Indian Journal of
Advances in Chemical Science

Article

Study of Electrical and Thermal Properties of Triazine Schiff's Base Complexes with Transition Metal(II) Ions

Kukalkar Madhuri, Murhekar Gopalkrushna

Organic Synthesis Division, Department of Chemistry, Government Vidarvha Institute of Science and Humanities Amravati, Maharashtra, India

ABSTRACT

In this investigation, the electrical and thermal properties of newly synthesized Schiff bases from TRIPOD with different substituted aniline and complexes of TRIPOD-SBNA with transition metal(II)ions were studied. An examination of the thermograms of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II)complexes indicates that they are with varying thermal stability undergoing decomposition at different temperatures. Their percent weight loss as computed from the thermograms suggests that the final product of decomposition in them corresponds to respective metal oxide. Further, the thermogravimetric results offer supports to the composition of the complex polymer conjugates. The electrical conductivity of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes showed a tendency to increase by increasing the temperature upto 407 K and indicates their semiconducting behavior.

Key words: Complexes, TRIPOD, Tripodal Schiff's Bases, TRIPOD-SBNA.

1. INTRODUCTION

1,3,5-triazine is a very important class of six-membered aromatic heterocyclic compounds receiving much attention in scientific research [1]. There has been a growing interest on synthesis, structural studies, and applications of transition metal complexes of substituted Triazines due to their interesting electronic and optical features with excellent pharmacological properties [2-6]. A further interesting aspect of S-Triazine is the redox properties, which makes 2,4,6-trisubstitutedtriazines as important building blocks in electronic and polymeric materials. With a delocalized electron system Triazine based ligands have been studied as materials for non-linear optical applications. On the basis of the above-mentioned background in this investigation, the electrical and thermal and properties of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II)complexes were studied [2,6-11].

2. MATERIALS AND METHODS

In this work, the electrical thermal and properties of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II)complexes were studied. It is discussed one by one in detail.

2.1. Electrical Properties of Tripod Schiff's Bases

The possibility of improving the conductivity of heterocyclic compounds, which are conventionally insulators, to metallic levels has attracted not only chemists but also physicists and even material scientists. Many researchers have tried to combine the process ability and other attractive properties of heterocyclic compounds with the electronic properties of metals or semiconductors. Conducting polymers are different from electrically conductive polymers as they are conductive only if the individual conductive particles are in contact and form a coherent phase [12]. For significant electrical conductivity in heterocyclic compounds, there has to be the correct combination of both structural and electrical features.

The shape of the heterocyclic compounds must be such that extensive inter-complex interaction can occur in solid state. Electron transport will be facilitated by the close approach of the matrix and therefore the absence of bulky non-electrolytic polymer is an advantage. Detailed structural studies have shown the importance of inters tack interaction (e.g. H-bonded, polymer-polymer bonding) in stabilizing these structures and these interactions can also have an important role on the electrical conduction properties. Heterocyclic compounds can conveniently be divided into two categories: semiconductor and metallic behavior.

Semiconductor type behavior: Semiconductors are characterized by relative low conductivity and a positive temperature-dependent conductivity. The most heterocyclic compounds exhibit detectable electrical conductivity belonging to this class. The temperature dependence of the conductivity is given by:

$$\sigma = \sigma_0 \exp[-Ea/kT]$$

Where σ is the conductivity
Ea is the thermal activation energy for the electrical conduction,
σ_0 is the parameter depending on the semiconductor nature and
k is the Boltzmann constant.

***Corresponding author:**
E-mail: gopalmurhekar@gmail.com

ISSN NO: 2320-0898 (p); 2320-0928 (e)
DOI: 10.22607/IJACS.2022.1001002

Received: 20th September 2021;
Revised: 20th December 2021;
Accepted: 02nd January 2022

The electrical conductivity of the heterocyclic compounds has a positive temperature coefficient. That is, with the increase in temperature, conductivity increases exponentially. The increase starts when charge carriers have enough activation energy. Also, during the increase of temperature, the mobility of these carriers increases. This is a property of typical semiconductivity. The temperature dependence of semiconductors has the general form

$$\sigma = \sigma_0 \exp [-Ea/kT]$$

Where Ea is the thermal activation energy for the electrical conduction, σ_0 is the parameter depending on the semiconductor nature and k is the Boltzmann constant.

