance with the suggested structures. The IR spectra showed the strong absorption band of NH of the ring in the region 3380-3360 cm^{-1}, in addition to, characteristic band of (Ar-C=O) at about 1730-1630 cm^{-1}. In the ^1H NMR spectra, a characteristic signal due to the NH proton of the ring appeared at 5.5-5.7 ppm and this values are similar to reported in literature (21). The structures of compounds 4a-r were further confirmed by ^{13}C NMR spectra, which account for the different carbons of these spirotriazoles. The signal at 85-90 ppm was attributed to the C-5 (spiro carbon) of the triazole ring is of special significance. This assignment is in good agreement with literature data for spiro carbons (4,7-10). The signal at about 147 ppm was attributed to the C-3 carbon of the triazoles, and this is similar to reported values of azomethine carbons of five-membered heterocycles (7-10).

In conclusions, the reaction of nitrilimines 2 with 1-methyl, 1-isopropyl and 1-benzyl-4-piperidone oximes 3 leads to formation of heterocyclic spirotriazoles 4a-r.



Scheme 2: Reaction of nitrile oxide with oximes

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Received on October 31, 2006