



Research Paper

Recent advances in biological and catalytic activities of schiff base containing acetylacetonate and their metal complexes-a short overview

Accepted 7th September, 2020

ABSTRACT

Acetylacetonate containing Schiff base and their metal complexes have a wide range of applications in microbiology as anti-microbial agents, the chemical industry as catalyst, and is an important chemical in cancer treatment. The extraordinary ligating properties of acetylacetonate enable them to form a large number of complex compounds with transition metals, a vast majority of which find abundant applications in potential areas. This has stimulated researchers to explore novel applications of the synthesized ligands and the metal complexes thereof. This review presents a report of the studies on the biological activities, anticancer properties, and catalytic activities of acetylacetonate and their metal complexes.

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Key words: Acetylacetonate, biological activities, anticancer properties, and catalytic activities.

INTRODUCTION

Preparation of Schiff base metal complexes received increasing interest owing to their versatile coordination behavior and in the understanding of molecular processes (Shamsipur et al., 2000; Reddy et al., 2015; Divya et al., 2017). Schiff base metal complexes are of noteworthy attention in terms of its structural and coordination chemistry. They show diverse chemical, optical and magnetic properties by tailoring with diverse ligands. In particular, the study of metal complexes of Schiff base (SB) ligands seems to be attractive in terms of uncommon structure and stability. SB complexes are considered to be among the most significant stereo chemical models in transition metal coordination chemistry due to their preparative accessibility and structural diversity (Qiu et al., 2001; Yang et al., 2001). Structurally, a Schiff base (SB) (also known as imine or azomethine) is a nitrogen analogue of an aldehyde or ketone in which the carbonyl group ($>C=O$) is replaced by an imine or azomethine group (Dos Santos et al., 2005). Schiff base metal complexes which typically contain nitrogen, sulphur or oxygen as ligand atoms have become progressively important because these SB can bind with different metal centre involving several coordination sites and permit successful synthesis of metal complexes

(Alexander, 1995) The extraordinary affinity for the chelation of the SB towards the transition metal ions is exploited in synthesizing their solid complexes (Quiroga et al., 2004). The interaction of these donor ligands and metal ions gives complexes of different geometries and literature survey exposes that these complexes are biologically active compounds (Asraf et al., 2019; Sarker et al., 2019; Sarke et al., 2019). Thus, currently, SB and their metal complexes have attained much attention of researcher because of their extensive biological activities (West et al., 1993; Wang and Guo 2006). The advances in inorganic chemistry deliver better openings to use SB metal complexes as therapeutic agents. Research has shown momentous improvement in utilization of SB transition metal complexes as drugs to treat numerous human diseases.

The use of SB transition metal complexes as therapeutic compounds has become more and more pronounced. Synthetic SB metal complexes are a developing class of compounds with varying chemistry, different molecular topologies and sets of donor atoms. It is a known fact that N atom plays a crucial role in the coordination of metals as the active site of numerous metallo biomolecules (West et al., 1993; Wang and Guo 2006; Babahan et al., 2013). These

Figure 1: Proposed structure of the ligands

complexes offer a great variety in their action; as antibacterial (Babahan et al., 2013; Ejike and Ajibade 2015; Patil et al., 2012), antifungal (Chohan et al., 2010; Jarrahpour et al., 2007), anticancer (Parashar et al., 1989; Gaowen et al., 1995) and anti-inflammatory agents (Karem et al., 2018; Blahova et al., 1994). Due to the appeal of new metal-based antibacterial compounds, Schiff base metal chemistry is becoming an emerging area of research. Schiff base metal complexes are efficient catalysts both in homogeneous and heterogeneous reactions (Asraf et al., 2019; Asraf et al., 2016; Asraf et al., 2015) and the activity of these metal complexes varied with the type of ligands, coordination sites and metal ions (Gupta and Sutar, 2008). Catalytic activities of Schiff base metal complexes are plentifully found in literature. In this regard, more selective behavior of Schiff base complexes has been observed for a number of reactions like hydroxylation, oxidation, epoxidation and aldol condensation. On the other hand, acetylacetone is an organic compound that excellently exists in two tautomeric forms that rapidly interconvert. It worked as a building block for the preparation of heterocyclic compounds. It may undergo condensation reaction between its ketone moiety and that of amine group of amino acid to form the desired ligand with azomethine (-HC=N-) linkage (Rehman et al., 2013). The chemistry of Schiff bases and their metal complexes have gained attraction of the interest of researchers despite their vast report in literature (Stănilă et al., 2011). These are connected to the adaptability of these compounds in inorganic synthesis as well as their several applications in biology (Tai et al. 1984), pharmacology (Da Silva et al., 2011) and industries (Kumar et al., 2009) etc. This review goes over the main biological and catalytic applications of

Schiff bases derived from acetylacetone and their complexes.