A versus 1000/T yields a straight line whose slope can be used to determine the σ A plot of ln thermal activation energy of the heterocyclic compounds (Triazines).

3. EXPERIMENTAL PROCEDURE

Voltage drop method was used for the measurement of the resistance of pellet using a Systronic microvoltmeter as a function of temperature in the range 1V to 100 V. The connecting wires of the sample holders from the furnace were connected to the two terminals of the instrument. In this way, the corresponding resistance (R) of the pellet was measured directly by keeping the pellet in the sample holder.

$$R = \left(\frac{V_T - V_R}{V_R}\right) \times 10^{-5}\,\Omega$$

Where, V_T = total voltage range applied
V_R = actual voltage across resistance
R = resistance of the pellet.
Resistivity (ρ) was then calculated using the relation

$$\rho = (R \times A)/t$$

Where, A = surface area of pellet
t = thickness of pellet

The electrical conductivity (σ) varies exponentially with the absolute temperature according to well-known relation

$$\sigma = \sigma_0 \exp(-Ea/kT)$$

Where, σ = electrical conductivity at temperature T
σ_0 = electrical conductivity at temperature T = ∞
Ea = activation energy of electrical conduction
k = Boltzmann constant of electrical conduction
T = absolute temperature

This relationship has been modified as -

$$\log\sigma = \log \sigma_0 + [-Ea/2.303\ kT]$$

According to this relation, a plot of a log σ versus 1/T would be linear with a negative slope. The slope of the straight-line part of the plot ln σ versus 1000/T has been used in determining the thermal activation energies of the polymer conjugates. Such plots were made on the basis of each set of data. The plots of temperature dependence of electrical conductivity of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes have been drawn.

The d. c. electrical resistivity was determined as a function of temperature in the range 305 K ≤ T ≤407 K. The results of electrical conductivity and activation energy are incorporated in Table 1. The temperature dependence of the electrical conductivity of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes are shown in Figure 1.

Table 1: Electrical conductivity and activation energy TRIPOD compounds.

S. No.	Samples	σ ($\Omega^{-1}cm^{-1}$)	Ea (eV)
1.	TRIPOD	1.17×10^{-7}	0.579
2.	TRIPOD-SBNA	5.42×10^{-7}	0.878
3.	TRIPOD-SBCA	3.19×10^{-7}	0.873
4.	TRIPOD SBNA-Co (II)	4.88×10^{-7}	0.897
5.	TRIPOD SBNA-Ni (II)	5.57×10^{-7}	0.711
6.	TRIPOD SBNA-Cu (II)	6.53×10^{-7}	0.879

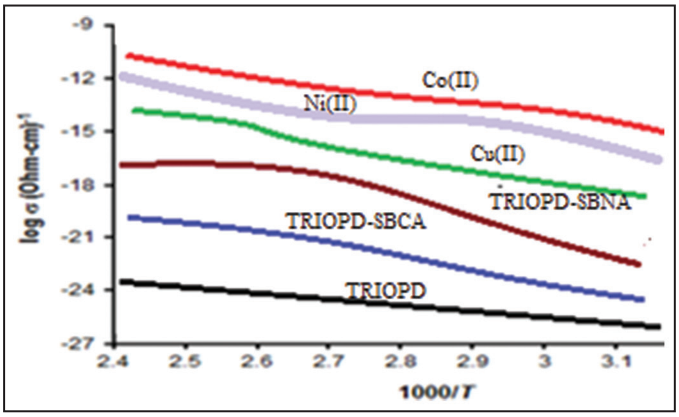

Figure 1: Plot of log σ*vs*1000/*T* for TRIOPD compound.

