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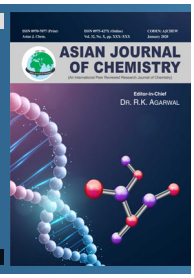

Synthesis, Structural Investigation and Antimicrobial Properties of Macrocyclic Zinc(II) Complexes with N_2O_2-Donor Schiff Bases Incorporating 1,2,4-Triazole Ring

ARTI VISHWKARMA, AKHILESH K. SRIVASTAVA, OM P. PANDEY and SOUMITRA K. SENGUPTA*

Department of Chemistry, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur-273009, India

*Corresponding author: E-mail: sengupta@hotmail.co.uk

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A novel series of nano-sized zinc(II) complexes of type [{Zn(M)$(H_2O)_2$}$(CH_3COO^-)_2$] (where M = macrocyclic ligands) has been synthesized by the *in situ* reactions of Schiff bases derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles, salicyldehyde/2-hydroxy-1-naphthaldehyde and 1,4-dibromobutane/1,5-dibromopentane in presence of zinc(II) acetate dihydrate in absolute ethanol. The structures of all these zinc(II) complexes were established on the basis of elemental analyses and spectral data (IR, ^{1}H NMR and ^{13}C NMR). Scanning electron microscopy studies have been carried out to investigate the particle size and surface morphology of a particular complex while thermal studies confirm the presence of coordinated water molecules in all the zinc(II) complexes. The antimicrobial effects of all the synthesized complexes were studied against different species of pathogenic fungi and bacteria.

Keywords: Macrocyclic ligand, Schiff base, 1,2,4-Triazoles, Zinc(II) complexes, Antimicrobial activity.

INTRODUCTION

Heterocyclic compounds plays important role in the majority of the life processes as drugs or building blocks in materials with extensive applications. 1,2,4-Triazoles are a class of heterocyclic compounds with five-membered ring containing nitrogen, which possess good biological behaviour [1-10]. Generally, it has been observed that the occurrence of two or more pharmacological moieties in a fragment enhances the activity of the hybrid molecule and also responsible for its therapeutic outcome and higher bioactivity [11]. 1,2,4-Triazoles have significant capacity of metal binding, as it forms a range of complexes having different coordination number and geometries with different number of metal ions. The three nitrogen donors of the 1,2,4-triazoles can easily bind to the metal ions and they are accountable for the complex formation ability of 1,2,4-triazoles. The arrangement of nitrogen atoms in the triazole ring enables 1,2,4-triazoles to coordinate together in order to create complexes which can be medicinally and biologically important [12-14]. A number of complexes containing macrocyclic ligands have been synthesized by the template condensation method using metals as templates in such reactions and this helps to study the model biological systems to recognize the chemical changes occurring in such cases [15,16]. Cyclic compounds have been obtained both from structural modification of selected simple rings and also by means of synthetic procedure blueprint to create the vital macrocycle directly from noncyclic precursors [17-19]. The coordination manners of Schiff bases towards metal ions depends upon the type of functional groups like -OH *ortho* to azomethine >C=N group are recognized to form stable chelates [20,21]. The biological consequence of synthetic macrocyclic complexes specially those of azamacrocycles, create interest in the blue-print of new complexes [22]; while kinetic inertness of transition metal complexes containing polyazamacrocyclic ligands are responsible for their important industrial applications [23,24].

In this article, studies on a series of macrocyclic zinc(II) complexes with Schiff bases derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles, salicyldehyde/2-hydroxy-1-naphthaldehyde and 1,4-dibromobutane/1,5-dibromopentane are reported. These compounds have been analyzed with the help of different physico-chemical techniques and studied as antimicrobial agents against different microbes.