BIOLOGICAL ACTIVITY

Antibacterial activity

A series of amino acid-derived Schiff base (Figure 1) and their cobalt(II), copper(II), nickel(II), and zinc(II) metal complexes have been synthesized by Zahid et al. (2006). Ligands were derived by the condensation of β -diketones with glycine, phenylalanine, valine, and histidine and act as bidentate towards metal ions via the azomethine-N and deprotonated-O of the respective amino acid. All the synthesized ligands as well as the metal complexes (Figure 2) were tested for their antibacterial activity against six human pathogenic bacteria *Escherichia coli*, *Shigella flexeneri*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Bacillus subtilis* and *Staphylococcus aureus* bacterial strains and for in vitro antifungal activity against *Trichophyton longifusus*, *Candida albicans*, *Aspergillus flavus*, *Microsporium canis*, *Fusarium solani*, and *Candida glabrata*. The results of these studies show the metal (II) complexes to be more antibacterial/antifungal against one or more species as compared to the free ligands (Zahid et al., 2006). The Schiff base ligand was synthesized by the condensation of 4(diethyl amino)-2-hydroxy benzaldehyde (10mmol) and 4-nitrobenzohydrazine (10mmol) in methanol solvent by Charity et al. (2017). Complexation was performed with the synthesized ligand and cobalt (II), Manganese (II), Magnesium (II) salts of acetylacetone derived from metal hydroxide and acetylacetone. Potentiality of the

Figure 2: Proposed structure of the complexes.

Figure 3: 4-(2-hydroxyphenylimino) pentan-2-one.

Figure 4: 4-(Phenylimino)Pentan-2-One

synthesized ligand and complexes as antibacterial agent was assessed against two bacteria *Staphylococcus aureus* and *Enterococcus faecalis*.

The outcome of these studies demonstrated that Mn (II) complex show higher antibacterial activity than other

complexes and the ligand itself (Charity et al., 2017).The ligands were derived from acetyl acetone with aniline, 2-aminophenol, para anisidine and hydrazine hydrate (Figures 3 and 4) by the condensation method in methanolic solvent medium by Prasad et al. (2013). Further

Figure 5: Proposed structure of Zn complex

antibacterial and antifungal activity of these derived ligands have been evaluated against *Bacillus subtilis* and *candida*. It has been found that, among the synthesized ligands, 4-(phenylimino) pentan-2-one exhibit highest activity in both cases with respect to the other ligands. In addition to this it shows more activity against the selected bacteria and fungi species than the standard drug amoxicillin and moconazole respectively (Prasad et al., 2013). A series of ligands were derived from the Condensation of 2-hydroxy-1-naphthaldehyde or acetyl acetone with various amino-acids like; glycine, b-alanine, DL-valine, DL-4-aminobutyric acid, L-methionine, L-leucine and phenylglycine by Mala et al. (1997). Condensation of derived Schiff bases with dibutyltin(IV) oxide as 1:1 molar ratio gives complexes of dibutyltin(IV). An attempt has been made to test antibacterial and antifungal activity of the resulting complexes against some bacteria species *streptococcus faecalis*, *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and fungi species *candida albicans*, *Cryptococcus neoformans*, *Sporotrichum schenckii*, *Trichophyton mentagrophytes* and *Aspergillus fumigatu*.

The result of these studies have revealed that metal complexes that were synthesized from Schiff base of 2-hydroxy-1-naphthaldehyde and amino acids tend to exhibit greater activity towards the bacteria and fungi than which derived from the acetylacetone and amino-acids(Mala et al., 1997). Synthesis of the ligands was carried out via two steps by Wageih and Moawad. First step was followed by the formylation of 8-hydroxyquinoline -5-sulphonic acid according to Sein and Ray method and second step was the assymetric ligand formation step executed by the Diehi and Hach method. Metal complexes were prepared by adding aqueous solution of Co (II), Ni(II),Cu(II) perchlorates (0.001M) to the etanolic solution of ligands (0.001M) that was previously dissolved and NaOH (0.002M) was also added to make the ligands ionic. Antibacterial and antifungal activity of all the derived complexes, ligands and metal salts were done for comparative studies. It was accomplished on gram negative (*Sercinalueta*) and gram positive (*Escherichia coli*) bacteria and two fungi *aspergillous niger* and *candida albicans*. From the study of

Minimal Inhibitory Concentration (MIC) zone an assignment has been made that uncomplexed ligands show greater activity when it is complexed with the metal salts due to the chelate formation. Complexes in the form of chelate may penetrate the cell wall of fungi and converted to half chelate immediately by dissociation. Thus, half chelate might be a toxic component by binding or blocking the existing metal substances located on enzymes. From that point of view, Cu complex has the lowest MIC value (Waeigh and Mona 2001). Direct complexation was done by adding methanolic solution of acetylacetone to the solution of 2-aminopyridine and subsequent addition of Zinc-acetate (di-hydrated) salt (Figure 5) followed by the condensation for few hours by Jafari et al. (2018).