4. RESULTS AND DISCUSSION

4.1. Electrical Conductivity of Schiff Bases and Complexes Synthesized from TRIPOD

The electrical conductivity and activation energy of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal (II) complexes are cited in Table 1 and the temperature dependence of log σ of these compounds is shown in Figure 1.

It is observed that,

1. The plots of log σ versus 10^3/T are found to be linear in the studied temperature range 305-407 K [13,14]
2. Electrical conductivity of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes lies in the range of 1.17×10^{-7}–$6.53 \times 10^{-7}\ \Omega^{-1}cm^{-1}$
3. The electrical conductivity of these Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal (II) complexes follows the order, TRIPOD <TRIPOD-SBCA<TRIPODSBNA-Co(II)<TRIPOD- SBNA< TRIPOD SBNA-Ni(II) <TRIPODSBNA-Cu(II)
4. The activation energy of electrical conduction of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes has been found to increase in the order, TRIPOD <TRIPODSBNA-Ni(II) < TRIPOD-SBCA < TRIPOD-SBNA< TRIPODSBNA-Cu(II) <TRIPODSBNA-Co(II).

4.2. Thermal Properties of Tripod Schiff 'S Bases

This part of chapter deals with the thermal properties of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes. Thermal

Table 2: Thermal data of TRIPOD-Schiff's bases.

Samples	Half decomposition temperature (°C)	Activation energy (KJ/mole)	Frequency factor Z (s^{-1})	Entropy change –ΔS (J/mol/K)	Free energy change ΔG (k J/mol)
TRIPOD	275	73.00	16.17	951	545.43
TRIPOD- SBNA	532	27.11	27.41	236.27	145.47
TRIPOD- SBCA	396	35.98	80.31	295.35	127.98
TRIPOD SBNA-Co (II)	616	23.42	155.70	211.85	159.27
TRIPOD SBNA-Ni (II)	337	19.15	147.39	208.27	80.97
TRIPOD SBNA-Cu (II)	614	23.23	156.09	210.73	158.97

analysis is a branch of material science where the properties of material are studied as they change with temperature.

The TGA technique finds wide applications, especially in analytical chemistry. Qualitative and quantitative analysis for wide range of sample types, especially for inorganic materials. Kinetic studies where weight changes can be clearly attributed reactions, volatilizations, and adsorption and desorption may be studied. There are three types of thermogravimetry.

In the present investigation, non-isothermal or dynamic thermogravimetric analysis is carried out for thermal analysis of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes. During the thermal analysis of the compounds. The following types of reaction may generally occur.

4.3. Determination of Water Molecules from Thermal Decomposition

The TG data gives important information about stoichiometry, thermal stability, and nature of water molecules. According to Nikolaev [17], water eliminated below 140°C can be considered as lattice (crystal) water and water eliminated above 150°C may be due to the coordinated to the metal ion.

4.4. Determination of Kinetic Parameters

In the present investigation, the Horowitz-Metzger method has been used for the evaluation of kinetic parameters of newly synthesized Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes.

4.5. Horowitz-Metzger Method

In the present investigation, the newly synthesized Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes were studied by thermogravimetric analysis to suggest the presence of water molecule (lattice/coordinated) and to compare the thermal stability of the compounds. The thermograms, gave information about its nature and percent weight losses at various temperatures. The kinetics of thermal decomposition steps were investigated by the non-isothermal method. Table 2 gives the results of the thermogravimetric analysis are discussed for each newly synthesized Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes [15,16].

4.6. Thermal Study of Tripod-Schiff's Bases

An analysis of the thermograms of all Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes as shown in Figure 2 and indicate that these Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal

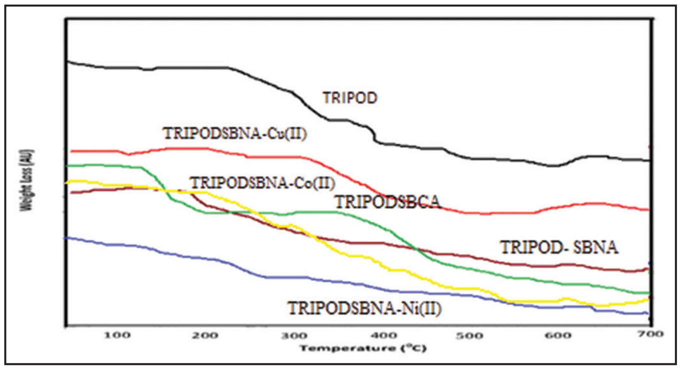

Figure 2: Thermograms of TRIPOD -Schiff's bases.