EXPERIMENTAL

The solvents were purchased from Merck while the metal salt zinc acetate dihydrate was purchased from Aldrich. The ligands were prepared as reported in literature [25]. Melting

points were determined by Buchi 530 apparatus in open capillary tubes. Elemental analysis was performed with the help of Vario EL III Carlo Erba 1105 CHN analyser. Elemental (C, H, N) analysis indicated that calculated and observed values were within agreeable limits. IR spectra were recorded in KBr using Shimadzu 8201 PC model spectrophotometer; NMR spectra were recorded in DMSO-d_6 solvent by a Bruker DRX-300 spectrometer using TMS as an internal reference. Thermogravimetric study of the complexes was carried out under nitrogen atmosphere with a heating rate of 20 °C/min using a Perkin Elmer-STA 6000 thermal analyser instrument. Powder X-ray diffraction pattern were recorded using an X-ray powder diffractometer with CuKα radiation (λ = 1.5406 Å). SEM micrograph of Zn(II) complexes were recorded on a JOEL model JSM-6390LV scanning electron microscope.

Synthesis of Schiff bases derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino 1,2,4-triazoles and salicyldehyde/2-hydroxy-1-naphthaldehyde: To an ethanolic solution (25 mL) of 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles [25] and salicyldehyde/2-hydroxy-1-naphthaldehyde in 1:2 M ratio, respectively, added few drops of concentrated hydrochloric acid and the reaction mixture was refluxed for 6-7 h. The resultant reaction mixture was concentrated to 10 mL and ether was added in order to separate the product. The precipitate formed, was filtered off and washed with ethanol and ether.

Synthesis and characterization of zinc(II) macrocyclic complexes: 1,4-Dibromobutane/1,5-dibromopentane (0.01 mol) and ethanolic solution of zinc(II) acetate dihydrate (0.01 mol) was added simultaneously to a refluxing solution of appropriate Schiff base, derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles and salicyldehyde/2-hydroxy-1-naphthaldehyde (0.01 mol) in ethanol (25 mL) with continuous stirring. The reaction mixture was refluxed for about 18 h and then the resulting solution was concentrated and cooled. The resultant coloured complex thus obtained, was filtered off, washed several times with ethanol and dried *in vacuo*. The analytical data corresponds to the molecular formula $[Zn(M)(H_2O)_2](CH_3COO)_2$ (where M = macrocyclic ligands derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles, salicyldehyde/2-hydroxy-1-naphthaldehyde and 1,4-dibromobutane/1,5-dibromopentane). Synthesis of the ligands and their corresponding macrocyclic zinc(II) complexes are schematically represented in the **Scheme-I**.

Complex 1: $[Zn(M^1)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 255 °C. Anal. calcd. (%): C, 53.62; H, 5.10; N, 12.51; Zn, 9.73. Found (%): C, 53.51; H, 5.07; N, 12.42; Zn, 9.68. FT-IR (KBr) (ν; cm^{-1}): 3429 (-OH), 3191 (-NH), 1612 (-C=N), 1576 (C-N-C-triazole), 505 (Zn–O), 435 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.45 (s, -NH), 5.54 (s, 2H, -OH), 8.11 (s, 2H, H-C=N-), 7.08-7.61 (m, 13H, Ar-H), 3.46 (t, 4H, $-CH_2$), 2.29 (s, 3H, H_3CCOO-) 1.84 (m, 4H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 157.1 (2C, -C=N, triazole), 154.4 (2C, -HC=N), 112.5-136.4 (18C, Ar-C), 68.5 (2C, $-(CH_2)_2$-), 23.5 (2C, $-(CH_2)_2$-).

Complex 2: $[Zn(M^2)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 278 °C. Anal. calcd. (%): C, 51.01; H, 4.71; N, 11.90; Zn, 9.26. Found (%): C, 50.96; H, 4.68; N, 11.86; Zn, 9.21. FT-IR (KBr) (ν; cm^{-1}): 3425 (-OH), 3196 (-NH), 1601 (-C=N), 1573 (C-N-C-triazole), 497 (Zn–O), 437 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.51 (s, -NH), 5.57 (s, 2H, -OH), 8.15 (s, 2H, H-C=N-), 7.67-6.96 (m, 13H, Ar-H), 3.50 (t, 4H, $-CH_2$), 2.30 (s, 3H, H_3CCOO-), 2.08 (m, 4H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 157.4 (2C, -C=N, triazole), 154.7 (2C, -HC=N), 112.8-136.9 (18C, Ar-C), 68.9 (2C, $-(CH_2)_2$-), 23.8 (2C, $-(CH_2)_2$-).

