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PALLADIUM-CATALYZED ROUTE TO NOVEL FIVE- AND SIX-CYCLIC HETEROCYCLIC SYSTEMS CONTAINING THIAZOLE, IMIDAZOLE AND OXEPINE RINGS

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ABSTRACT

Novel and simple two step catalytic method for the preparation of novel five- and six-cyclic heterocyclic systems containing thiazole, imidazole and oxepine rings from 3-chloromethylbenzo[4,5]imidazo[2,1-b]thiazole and *o*-bromobenzyl alcohols or 2-bromo-3-hydroxymethylpyridine was described.

Keywords: Palladium catalyst, coupling, 3-chloromethylbenzo[4,5]imidazo[2,1-b]thiazole, phase transfer catalysis, five- and six-cyclic heterocyclic systems

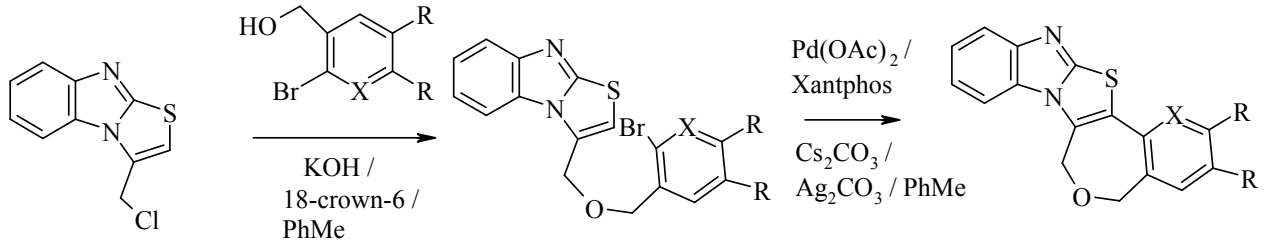
INTRODUCTION

Seven-membered heterocyclic motifs are usually present in the wide range of biologically active molecules [1]. Wide range of recent chemical review literature is dedicated to synthesis and transformation of seven membered rings [2-5]. The most important and updated development in palladium-catalyzed synthesis of different heterocyclic compounds including oxepine ring using intramolecular Heck type reaction was recently highlighted in some reviews [6-9]. Beside this synthesis of oxepines and their benzo derivatives by ring closing metathesis were well documented [10]. Among these works some recent publications were connected with benzoxepine ring preparation by palladium [11,12] or osmium [13] catalysis. However, there is no data in the literature connected to synthesis of different types of fused thiazolooxepines, thiazolobenzoxepines and related compounds and therefore is the main aim of the present work. Beside this, amount of methods for the preparation of large-membered ring systems by intramolecular Heck type cyclisation is limited and yields of products in such reactions usually are not high. Our interest in polycyclic compounds containing imidazothiazole and related fragments is also connected with a wide range of biological activity of imidazothiazole heterocyclic systems [14,15].

RESULTS AND DISCUSSION

Herein we report a novel and simple palladium-catalyzed method for the preparation of novel five- and six-cyclic heterocyclic systems containing thiazole, imidazole and oxepine rings from 3-chloromethylbenzo[4,5]imidazo[2,1-*b*]thiazole (**1**) and *o*-bromobenzyl alcohols or 2-bromo-3-hydroxymethylpyridine. The synthesis of compounds **5-7** was carried out using two step method. The first step included selective O-alkylation of *o*-bromobenzyl alcohols or 2-

bromo-3-hydroxymethylpyridine in the phase transfer catalytic system 3-chloromethylbenzo[4,5]imidazo[2,1-*b*]thiazole (**1**) / solid KOH / 18-crown-6 / PhMe (Scheme 1). Substituted 3-[2-bromophenyl(or pyridyl)methoxymethyl]benzo[4,5]imidazo[2,1-*b*]thiazoles **(2-4)** were isolated by column chromatography in 50-77 % yields.