(II) complexes undergo single step decomposition after dehydration, while TRIPOD undergo two steps decomposition. In all the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes rapid weight loss has been observed.

On the basis of half decomposition temperature, the thermal stability order of compounds was found to be, TRIPOD <TRIPODSBNA-Ni(II) < TRIPOD-SBCA< TRIPOD-SBNA< TRIPODSBNA-Cu(II) <TRIPODSBNA-Co(II)

An examination of the thermogram of the Schiff's bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II)complexes indicates that they are with varying thermal stability undergoing decomposition at different temperatures. The percent weight loss as computed from the thermograms of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II) complexes suggests that the final product of decomposition in them corresponds to respective metal oxide. Further, the thermogravimetric results offer supports to the composition of the complex polymer conjugates. The value of thermodynamic parameters is nearly the same for each Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II) complexes. This similarity indicates that the basic steps involved in the thermal degradation of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II) complexes are the same. The negative values of apparent energy of activation indicate that the activated Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal(II) complexes have a more ordered or more rigid structure than the reactants or intermediates and the reactions are slower than normal [18,19].

5. CONCLUSION

From the results of electrical conductivity of all the polymer matrixes under investigation, the following conclusions can be drawn,

1. The electrical conductivity of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal (II) complexes showed a tendency to increase by increasing the temperature upto 407 K and obeyed log σ versus 1/*T* relation indicates their semiconducting behavior [20-23]
2. The variation in the electrical conductivity and activation energy of electrical conduction with the metal ions in TRIOPDSBNA complexes may be explained on the basis of influence of the incorporation of different metal ions in the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal (II) complexes which increases the ionization tendency [24]
3. Activation energy is a direct measure of the band gap of semiconductors, lower the activation energy, lower will be the band gap [25-28].

An examination of the thermogram of the TRIPOD compounds indicates that they are with varying thermal stability undergoing decomposition at different temperatures. The percent weight loss as computed from the thermograms of the complex TRIPOD compounds suggests that the final product of decomposition in them corresponds to respective metal oxide. Further, the thermogravimetric results offer supports to the composition of the complex TRIPOD compounds. The value of thermodynamic parameters is nearly the same for each TRIPOD compounds. This similarity indicates that the basic steps involved in the thermal degradation of TRIPOD compounds are the same. The negative values of apparent energy of activation indicate that the activated TRIPOD compounds have a more ordered or more rigid structure than the reactants or intermediates and the reactions are slower than normal [29-33]. In the present investigation, synthesis and characterization of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes have been attempted due to their wide range of applications in various fields science. The present investigation is summarized in the form of the following conclusions, Electrical properties show that the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes is semiconductor nature. The thermogram of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes indicate that they have varying degree of thermal stability and undergo decomposition at different temperatures. The percent weight loss as computed from the thermograms of the Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD-SBNA with transition metal (II) complexes suggest that the final product of decomposition in them corresponds to respective metal oxide. Further, the thermogravimetric results offer supports to the composition of Schiff bases synthesized from TRIPOD with different substituted aniline and ligand TRIPOD- SBNA with transition metal (II) complexes. The experimental studies in the present investigation show that the use of TRIPOD-SBNA and TRIPOD-SBCA brings some changes in structure and enhance electrical properties, thermal stability, properties of the TRIPOD compounds [34-38].

6. ACKNOWLEDGMENT

We would like to express our sincere gratitude to Department of Chemistry, Govt.V.I.S.H. Amravati for providing research and library facilities.