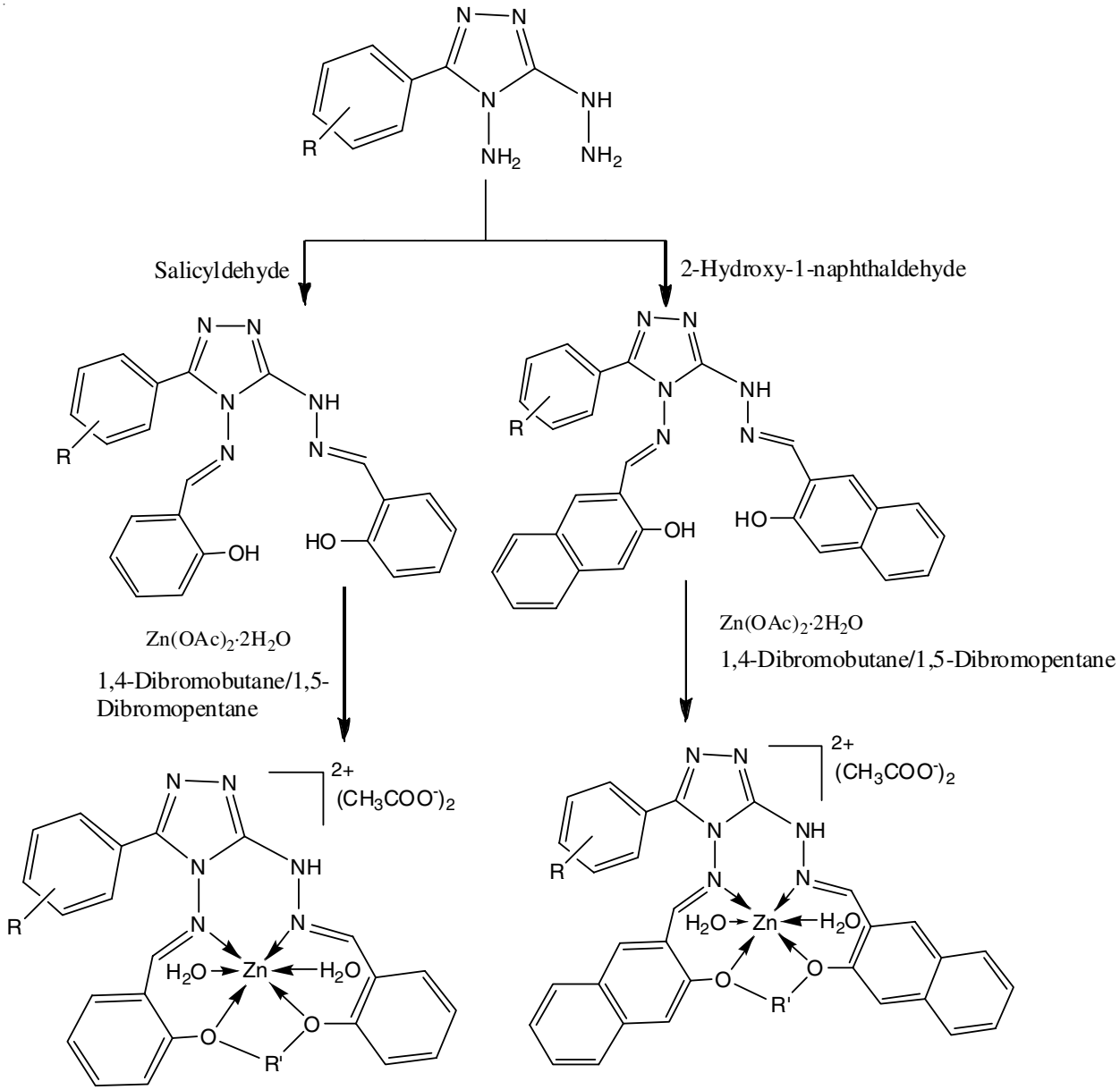
Complex 3: $[Zn(M^3)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 247 °C. Anal. calcd. (%): C, 54.27; H, 5.29; N, 12.25; Zn, 9.53. Found (%): C, 54.21; H, 5.25; N, 12.19; Zn, 9.48. FT-IR (KBr) (ν; cm^{-1}): 3422 (-OH), 3187 (-NH), 1607 (-C=N), 1575 (C-N-C-triazole), 495 (Zn–O), 431 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.42 (s, -NH), 5.49 (s, 2H, -OH), 8.09 (s, 2H, H-C=N-), 7.52-6.96 (m, 13H, Ar-H), 3.41 (t, 4H, $-CH_2$), 2.24 (s, 3H, H_3CCOO-) 1.81 (m, 4H, $-CH_2$), 1.27 (m, 2H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 157.5 (2C, -C=N, triazole), 154.1 (2C, -HC=N), 112.1-135.8 (18C, Ar-C), 68.1 (2C, $-(CH_2)_2$-), 23.1 (2C, $-(CH_2)_2$-), 19.2 (1C, $-(CH_2)_2$-).