The complex compound was then subjected to investigate antibacterial activity against four pathogenic bacteria. The selected species under test were *Bacillus subtilis* (Gram positive), *Staphylococcus aureus* (Gram-positive), *Enterobacter cloacae* (Gram-negative), and *Escherichia coli* (Gram-negative). From the values of Minimal Inhibitory Concentrations (MIC) and Mnimum Inhibitory Concentrations(MBC) it has been concluded that synthesized complex has remarkable activity against all the bacteria in concentration range over $150-325\mu\text{g ml}^{-1}$ at 37°c (Jafaria et al., 2018). The Schiff base ligand, Tris[(4-hydroxy-pentenylidene-2imino)-ethyl]amine was prepared from acetylacetone and tris(2-aminoethyl)amine and Fe(III), Ni(II), and Mn(III) complexes were prepared by Roya and Sara, (2015). Antibacterial activity of the derived complexes were evaluated against both of the Gram-negative bacteria; *Escherichia coli*, *Pseudomonas aeruginosa* and Gram-positive bacteria; *Staphylococcus aureus*, *Bacillus cereu*. The outcome of these studies have indicated that metal complexes were more potent as antibacterial agent as compared to the ligand. Even the complexes have comparable potentiality against all the bacteria with respect to standards used; Choloramphenicol, Ampicilin (Roya and Sara 2015). Schiff base ligand was synthesized from thiosemicarbazide and 2,6-diace- tylypyridine and then complexation of ligand with Pd(II), Pt(II), Rh(III) and Ir(III) metal salts was performed by Monika and Sulekh, (2012). Antifungal and antibacterial activity of all the synthesized

Figure 6: Structure of the ligand.**Figure 7:** Proposed structure of Cu, Cd and Hg complexes.

compounds, ligand and metal salts were tested for the sake of comparative studies against some common bacteria; *S.aureus*, *E.coli* and fungi; *A. niger*, *A. fumigates* *Fusarium modum*. Upon conclusion it has been suggested that metal complexes has higher activity than free ligand and metal salts and it also indicated that pd complex show better activity as compared to the other complexes. Advancement in activity was explained on the basis of Chelation Theory.

Polarity of the central metal atom reduced through the interaction with donor atoms upon chelation. Subsequently the enhanced lipophilic nature of corresponding metal atoms that facilitate penetration through the lipid layer of the microbe cell membrane (Monik and Sulekh , 2012). Schiff base ligands derived from acetylacetone and aromatic aldehydes (benzaldehyde), cinnamaldehyde and transition metal complexes of ligands with Cu(II), Ni(II), Co(II) chloride salts have been synthesized with the aid of condensation in ethanol by Sumathi et.al.(2011). Biological activities of all the complexes, ligands and salts were tested against bacteria and fungus (*P. aeruginosa*, *S. aureus*, *E. coli*, *C. albicans*) using Amikacin and ketoconazole as reference

standard. Result of these studies have indicated that derived complexes show more activity in opposition to fungus and bacteria than the ligands. Chelation was said to be the reason of enhance activity of complexes. Neither of the complexes nor ligands were active than the used standard drugs (Sumathi et al., 2011). A Schiff base was prepared from acetyl acetone and leucine then Complex of the ligand was derived from condensing with cobalt (II) chloride salt (Mohammed et al., 2017). Antifungal activity was evaluated for both of the ligand and complex against, *C. albican and*, *Sacchromyces cerevisiae*. It has been suggested that Co complex was potentially active against the organisms used both the moderate and excess concentrations. On the contrary, ligand shows no resistant behavior towards the selected pathogens. A new Schiff base ligand (Figure 6) was derived from naphthofuran-2-carbohydrazide and diacetylmonoxime (derivative of acetylacetone).