7. REFERENCES

1. G. Blotny, (2006) Recent applications of 2,4,6-trichloro-1,3,5-triazine and its derivatives in organic synthesis, ***Tetrahedron,* 62**: 9507-9522.
2. A. Diaz-Ortiz, J. Elguero, C. Foces-Foces, A. de la Hoz, A. Moreno, S. Moreno, A. Sanchez Migallon, G. Valiente, (2003) Synthesis, structural determination and dynamic behavior of 2-chloro-4,6-bis(pyrazolylamino)-1,3,5-triazines, ***Organic and Biomolecular Chemistry***, **1**: 4451-4457.
3. A. Díaz-Ortiz, J. Elguero, A. de la Hoz, A. Jimenez, A. Moreno, S. Moreno, Sanchez A. Migallon, (2005) Microwave-assisted synthesis and dynamic behaviour of N^2,N^4,N^6-Tris(1***H***-pyrazolyl)-1,3,5-triazine-2,4,6-triamines, ***QSAR and Combinatorial Science***, **24**: 649-659.
4. B. T. Pelado, J. R. Ramírez, A. Sanchez-Migallon, (2014) Green synthesis of 1,3,5-triazines with applications in supramolecular chemistry and materials chemistry, ***Journal of Heterocyclic Chemistry,* 2**: 308.
5. P. DeShong, (2006) Protecting Groups, 3rd Edition By Philip J. Kocienski (University of Leeds). Georg Thieme Verlag: Stuttgart, New York. 2005. xvi + 679 pp. $89.95. ISBN 3-13-135603-0, ***Journal of the American Chemical Society***, **128(21)**: 7111-7112.
6. E. Hollink, E. E. Simanek, D. E. Bergbreiter, (2005) Strategies for protecting and manipulating triazine derivatives, ***Tetrahedron Letters***, **46**: 2005-2008.
7. C. Capasso, C. T. Supuran, (2015), An overview of the selectivity and efficiency of the bacterial carbonic anhydrase inhibitors, ***Current Medicinal Chemistry***, **22**: 2130-2139.
8. I. Ghiviriga, D. C. Oniciu, (2002) First synthesis, rotamerism and herbicidal evaluation of substituted s-triazines with serinolic fragment, Chemical Communications, **2002**: 2718-2719.
9. A. J. Kirby, (1997) Efficiency of proton transfer catalysis in models and enzymes. ***Accounts of Chemical Research***, **30**: 290-296.
10. N. Hussain, G. L. Talesara, (2009) Synthesis and antimicrobial activity of some new phthalimidoxy derivatives of triazine containing pyrimidine and isoxazole, Journal India Council Chemical, **26(1)**: 31.
11. Z. Brozowski, M. Gdaniec, (2000), Synthesis, structural characterization and antitumor activity of novel 2,4-diamino-1,3,5-triazine derivatives, ***European Journal of Medicinal Chemistry***, **35(12)**: 1053-1064.
12. Y. A. Al-Soud, M. N. Al-Dweri, N. A. Al-Masoudi, (2004) Synthesis, antitumor and antiviral properties of some 1,2,4-triazole derivatives, ***Farmaco***, 59(10): 775.
13. T. Nagata, Y. Obora, (2020), Transition metal mediated/catalyzed synthesis of pyridines, pyrimidines, and triazines by [2+2+2] cycloaddition reactions, ***Asian Journal of Organic Chemistry***, **9(10)**: 1532-1547.
14. F.A. El-Samahy, A. M. Abd Elkarim, M. El-Sedik, A. H. Salama, F. H. Osman, (2017) Some dielectric properties of novel nano-s-triazine derivatives, ***Journal of Physical Organic Chemistry***, **30(23)**: 3703.
15. K. M. Khan, S. Rahat, M. I. Choudhary, (2002) Synthesis and biological screening of 2-substituted 5,6-dihydro-5-oxo-4H-1,3,4-oxadiazine-4-propanenitriles and of their intermediates, ***Helvetica Chimica Acta***, **85(2)**: 559-570.
16. T. Carofiglio, A. Varotto, U. Tonellato, (2004) One-pot synthesis of cyanuric acid-bridged porphyrin-porphyrin dyads, ***The Journal of Organic Chemistry***, **69(23)**: 8121-8124.
17. T. J. Mooibroek, P. Gamez, (2007) The s-triazine ring, a remarkable unit to generate supramolecular interactions, ***Inorganica Chimica Acta***, **360(1)**: 381-404.
18. J. R. Porter, S. C. Archibald, J. A. Brown, K. Childs, D. Critchley,