Complex 4: $[Zn(M^4)(H_2O)_2](CH_3COO)_2$. Yield: 65%; m.p. (decomp.): 262 °C. Anal. calcd. (%): C, 51.68; H, 4.90; N, 11.67; Zn, 9.08. Found (%): C, 51.59; H, 4.84; N, 11.64; Zn, 9.01. FT-IR (KBr) (ν; cm^{-1}): 3421 (-OH), 3192 (-NH), 1598 (-C=N), 1571 (C-N-C-triazole), 491 (Zn–O), 428 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.46 (s, -NH), 5.53 (s, 2H, -OH), 8.13 (s, 2H, H-C=N-), 7.58-7.01 (m, 12H, Ar-H), 3.45 (t, 4H, $-CH_2$), 2.28 (s, 3H, H_3CCOO-) 2.05 (m, 4H, $-CH_2$), 1.29 (m, 2H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 157.8 (2C, -C=N, triazole), 154.5 (2C, -HC=N), 112.4-135.5 (18C, Ar-C), 68.5 (2C, $-(CH_2)_2$-), 23.6 (2C, $-(CH_2)_2$-), 19.7 (1C, $-(CH_2)_2$-).

Complex 5: $[Zn(M^5)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 295 °C. Anal. calcd. (%): C, 59.11; H, 4.96; N, 10.88; Zn, 8.47. Found (%): C, 59.14; H, 4.94; N, 10.85; Zn, 8.42. FT-IR (KBr) (ν; cm^{-1}): 3433 (-OH), 3207 (-NH), 1610 (-C=N), 1584 (C-N-C-triazole), 541 (Zn–O), 474 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.48 (s, -NH), 5.62 (s, 2H, -OH), 8.12 (s, 2H, H-C=N-), 7.15-7.65 (m, 17H, Ar-H), 3.48 (t, 4H, $-CH_2$), 2.32 (s, 3H, H_3CCOO-), 1.90 (m, 4H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 158.4 (2C, -C=N, triazole), 155.6 (2C, -HC=N), 115.4-145.5 (26C, Ar-C), 69.8 (2C, $-(CH_2)_2$-), 23.9 (2C, $-(CH_2)_2$-).