Complexation of the synthesized ligand was carried out by refluxing chloride containing salts of Co(II), Ni(II), Cu(II), Cd(II), and Hg(II) (Figure 7) in ethanol by

Sumathi and Halli, (2014). Investigation of biological activities of the complexes and the ligand was performed against *E. coli*, *S. aureus*, *B. subtilis*, *P. aeruginosa* bacteria and *A. niger*, *A. flavus*, *Cladosporium oxysporum*, and *C. albicans* fungi. From the studies it was implied that the complexes show better biological activity in contrast to the ligand. Specifically, complex of Cd(II) and Hg(II) have shown maximum resistant to the subjected pathogens as compared to the remaining complexes, since lipophilic nature of the complexes enhanced abruptly due to chelation (Sumathi and Halli 2014). Ethanolic solution of cobalt (II), nickel (II) hydrated salts have been added to the mixture of acetylacetone and 2-aminopyridine and the reaction mixture was refluxed to obtain complexes by Mehdi et al.(2019). The complexes were subjected to investigate antimicrobial activity against pathogenic bacteria; *S. aureus*, *B. subtilis* [Gram-positive], *E. coli*, *Enterobacter cloacae* [Gram-negative]. Chloramphenicol and kanamycin were also applied as standard drugs. From the experimental values of minimum inhibitory concentrations, a conclusion has been drawn that complexes show admissible antibacterial activity against the gram negative bacteria than gram positive and it also been illustrated Co(II) complex was good antibacterial agent rather than Ni(II) complex (Mehdi et al., 2019). Condensation of acetylacetone (10 mmol) and 4-hydroxy-3-methoxybenzaldehyde (10 mmol) in ethanol (40 ml) in the presence of piperidine (0.05 ml) was carried out to obtain 3-(4-hydroxy-3-methoxybenzyl) pentane-2, 4-dione. Knoevenagel condensate Schiff base ligand was derived by the further condensation of 3-(4-hydroxy-3-methoxybenzyl) pentane-2, 4-dione and 4- aminoantipyrine in ethanol by Rajakkani et al.(2017).

Chloride salts of Co(II), Ni(II), Cu(II) and Zn(II) were used for complex formation with the previously synthesized ligand. Biological efficiency of the complexes and ligand have been evaluated against bacteria and fungus. Two Gram-positive bacteria (*S. aureus* and *B. subtilis*) three Gram negative bacteria (*E. coli*, *Klebsiella pneumoniae* and *Salmonella typhi*) and five fungi (*A. niger*, *Fusarium solani*, *Curvularia lunata*, *Rhizoctonia bataticola* and *C. albicans*) were taken to undertake that test. From the studies of Minimum Inhibitory Concentration values it has been elucidated that complexes show potent activity than the free ligand. Furthermore, it assumed improve activity of complexes due to the chelation property (Rajakkani et al., 2017). The ligand was obtained from Benzidine (0.0051 moles) and acetylacetone (0.0102 moles) required amount of ethanol through refluxation. Ethanolic solution of metal; Cr(III), Fe(III), Co(II), Ni(II), Cu(II) and Zn(II) chloride salts were refluxed with the ligand (1:1 or 1:2 ratio) separately to synthesize complexes by Abdul hakim et al.. The authors mentioned that both the ligand and complexes had acceptable biological activities (Abdulhakim et al., 2008). Oxovanadium(IV) complexes were synthesized from Schiff base ligands which were obtained from acetyl acetone and

amino acids by Misbahur et al.(2013). In vitro antibacterial activity of the complexes and ligands were studied against two Gram-negative (*E. coli*, *Salmonella typhi*) and two Gram-positive (*B. subtilis*, *S. aureus*) bacterial species. In addition, *Trichophyton longifusus*, *C. albicans*, *A. flavus*, and *C. glabrata* species were used to study antifungal activity by disc diffusion method. Standard drug, chlorohenicol was also employed for activity comparison.

Evaluated data have revealed that complexes have higher activity than ligands but lower than the standard drug used and potent activity of complexes was presumed upon chelation (Misbahur et al., 2013). Cu(II), Ni(II) and Mn(II) complexes have been derived by the condensation of corresponding metal salts with Schiff base which was obtained from Phenylalanine and acetylacetone by Siraj and Sadiq. The ligand along with its synthesized metal (II) complexes were tested for their antibacterial activity against *S. aureus* (Gram-positive), *E. coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (Gram-negative) bacterial strains and antifungal activity against *C. albicans*, *F. solani* and *A. fumigatus* with the variation of concentrations. Tentative inhibition zone (mm) of Schiff base and the metal complexes ascertained to have potential antibacterial and antifungal resistance property at high concentrations. Especially, Cu(II) complex has highest inhibition zone against *S. aureus* and supposed to treat disease caused by it (Siraj and Sadiq, 2016).