J. C. Head, J. C. Head, B. Hutchinson, T. A. H. Parton, M. K. Robinson, A. Shock, G. J. Warrellow, A. Zomaya, (2002) Discovery and evaluation of N-(triazin-1, 3, 5-yl) phenylalanine derivatives as VLA-4 integrin antagonists, ***Bioorganic and Medicinal Chemistry Letters***, **12(12)**: 1591-1594.

19. B. L. Mylari, G. J. Withbroe, D. A. Beebe, N. S. Brackett, E. L. Conn, J. B. Coutcher, P. J. Oates, W. J. Zembrowski. (2003) Design and synthesis of a novel family of triazine-based inhibitors of sorbitol dehydrogenase with oral activity: 1-{4-[3R, 5S-dimethyl-4-(4-methyl-[1, 3, 5] triazin-2-yl)-piperazin-1-yl]-[1, 3, 5] triazin-2-yl}-(R) ethanol. ***Bioorganic and Medicinal Chemistry***, **11(19)**: 4179-4188.
20. B. Klenke, M. Stewart, M. P. Barrett, R. Brun, I. H. Gilbert, (2001) Synthesis and biological evaluation of s-triazine substituted polyamines as potential new anti-trypanosomal drugs, ***Journal of Medicinal Chemistry***, **44(21)**: 3440-3452.
21. G. D'Atri, P. Gomarasca, G. Resnati, G. Tronconi, C. Scolastico, C. R. Sirtori, (1984) Novel pyrimidine and 1, 3, 5-triazine hypolipemic agents, ***Journal of Medicinal Chemistry***, **27(12)**: 1621-1629.
22. A. Agarwal, K. Srivastava, S. Puri, P. M. Chauhan, (2005) Syntheses of 2, 4, 6-trisubstituted triazines as antimalarial agents, ***Bioorganic and Medicinal Chemistry Letters***, **15(3)**: 531-533.
23. K. Srinivas, U. Srinivas, V. J. Rao, K. Bhanuprakash, K. H. Kishore, U. Murty, (2005) Synthesis and antibacterial activity of 2, 4, 6-tri substituted s-triazines, ***Bioorganic and Medicinal Chemistry Letters***, **15(4)**: 1121-1123.
24. G. A. McKay, R. Reddy, F. Arhin, A. Belley, D. Lehoux, G. Moeck, (2006) Triaminotriazine DNA helicase inhibitors with antibacterial activity, ***Bioorganic and Medicinal Chemistry Letters***, **16(5)**: 1286-1290.
25. A. Ghaib, S. Menager, P. Verite, O. Lafont, (2002) Synthesis of variously 9, 9-dialkylated octahydropyrimido [3, 4-a]-s-triazines with potential antifungal activity, ***Farmaco***, **57(2)**, 109-116.
26. C. Zhou, J. Min, Z. Liu, A. Young, H. Deshazer, T. Gao, (2008) Synthesis and biological evaluation of novel 1, 3, 5-triazine derivatives as antimicrobial agents, ***Bioorganic and Medicinal Chemistry Letters***, **18(4)**: 1308-1311.
27. Z. E. Koc, H. Bingol, A. O. Saf, E. Torlak, A. Coskun, (2010) Synthesis of novel tripodal-benzimidazole from 2, 4, 6-tris (p-formylphenoxy)-1, 3, 5-triazine: Structural, electrochemical and antimicrobial studies, ***Journal of Hazardous Materials***, **183(1)**: 251–255.
28. N. Desai, A. H. Makwana, K. Rajpara (2016) Synthesis and study of 1, 3, 5-triazine based thiazole derivatives as antimicrobial agents, ***Journal of Saudi Chemical Society***, **20**: S334-S341.
29. S. Vembu, S. Pazhamalai, M. Gopalakrishnan, (2015) Potential antibacterial activity of triazine dendrimer: Synthesis and controllable drug release properties. ***Bioorganic and Medicinal Chemistry***, **23(15)**, 4561–4566.