Complex 6: $[Zn(M^6)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 310 °C. Anal. calcd. (%): C, 56.59; H, 4.62; N, 10.42; Zn, 8.11. Found (%): C, 56.45; H, 4.57; N, 10.39; Zn, 8.02. FT-IR (KBr) (ν; cm^{-1}): 3431 (-OH), 3209 (-NH), 1609 (-C=N), 1580 (C-N-C-triazole), 538 (Zn–O), 468 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.58 (s, -NH), 5.65 (s, 2H, -OH), 8.18 (s, 2H, H-C=N-), 7.18-7.69 (m, 16H, Ar-H), 3.51 (t, 4H, $-CH_2$), 2.34 (s, 3H, H_3CCOO-) 2.12 (m, 4H, $-CH_2$). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 158.9 (2C, -C=N, triazole), 155.8 (2C, -HC=N), 120.5-145.9 (26C, Ar-C), 70.2 (2C, $-(CH_2)_2$-), 24.2 (2C, $-(CH_2)_2$-).

Complex 7: $[Zn(M^7)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 278 °C. Anal. calcd. (%): C, 59.58; H, 5.13; N, 10.69; Zn, 8.32. Found (%): C, 59.41; H, 5.09; N, 10.61; Zn, 8.25. FT-IR (KBr) (ν; cm^{-1}): 3428 (-OH), 3205 (-NH), 1611 (-C=N), 1581 (C-N-C-triazole), 535 (Zn–O), 469 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.44 (s, -NH), 5.58 (s, 2H, -OH), 8.10 (s, 2H, H-C=N-), 7.12-7.62 (m, 17H, Ar-H), 3.45 (t, 4H, $-CH_2$), 2.27 (s, 3H, H_3CCOO-), 1.86 (m, 4H, $-CH_2$), 1.31 (m, 2H, $-CH_2$). ^{13}C



Scheme-I: Reaction scheme for the synthesis of Schiff bases and their corresponding macrocyclic zinc(II) complexes

NMR (DMSO-d_6) [δ; ppm]: 158.2 (2C, -C=N, triazole), 155.3 (2C, -HC=N), 115.4-144.8 (26C, Ar-C), 69.3 (2C, -$(CH_2)_2$-), 23.4 (2C, -$(CH_2)_2$-), 19.8 (1C, -$(CH_2)_2$-).

Complex 8: $[Zn(M^8)(H_2O)_2](CH_3COO)_2$. m.p. (decomp.): 290 °C. Anal. calcd. (%): C, 57.08; H, 4.79; N, 10.24; Zn, 7.97. Found (%): C, 57.01; H, 4.73; N, 10.12; Zn, 7.86. FT-IR (KBr) (ν; cm^{-1}): 3426 (-OH), 3204 (-NH), 1605 (-C=N), 1578 (C-N-C-triazole), 530 (Zn–O), 464 (Zn–N). ^{1}H NMR (DMSO-d_6) [δ; ppm]: 9.53 (s, -NH), 5.61 (s, 2H, -OH), 8.17 (s, 2H, H-C=N-), 7.14-7.64 (m, 17H, Ar-H), 3.49 (t, 4H, -CH_2), 2.30 (s, 3H, H_3CCOO-), 2.06 (m, 4H, -CH_2), 1.34 (m, 2H, -CH_2). ^{13}C NMR (DMSO-d_6) [δ; ppm]: 158.0 (2C, -C=N, triazole), 155.5 (2C, -HC=N), 120.1-144.3 (26C, Ar-C), 69.5 (2C, -$(CH_2)_2$-), 23.7 (2C, -$(CH_2)_2$-), 20.2 (1C, -$(CH_2)_2$-).