Anticancer property

The ligand 2-hydroxy-N'-((Z)-3-(hydroxyimino)-4-oxopentan-2-ylidene) benzohydrazide (Figure 8) was derived from 2-Hydroxy benzohydrazide and diacetylmonoxime (a derivative of acetylacetone) in ethanol. A series of noble metal complexes (Figure 9) were synthesized by the condensation of copper(II), Nickel, cobalt(II), manganese(II), zinc(II) and cadmium(II), Mercury(II), and iron(II) acetate salts with H₂L by Abdoussaad et al.(2015). Cytotoxicity of ligand and the complexes were tested against human liver HepG₂ cancer cells and applied concentration range were 0.1–100 µg/L. IC₅₀ value was evaluated for each complexes as well as ligand in addition, Sorafenib (Nexavar) standard drug was also employed for comparative studies. From IC₅₀ values it was confirmed that ligand and its complexes (IC₅₀= 2.24–6.49 µM) have significant anticancer activity as compared to standard drug used. Beside this, Cu-complex has lowest IC₅₀ (2.24 µM) value which attributed to its highest anticancer property. Appreciable cytotoxic effect of the complexes was illustrated with the aid of Tweedy's chelation theory (Abdoussaad et al., 2015). Antitumor activities of Organotin(IV) Complexes were examined against (ID₅₀ values measured in ng ml⁻¹) against MCF-7 and EVSA-T (two breast cancers), WiDr (a colon cancer), IGROV (an ovarian cancer), M₁₉ MEL (a melanoma), A₄₉₈ (a renal

Figure 8: (E)-2-Hydroxy-N- ((Z)-3-(hydroxyimino)-4-oxopentan-2-ylidene) benzohydrazide Ligand.

Figure 9: Proposed structure of the complexes.

cancer) and H₂₂₆ (a lung cancer) of Bu₂SnL-1(I), Bu₂SnL-2(I), Bu₂SnL-6(II), Ph₂SnL-1(I) and Ph₂SnL-2(I). ID₅₀ values of clinically used compounds (Carboplatin, Cisplatin, 5-Fluorouracil, Methotrexate, Doxorubicin) and of tri-n-butyltin pentafluoro cinnamate were also evaluated. Evaluated ID₅₀ values have showed that all the complexes have higher activity against all the cell lines than of reference compounds, carboplatin and cisplatin. Moreover, Bu₂SnL-1(I), Bu₂SnL-2(I), Bu₂SnL-6(II) were considerably more active as compared to 5-fluorouracil but less active than methotrexate and doxorubicin. In addition, dibutyltin derivatives of the Schiff bases were found to be more effective anticancer agent than of which derived from diphenyltin.

In vitro cytotoxic activity of the synthesized compounds (Figure 10) were tested against a couple of cancer cell lines, MCF-7 and HeLa, and a couple of non-cancerous cell lines, NHDF and HEK, using MTT assay, cisplatin was used as standard (positive control). The cell lines were subjected to the synthesized compounds for 48 h at a range of concentrations (0–100 μM). IC₅₀ values (concentration of drug required to inhibit growth of 50% of

cancer cells) were calculated and results have revealed that Complexes (1–4) show acceptable cytotoxic activity against the experimental cell lines. IC₅₀ values of the complexes have been confirmed that, complex (1) was potentially stronger to inhibit the proliferation of HeLa and MCF-7 cells than cisplatin under same experimental conditions. Evaluated IC₅₀ values for complex 1 were found to be 18 and 16 μM whereas 22 μM and 26 μM for cisplatin that clearly indicating the anticancer activity of complex (1) is better than that of cisplatin. Specifically, results of in vitro cytotoxic activity indicate that the IC₅₀ values of the synthesized complexes against non-cancerous human cell lines (NHDF and HEK) are found to be above 72 μM which indicates that complexes (1–4) are very specific towards cancer cell lines only.

Catalytic activity

A number of acetylacetonate–metal salts [M(acac-py)₂][Cl₂] were derived by the reaction of 3-chlorine-acetylacetonate and pyridinium with Cu and Co acetate salts (Figure 11).