30. A. B. Patel, K. H. Chikhalia, P. Kumari, (2014) An efficient synthesis of new thiazolidin-4-one fused s-triazines as potential antimicrobial and anticancer agents. ***Journal of Saudi Chemical Society***, **18(5)**: 646-656.
31. R. Shanmugakala, P. Tharmaraj, C. Sheela, (2014) Synthesis and spectral studies on metal complexes of s-triazine based ligand and non linear optical properties, ***Journal of Molecular Structure***, **1076**: 606-613.
32. R. P. Robinson, K. M. Donahue, (1994) Synthesis of *N*-alkoxycarbonyl and *N*-carboxamide derivatives of anti-inflammatory oxindoles, ***Journal of Heterocyclic Chemistry***, **31(6)**: 1541-1544.
33. G. Matela, R. Aman, C. Sharma, S. Chaudhary, (2013) Synthesis, characterization and antimicrobial evaluation of diorganotin (IV) complexes of Schiff base, ***Indian Journal of Advances in Chemical Science***, **3**: 157-163.
34. S. Vidyasagar Babu, K. Hussain Reddy, (2013) Second derivative spectrophotometric determination of copper (II) using 2-acetylpyridine semicarbazone in biological, leafy vegetable and synthetic alloysamples, ***Indian Journal of Advances in Chemical Science***, **1**: 105-111.
35. S. Vidyasagar Babu, K. Hussain Reddy, (2012) Direct spectrophotometric determination of mercury (II) using 2-acetylpyridine thiosemicarbazone in environmental samples, ***Indian Journal of Advances in Chemical Science***, **1**: 65-72.
36. S. Kondaiah, G. N. R. Reddy, D. Rajesh, J. Joseph, (2013) Synthesis, characterization, and antibacterial activity of the Schiff base derived from P-toluic hydrazide and o-vanilin (OVPTH ligand) and its Mn(II), Co(II), Ni(II) and Cu(II) complexes, ***Indian Journal of Advances in Chemical Science***, **1**: 228-235.
37. Z. Y. Peng, M. X. Wang, Y. Q. Luo, P. Liu, (2020) Selective homocysteine detection of nitrogen-doped graphene quantum dots: Synergistic effect of surface catalysis and photoluminescence sensing, ***Synthesizers Mater Aging***, **267**: 116432.
38. J. Xiao, S. Ren, Q. Liu, (2020) Atom-efficient synthesis of 2,4,6-trisubstituted 1,3,5-triazines via Fe-catalyzed cyclization of aldehydes with NH 4 I as the sole nitrogen source, ***RSC Advances***, **10(37)**: 22230-22233.

***Bibliographical Sketch**

Dr. Gopalkrushna Haribhau Murhekar, M.Sc, Ph.D,M.Phil, SET born in Akot, Akola (Dist), MS, India on 27-02-1981. Graduated in (2002) from Shivaji college Akot, MS, India and obtained M.Sc in Chemistry (2004) from Govt. V. I. S. H. Amravati, MS., India. Obtained Ph.D from SGBAU Amravati University Amravati MS, India in 2016 on the topic "Synthesis and characterization of Polyvinyl Alcohol Conjugates." working as Assistant professor at Govt. V. I. S. H. Amravati, 04 students are awarded Ph. D and 05 M. Phil, under her guidance and many more are doing research. Published around 45 research papers in national and international journals. He was a recipient of Warden of boys hostel, Her research interests are organic synthesis, Polymer drug delivery, heterocyclic chemistry, etc.