Antimicrobial properties of zinc(II) complexes

Antifungal activity of zinc(II) complexes: Antifungal activity of all the synthesized Schiff bases and their corresponding zinc(II) complexes were studied against two pathogenic fungal strains *viz. Aspergillus niger* and *Aspergillus alternate* by agar plate technique and the antifungal activity results were recorded as percentage of inhibtion using fluconazole as standard drug. For each test compound 1% standard solution was prepared using DMSO as solvent and 1 mL of the solution was mixed

with 9 mL of the solvent. Three concentration *viz*. 10, 100, 1000 ppm stock solutions were prepared for each compound and 1 mL of each concentration solution was mixed with 9 mL of agar medium in sterilized petriplates. After the medium was prepared, fungus strain was inoculated in the center of each plate and assay plates were incubated at 29 ± 2 ºC for 7 days.

Antibacterial activity of zinc(II) complexes: Antibacterial effect of all the synthesized Schiff bases and their respective zinc(II) complexes were screened against Gram-negative *Escherichia coli* and Gram-positive *Bacillus subtilis* by agar well diffusion method using tetracycline as standard drug. DMSO was used as solvent to study the antibacterial activity of each compound and the effects were recorded by measuring the inhibition zone (mm) around each disk after 24 h.

RESULTS AND DISCUSSION

Infrared spectra: The tentative assignments for the compounds were made by comparing the spectra with reported literature on analogous systems [26,27]. The acyclic ligands and their corresponding Zn(II) macrocyclic complexes show a medium band at *ca.* 3209-3187 cm^{-1} due to ν(N-H) [28]. The acyclic ligands [28] exhibit one medium intensity band at *ca.* 1624 cm^{-1} assignable to ν(C=N) which shifts to lower frequency (15-21 cm^{-1}) in the macrocyclic Zn(II) complexes and this change confirms the coordination of azomethine nitrogen to zinc ion by the appearance of a band at *ca.* 442-474 cm^{-1} attributed to ν(Zn-N). The acyclic ligands [27,28] exhibit a broad band at *ca.* 2705 cm^{-1} due to intramolecular hydrogen bonded –OH group which vanishes in their corresponding macrocyclic Zn(II) complexes which is confirmed by appearance of band at *ca.* 541-491 cm^{-1} assignable [29] to ν(Zn-O).

A broad band in the region *ca.* 3433-3406 cm^{-1} confirms the presence of coordinated water molecules in the macrocyclic complexes which is assisted by two weaker bands in the region *ca.* 810-747 and *ca*. 743-721 cm^{-1} due to (-OH) rocking and wagging modes of vibrations, respectively [29]. The existence of an ionic-acetate [30,31] groups in the macrocyclic Zn(II) complexes is confirmed by the appearance of an asymmetrical stretching band at *ca.* 1645-1623 cm^{-1} and a weak symmetrical stretching band at *ca.* 1426 cm^{-1}. Difference of nearly more than 150 cm^{-1} between the asymmetrical and symmetrical stretching vibration of the acetate ion confirms the monodentate nature of the acetate ion [32].

Proton magnetic resonance spectra: Acyclic ligands exhibit signal at *ca*. 10.54 ppm due to phenolic protons which vanishes in the corresponding macrocyclic zinc(II) complexes. A multiplet at *ca.* 7.14-7.65 ppm in the spectra of the macrocyclic zinc(II) complexes is due to aromatic protons. Free Schiff bases exhibit signals at *ca.* 9.46 and 8.01 ppm due to hydrazino NH and azomethine protons, respectively, out of which the first signal remains almost at same position while second signal shifts downfield in the spectra of corresponding macrocyclic Zn(II) complexes. The downfield shift of second signal at *ca.* 8.11 ppm reveals the drainage of the azomethine nitrogen to the central metal ion. A signal is observed at *ca.* 2.31 ppm indicating the presence of acetate ion in the macrocyclic Zn(II) complexes. A new signal at *ca.* 5.6 ppm in the spectra of all macrocyclic Zn(II) complexes is due to coordinated water protons.