Figure 10: Knoevenagel condensate Schiff base complexes

Figure 11: Preparation of $[M(\text{acac-py})_2][\text{Cl}]_2$

The synthesized salts were subjected to the oxidation of cholesteryl acetate by Pengfei et al. (2011) (Figure 12). The catalytic oxidation of cholesteryl acetate (10 mmol) was performed in presence of (1 mmol) NHPI, 70 ml acetone, 10 ml of 1, 4-dioxane with the variation of catalyst amount. It has been found that Co-catalyst is more efficient than the Cu-catalyst. From the experimental data it has been

indicated that only 2% of $[\text{Co}(\text{acac-py})_2][\text{Cl}]_2$ as catalyst give highest yield of 7-ketocholesteryl acetate (Oxidised product of cholesteryl acetate) under mild condition. Moreover, Co catalyst was reproducible by water wash method and regenerated catalyst can be used at least four times (Pengfei et al., 2011). Chemically efficient copper amino acid Schiff Base Catalyst was prepared by Meizhu et

Figure 12: The oxidation of cholesteryl acetate.

al. (2008). The Cu-complex was used as catalyst for the oxidation of alcohols. Catalysis of benzyl alcohol (2 mmol), have been conducted by adding catalyst (0.02 mmol) and [bmim] BF₄ (1 mL) in a micro reactor under constant stirring for short time, followed by the addition of tert-butyl-hydroperoxide (10 mmol) and stirred for few seconds. Yield of the product (benzoic acid) was 88%. Apart from benzyl alcohol, the catalyst was also applied to the other alcohols and yield of product were more than 80%. It has been identified that, this catalyst can be recycled and reused for further reactions and able to show significant catalytic activity (Meizhu et al., 2008). Transition metals (Vanadium (III), chromium (III), manganese (II), manganese (III), iron (III), cobalt (II), nickel (II), copper (II), zinc (II), manganese (II) hexafluoro) complexes of Acetylacetonate were bought from Sigma-Aldrich but Iron (III) hexafluoro acetylacetonate was taken from Tokyo Kasei Kogyo Co. by Atsushisudo et al.. The complexes were then employed to the ring-opening polymerization of benzoxazine as catalyst.

The result of these studies has indicated that acetylacetonate complexes of manganese, iron, and cobalt have comparable or slightly higher activity exhibited by p-toluenesulfonic acid. The replacement of acac ligand by hexafluoro acetylacetonate (F₆-acac) ligand, markedly enhance the activity of manganese and iron complexes as it possessed through augmented Lewis acidity. The ability to tolerate moisture, high activity, and thermal stability of the formed poly (benzoxazine) were the reason for selecting F₆-acac complex of manganese as optimum catalyst (Atsushi et al., 2009). Supported transition metal oxide catalysts (Mo, Cu, V) were obtained by the molecular designed dispersion method by Baltes et al. (1999). The corresponding transition metal acetylacetonate complexes were interacted with silica or alumina, and converted into the supported metal oxide thermally. The deposition of these acetylacetonate complexes takes place in two ways, either liquid phase or gas phase. Between the two methods, gas phase pathway plays a pivotal role for the generation of new catalysts as it eliminates the solvent effect. Moreover the rate of deposition depends on the stability, geometry of

the precursor complexes along with the supported properties and the synthesis methods. The deposition can be controlled by maintaining temperature and the concentrations of supported materials. Therefore, regulation of the reaction parameters, the molecular designed dispersion process is a very promising route of designing a catalyst system that acted as robust catalyst (Baltes et al., 1999). To the suspended solution of amino functionalized silica gel (SiO₂-NH₂) (3.0 g) a mixture of acetyl acetone (10 mmol) and copper acetate (5 mmol) in ethanol (30 ml) was added and the resultant mixture was allowed to reflux for 5 h. The solid was isolated by the filtration followed by washing with hot ethanol in order to dispel the excess copper acetate.

The separated solid was kept under vacuum (at 60°C) to dry and marked as SiO₂-NH₂-Cu(II) by Anbarasu et al. The efficiency of synthesized silica functionalized Cu(II) Schiff base complex as a catalyst was assessed for the oxidative condensation reaction of benzyl alcohol in presence of different aromatic/aliphatic amine. An attempt has been taken to find the maximum yield of the product (imines compounds) by the variation of catalyst amount like 10 mg, 20 mg, 30 mg, 40 mg, 50 mg and 100mg. The results suggested that rate of conversion benzyl alcohol with amine were found to be maximum (94%) while the amount of catalyst was 50 mg. It was also pointed that increasing amount of catalyst also increases the product but more than optimum (50 mg) amount failed to enhance the rate of reaction in toluene. The activity of that catalyst was comparable or slightly more than the reported catalysts, even it was found to be reusable with negligible loss of activity (Anbarasu et al., 2017). The novel acid-base hybrid catalyst, RNH₂-M(acac)₂ complex were produced by Tanaka and Adachi by the slow addition of M(acac)₂ dissolved in chloroform to a solution of n-alkylamine that was previously dissolved in chloroform and stirred for 2 h. The water-crosslinking reactions of EPR-g-MTMS was carried out in the presence of RNH₂-M(acac)₂ complex as catalyst, the same reaction was performed in the absence of catalyst at three different temperatures (30, 50, and 80°C). The results have indicated that catalytic activity of RNH₂-