X= CH, N; R= H; RR = $O(CH_2)_2O$

The second step of reaction is Pd(0)-catalyzed cyclization of 3-[2-bromophenyl(or pyridyl)methoxymethyl]benzo[4,5]imidazo[2,1-*b*]thiazoles **2-4**. Our previously experiments showed that catalytic system bromide **2-4 /** solid dry Cs_2CO_3 / $Pd(OAc)_2$ / Xantphos / Ag_2CO_3 in dry toluene was the best for the preparation of oxadiazepines **5-7**. Products **5-7** were isolated in 11-21 % yields (see Table 1 and Experimental section).

Structure of compound **5** was confirmed by X-Ray structural data (see Experimental section). Fig. 1 illustrates a perspective view of the molecule **5**, showing the thermal ellipsoids and the atom-numbering scheme followed in the text. In the seven-membered cycle of O14–C13–C4–C5–C14–C16–C15 the atoms of C4, C5, C14 and C16 lie in one plane. The deviations of C15, O14 and C13 atoms from this plane are equal –0.245(5), 0.790(4) and 0.375(5) Å, respectively. The other cycles in the molecule are planar.

In the crystal structure there are π-π stacking interactions between two molecules of **5** connected by a center of inversion. This fact leads to short intermolecular contacts: C5···C8 (1.379(5) Å) and C2···C12 (1.397(5) Å).

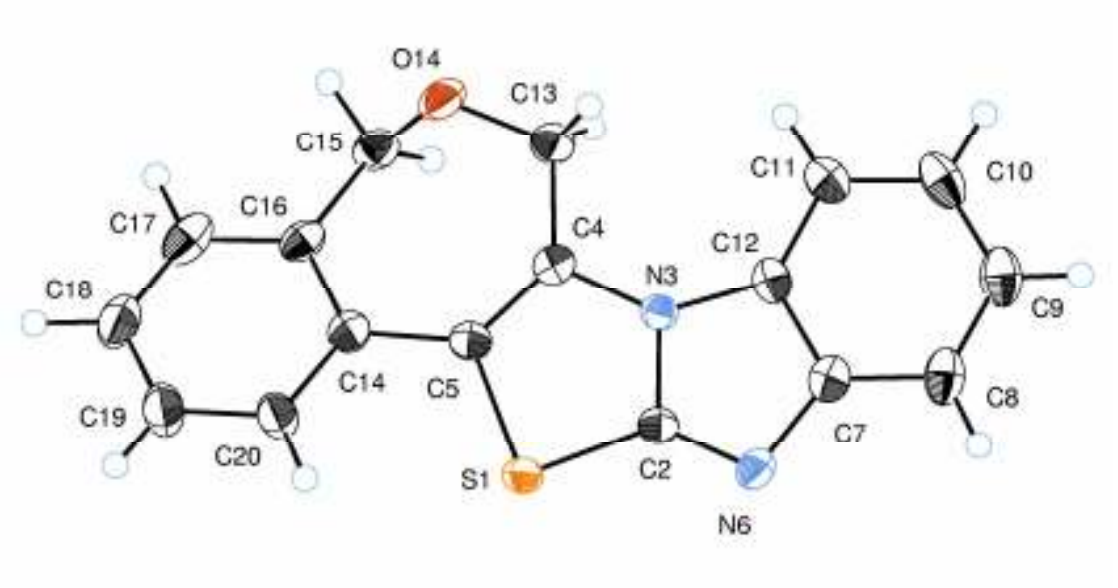
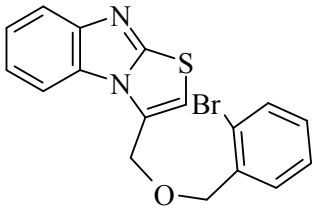
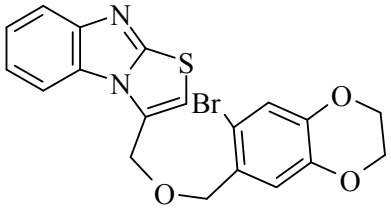
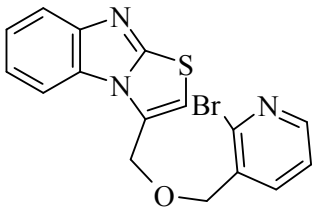
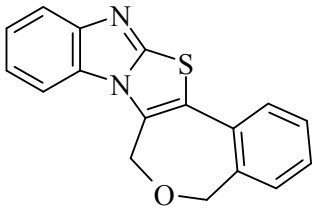
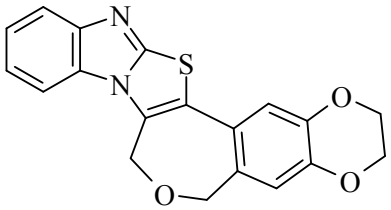
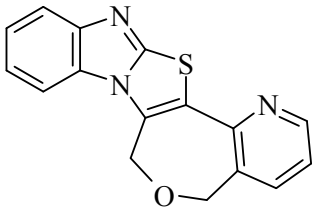