^{13}C NMR spectra: Acyclic ligands show signal at *ca.* δ 167 for their azomethine carbons, which shifts downfield at *ca.* δ 155 in their corresponding macrocyclic Zn(II) complexes due to coordination with the azomethine nitrogen. Free acyclic ligands and their corresponding macrocyclic Zn(II) complexes exhibit signals at *ca.* δ 152 and δ 158 attributed to the triazole ring carbons. Acyclic ligands and their corresponding macrocyclic zinc(II) complexes show a signal at δ 23 and δ 69 assignable to methylene carbons. Two signals at *ca.* 21 and 175 ppm corresponds to the acetate ion carbons in the macrocyclic Zn(II) complexes. A number of signals were observed at δ 115-137 in the spectra assignable to the aromatic rings.

Thermal analysis: In order to investigate the thermal stability of the macrocyclic complex $[Zn(M^1)(H_2O)_2](CH_3COO)_2$, thermogravimetric analysis (TGA-DTG) was carried out upto 736 °C. The thermogram for the complex displays that there is no loss of weight upto 138 °C. Weight loss in the range 138-175 °C is assignable to the loss of coordinated water molecules while gradual weight loss in the range 310-560 °C is attributable to the complete decomposition of Schiff bases around the zinc ion and the complex was converted into 10.47% (calc. 10.54%) zinc oxide as final residue.

SEM: The SEM studies were carried out in order to analyze the surface morphology of the selected macrocyclic complex $[Zn(M^1)(H_2O)_2](CH_3COO)_2$ and the micrograph (Fig. 1) shows nano-ranged globular particles with irregular arrangement.

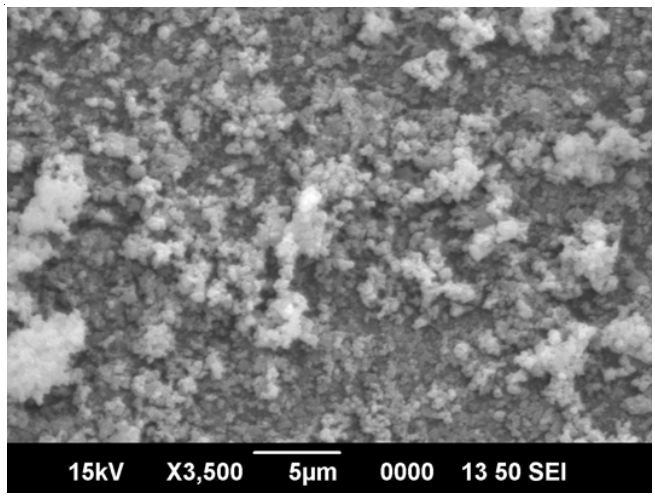


Fig. 1. SEM image of complex $[Zn(M^1)(H_2O)_2](CH_3COO)_2$

X-ray diffraction study: The XRD pattern of the complex $[Zn(M^1)(H_2O)_2](CH_3COO)_2$ (Fig. 2) clearly indicates the formation of nano-crystal which have been determined by Debye-Scherer equation [33,34] ($D = 0.94\lambda/\beta \cos\theta$). The size of the particles was found to be in the range 31 to 35 nm which falls in the nano range.

Biological studies of zinc(II) complexes: All the Zn(II) complexes were found to be more toxic than the corresponding ligands and the reason behind the increased toxicity of the complexes can be explained by chelation theory. According to which chelation reduces the polarity of the central metal

TABLE-1
ANTIFUNGAL SCREENING DATA OF ZINC(II) COMPLEXES

Compound	% Inhibition Compound dose (ppm)					
	A. niger			*A. alternata*		
	10	100	1000	10	100	1000
$[Zn(M^1)(H_2O)_2](CH_3COO)_2$	27	40	61	–	–	25
$[Zn(M^2)(H_2O)_2](CH_3COO)_2$	29	45	64	15	31	45
$[Zn(M^3)(H_2O)_2](CH_3COO)_2$	21	38	56	–	–	–
$[Zn(M^4)(H_2O)_2](CH_3COO)_2$	25	41	61	–	21	35
$[Zn(M^5)(H_2O)_2](CH_3COO)_2$	38	50	66	–	–	32
$[Zn(M^6)(H_2O)_2](CH_3COO)_2$	40	52	74	25	50	57
$[Zn(M^7)(H_2O)_2](CH_3COO)_2$	36	48	59	–	44	34
$[Zn(M^8)(H_2O)_2](CH_3COO)_2$	37	51	62	21	35	49
Fluconazole	100	100	100	100	100	100