Figure 13: Synthesis route of Re(V) Oxo complexes (Catalyst)

$M(\text{acac})_2$ was higher than the $M(\text{acac})_2$ and *n*-alkylamine. Enhanced activity of $\text{RNH}_2\text{-}M(\text{acac})_2$ catalyst was explained by the axial co-ordination of *n*-alkylamine to $M(\text{acac})_2$ (Shohei and Kenta 2019). Schiff base ligand bis(2-hydroxyanil) acetylacetonate (H_2haacac) was derived from 2-aminophenol and acetylacetonate in ethanol and complexes of general formula, $[M(\text{haacac})]$ of a tetradentate Schiff base ligand H_2haacac with transition metal Mn(II), Co(II), Ni(II) and Cu(II) were synthesized.

Therefore alumina supported metal complexes were subjected to the oxidation of cyclohexene with tert-butyl hydroperoxide (TBHP) as catalyst. 2-cyclohexene-1-ol ($-\text{OH}$), 2-cyclohexene-1-one ($\text{C}=\text{O}$) and 2-cyclohexene-1-(tert-butylperoxy) ($-\text{O}t\text{Bu}$) were the main oxidized products of this catalyst based reaction. Presence of non-coordinating solvent in reaction medium gave maximum yield of product as compared to the coordinating solvent beside this 70°C temperature was pointed as optimum temperature. From comparative studies, a conclusion has been made that alumina supported Mn(II) complex show higher catalytic activity than others. Moreover, at the end of reaction catalysts didn't change their color and recycled for the next reactions (Salavati and Banitaba, 2003). To evaluate the catalytic activity, synthesis of the complexes of ruthenium (II), $[\text{RuBr}(\text{acac})\text{L}_2]_2$ ($\text{L} = \text{PPh}_3, \text{AsPh}_3, \text{py}$; $\text{L}_2 = \text{bipy}$ or phen) and $\text{M}_2 [\text{RuBr}_3(\text{acac})]$ ($\text{M} = \text{Me}_4\text{N}, \text{Cs}$ or Rb) were narrated by Bipul et al.. Oxidation of PPh_3 , and AsPh_3 aid of molecular oxygen was carried out in presence of synthesized complexes as catalyst. A co-ordinating solvent acetonitrile was used in the reaction and the resultant product were OPPh_3 and OAsPh_3 . The conversion of PPh_3 to OPPh_3 was 65% whereas OAsPh_3 was only 25%. It assumed that acetonitrile influence to cleaves the bromo bridges of

the dimer which in turn forms the monomer $[\text{RuBr}(\text{acac})\text{L}_2(\text{CH}_3\text{CN})]$. Catalytic species assembled in the solution due to further loses of coordinated ligands (Bipul et al., 1995).

$\text{Mn}(\text{acac})_2$ -ethylenediamine catalysts was simply derived from $\text{Mn}(\text{acac})_2$ and *N,N'*-diethylethylene-diamine by Soichiro et al. Oxidative coupling polymerization (OCP) of *p*-alkoxyphenols with $\text{Mn}(\text{acac})_2$ -ethylenediamine catalysts was carried out in dichloromethane (CH_2Cl_2), under mild condition and O_2 existing atmosphere. The polymer obtained was essentially composed with *m*-phenylene backbone, on the other hand polymerization occurred by $\text{Mn}(\text{acac})_2$ afforded polymer consist of oxyphenylene backbone. The process of polymerization was accompanied by the one-electron oxidation to produce Mn(III) from Mn(II). A series of polymerization reactions were performed by changing amines along-with temperature and keeping $\text{Mn}(\text{acac})_2$ unaltered. Finding of reactions indicated that 57% yield of product with maximum unit ratio of $\text{CC}/\text{CO} = 95/5$ has obtained in case of synthesized catalyst which was described above. High effectiveness of that catalyst was governed by regiocontrolability (Soichiro et al., 2010). Bidentate ligands $\text{APOH} = (4\text{-anilino-3-penten-2-one})$, $\text{DPOH} = 4\text{-[2,6-dimethylanilino]-3-penten-2-one}$, and $\text{MTPOH} = 4\text{-[2-(methylthio)anilino]-3-penten-2-one}$ were derived from acetylacetonate and suitable amine by Sachse et al. (2007) according to modified method than the literature (figure). Substitution reactions of ligands with rhenium (V) oxo precursors $[\text{ReOCl}_3(\text{PPh}_3)_2]$ or $[\text{NBu}_4][\text{ReOCl}_4]$ gave rhenium(V) oxo complexes (Figure 13). Only $[\text{ReO}(\text{DPO})\text{Cl}_2(\text{PPh}_3)]$ compound was potent to the catalytic activity. Oxidation of *cis*-cyclooctene was performed in presence of synthesized catalyst with tert-butylhydroperoxide (TBHP) in non-coordinating solvent (Figure