Figure 1. ORTEP molecular structure of the compound **5**.

Table1. Synthesis of substituted 3-(2-bromophenyl(or pyridyl)methoxymethyl)benzo[4,5]imidazo[2,1-*b*]thiazoles (2-4) and five- and six-cyclic heterocycles 5-7.

Product	Yield, %	Melting point, ^{o}C	^{1}H NMR, δ, ppm	^{13}C NMR, δ, ppm	LC-MS
 **2**	77	151-152	4.74 and 4.93 (both s, 4H, CH_2), 6.75 (s, 1H, thiazole proton), 7.15 (t, 1H, J = 8.0 Hz, aryl), 7.22-7.27 and 7.34-7.43 (both m, aryl), 7.53, 7.78 and 7.87 (all d, 3H, J = 8.0 Hz, aryl)	64.62, 71.48, 109.46, 111.98, 119.04, 121.04, 122.91, 123.44, 127.50, 129.41, 129.45, 129.95, 130.01, 132.63, 136.26, 148.41, 156.93	375 (M^{+}+2)
 **3**	50	188-189	4.20 (m, 4H, CH_2CH_2), 4.62 and 4.88 (both s, 4H, CH_2), 6.73 (s, 1H, thiazole proton), 6.90 and 7.04 (both s, 2H, aryl), 7.27 and 7.37 (both t, 2H, J 7.2 Hz, aryl), 7.77 and 7.86 (both d, 2H, aryl)	64.17, 64.31, 71.08, 109.32, 112.05, 113.55, 118.40, 118.97, 120.94, 121.04, 123.40, 128.96, 129.94, 130.14, 142.98, 143.95, 148.38, 156.90	433 (M^{+}+2)
 **4**	63	75-77	4.71 and 4.98 (both s, 4H, CH_2), 6.79 (s, 1H, thiazole proton), 7.14-7.39 (m, 3H, aryl and pyridine), 7.69-7.86 (m, 3H, aryl and	65.07, 70.07, 109.92, 111.71, 119.21, 121.15, 122.90, 123.56, 129.52, 129.86, 134.03, 136.93, 141.65, 148.41, 149.10, 156.86	374 (M^{+})

			pyridine), 8.26 (dd, 1H, J = 4.0 and 2.0 Hz, pyridine)		
 **5**	14	>230	4.84 and 5.51 (both s, 4H, CH_2), 7.23-7.31 (m, 3H, aryl), 7.34-7.42 (m, 3H, aryl), 7.55 (t, 2H, J = 7.2 Hz, aryl), 7.79 (d, 1H, J = 8.4 Hz, aryl)	70.14, 73.75, 110.74, 119.46, 121.28, 123.67, 127.39, 127.77, 128.37, 128.39, 128.98, 130.01, 130.06, 130.81, 137.33, 148.02, 154.33	293 (M^++1)
 **6**	11	>230	4.29 (m, 4H, CH_2CH_2), 4.72 and 5.48 (both s, 4H, CH_2), 6.79 and 7.08 (both s, 2H, aryl), 7.25-7.35 (m, 2H, aryl), 7.55 and 7.78 (both d, 2H, J = 8.5 Hz, aryl)	- *	351 (M^++1)
 **7**	21	>230	4.88 and 5.54 (both s, 4H, CH_2CH_2), 7.18 (m, 1H, pyridine), 7.26 (m, 1H, aryl), 7.37 (t, 1H, J = 7.6 Hz, aryl), 7.48-7.55 (m, 2H, aryl and pyridine), 7.79 (d, 1H, J = 8.0 Hz, aryl), 8.55 (d, 1H, J = 4.8 Hz, pyridine	70.28, 72.87, 111.11, 119.54, 119.73, 121.30, 121.76, 123.78, 123.89, 127.11, 131.84, 132.23, 135.18, 136.80, 148.84, 151.48	294 (M^++1)