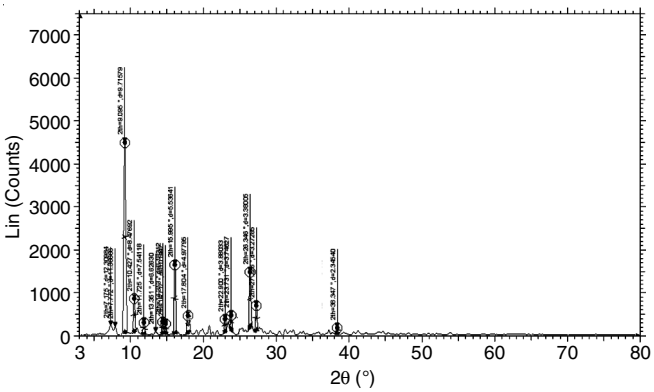


Fig. 2. XRD pattern of complex $[Zn(M^1)(H_2O)_2](CH_3COO)_2$

ion and it facilitates the permeation of the complex through lipid layer of cell membranes.

in vitro Antifungal effect of all the synthesized compounds was studied against *A. niger* and *A. alternata*, using fluconazole as standard drug and the results were recorded in percentage of inhibition at 1000, 100 and 10 ppm concentration. The activity of ligands enhances upon complexation and toxicity also increases with increase in concentration of the compound. Antifungal results show that all the Zn(II) complexes are more toxic to *A. niger*.

The antibacterial studies were evaluated against the bacterial strains *E. coli* and *B. subtilis*, using tetracycline as standard and the results were obtained by measuring the diameter of zone showing complete inhibition (mm). The antibacterial results indicate that all the Zn(II) complexes were more effective against *E. coli*. The effective antifungal and antibacterial activity of complexes with chloro group in phenyl ring are more toxic than the other complexes (Tables 1 and 2).

Conclusion

The complexes containing N_2O_2 type macrocyclic ligands were synthesized from Schiff bases derived from 3-(phenyl/substituted phenyl)-4-amino-5-hydrazino-1,2,4-triazoles, salicyldehyde/2-hydroxy-1-naphthaldehyde and 1,4-dibromobutane/1,5-dibromopentane in presence of Zn^{2+} ion. A distorted octahedral geometry of complexes has been proposed by the spectral data while the presence of coordinated water molecule was confirmed by TG analysis. XRD studies confirmed that the complexes are in nano-range and have monoclinic crystal system. The zinc(II) complexes show good antifungal and antibacterial activities due to chelation effect and compounds containing chloro group are found to be more toxic.

TABLE-2
ANTIBACTERIAL SCREENING DATA OF ZINC(II) COMPLEXES

Compound	Zone of inhibition (mm)	
	E. coli	*B. subtilis*
$[Zn(M^1)(H_2O)_2](CH_3COO)_2$	15	12
$[Zn(M^2)(H_2O)_2](CH_3COO)_2$	13	11
$[Zn(M^3)(H_2O)_2](CH_3COO)_2$	12	9
$[Zn(M^4)(H_2O)_2](CH_3COO)_2$	11	10
$[Zn(M^5)(H_2O)_2](CH_3COO)_2$	17	13
$[Zn(M^6)(H_2O)_2](CH_3COO)_2$	19	15
$[Zn(M^7)(H_2O)_2](CH_3COO)_2$	15	11
$[Zn(M^8)(H_2O)_2](CH_3COO)_2$	16	10
Tetracyclin	28	25

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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