* Compound **6** was identified by ^{1}NMR and LC-MS spectra only due to insufficient amount and stability

EXPERIMENTAL SECTION

^{1}H and ^{13}C NMR spectra were recorded on a Varian Mercury BB 400 MHz in $CDCl_3$ using HMDS as internal standard. LC-MS spectra were recorded on Alliance Waters 2695 instrument and Waters 3100 mass detector. 3-Chloromethylbenzo[4,5]imidazo[2,1-*b*]thiazole (**1**) was obtained from 2-mercaptobenzimidazole in the system $ClCH_2COCH_2Cl$ / Me_2CO / H_2SO_4 according procedure [16]. 2-Bromo-3-hydroxymethylpyridine was prepared from corresponding aldehyde in the presence of $NaBH_4$ in ethanol. Cs_2CO_3, $Pd(OAc)_2$, Xantphos and 18-crown-6 (Acros and Aldrich) were used without additional purification.

Typical procedure for the preparation of substituted 3-[2-bromophenyl(or pyridyl)methoxymethyl]benzo[4,5]imidazo[2,1-*b*]thiazoles 2-4. Solid KOH (0.15 g, 2.7 mmol) was added to solution of 3-chloromethylbenzo[4,5]imidazo[2,1-*b*]thiazole (**1**) (0.20 g, 0.9 mmol), 2-bromobenzyl alcohols or 2-bromo-3-hydroxymethylpyridine (0.9 mmol), 18-crown-6 (0.024 g, 0.09 mmol) in dry toluene (30 ml) and the reaction mixture was refluxed for 2h. Then reaction mixture was filtered and solvent was removed under reduced pressure and crude residue was chromatographed on silica using ethyl acetate as eluent. See Table 1.

Typical procedure for the preparation of five- and six-cyclic heterocyclic compounds 5-7. Mixture of 3-[2-bromophenyl(or pyridyl)methoxymethyl]benzo[4,5]imidazo[2,1-*b*]thiazoles (1.2 mmol), $Pd(OAc)_2$ (0.03 g, 0.12 mmol), Xantphos (0.14 g, 0.24 mmol), anhydrous Cs_2CO_3 (0.78 g, 2.4 mmol), Ag_2CO_3 (0.17g, 0.6 mmol) in dry toluene (5 ml) was heated at 135^{o}C for 23 h in glass reactor under argon. Reaction mixture was diluted with ethyl acetate (30 ml), filtered and solvent was removed under reduced pressure and crude residue was chromatographed on silica using ethyl acetate : hexane in different mixtures as eluent. See Table 1.

X-Ray crystallographic study of compound 5. Diffraction data were collected at –90°C on a Bruker-Nonius KappaCCD diffractometer using graphite monochromated Mo-Kα radiation (λ = 0.71073 Å). The crystal structure of **5** was solved by direct methods [17] and refined by full-matrix least squares [18]. All nonhydrogen atoms were refined in anisotropical approximation, all H-atoms were located from differencial Fourier map and refined by riding model. Crystal data for **5**: monoclinic; a = 7.4743(1), b = 7.1274(2), c = 24.5610(6) Å, β = 94.3471(9)°; V = 1304.66(5) Å^3, Z = 4, μ = 0.247 mm^{-1}; space group is $P\ 2_1/c$. A total of 3261 reflection intensities were collected up to $2\theta_{max}$ = 57°; for structure refinement 2457 independent reflections with $I > 3\sigma(I)$ were used. The final R-factor is 0.068. For further details, see crystallographic data for **5** deposited with the Cambridge Crystallographic Data Centre as Supplementary Publication Number CCDC 850017. Copies of the data can be obtained, free of charge, on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK.

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