Figure 14: Catalytic epoxidation of Cis-cycloctene.**Figure 15:** Synthesis of water soluble iron oxide nano particles by Fe (acac)₃ in 1-foemylpiperidine solvent.

14). This catalytic reaction was easily identifiable hence epoxide was only detectable product. In that case, result also supports higher activity of acetylacetonate based catalyst than salicylaldehyde-based catalysts (Anna et al., 2007).

A simple protocol using cationic acetylacetonate palladium complexes with mono-/bidentate phosphine ligands activated with BF₃·OEt₂ as in situ-formed catalyst for polymerization of endo/exo mixture of 5-methoxycarbonylnorbornene (activity up to 1.1·10⁴ g mol⁻¹ h⁻¹) or 5-phenylnorbornene (7.2·10⁵ g mol⁻¹ h⁻¹) and norbornene (3.3·10⁸ g mol⁻¹ h⁻¹) have been developed. It was observed that the nature of the ligands strongly influence the catalytic activity. The catalyst system Pd(II)/BF₃·OEt₂ was also active for the copolymerization of norbornene with 5-methoxycarbonylnorbornene. DFT calculations of isomers upon single insertion of 5-methoxycarbonylnorbornene into Pd-H bond and NMR/FTIR studies for pre-catalyst activation mechanism was also performed. The easily available two component catalyst systems [Pd(acac) (PR₃)₂]BF₄/nBF₃·OEt₂ was highly useful for the addition (co-)polymerization of norbornene and its important derivatives 5-methoxycarbonylnorbornene and 5-phenylnorbornene (Suslova et al., 2018). Nanocrystalline iron, chromium and manganese oxide were derived by adopting most a multipurpose, expedient and harmless solvothermal method Amanda et al.(2007).This method have employed the

reactions of metal [Fe(III),Mn(III) and Cr(III)] acetylacetonate precursors with the variation of oxygen containing solvents and appropriate reaction conditions (heat &temperature). 2-Acetylpyridine (AP) bp 188°C, p-anisaldehyde (PA) bp 250°C, γ-butyrolactone (BL) bp 204°C, Ethylene carbonte (EC) bp 250°C, 1-formylpiperidine (FP) bp 220°C have been used as capping ligands/solvents that affected the solubility of nanocrytalline metal oxides in both the polar and nonpolar solvent(Figure 15).

Acetylacetonate precursors have been found to be advantageous for being environmental friendly, inexpensive and ease of preparation (Amanda et al., 2007). Recyclable catalyst has been designed at molecular level by anchoring of a metal complex catalyst onto a solid support by means of covalent bond. Nevertheless/however performance of the derived solid catalyst depends largely on the stability and flexibility of the linker between metal complex and solid support. A ring-opening reaction of 2-butoxy-3, 4-dihydropyrans was carried out in presence of a nucleophile to produce 2-alkylated 1, 3-dicarbonyl compounds. In particular, when the nucleophile were mercaptans, progress of the reaction took place smoothly and featured by good atom-economy (environmental friendly), admissible yield of product at mild conditions have been obtained by Bingbing et al.(2015). With the aid of this reaction, they have used, 2-butoxy-3, 4-dihydropyrans as dual anchoring reagents and ligand

donors to modify a ready-made SH-functionalized HMS. This opened an easy way to construct a robust and flexible linker for anchoring a metal acetylacetonate complex catalyst onto HMS support. Therefore, obtained HMS was be used to immobilize $\text{Cu}(\text{acac})_2$, $\text{Zn}(\text{acac})_2$ and $\text{Ru}(\text{acac})_3$ complexes. The obtained solid catalysts were fully characterized by many physicochemical methods. These catalysts were accompanied by trustworthy activity in various organic reactions as compared to their homogeneous counterparts. Moreover, catalysts were asserted to be perfectly robust and recyclable for several times with prominent activity (Bingbing et al., 2015).

CONCLUSION

The transition metal complexes derived from acetylacetonate containing Schiff base ligands were exceptionally stable. Studies of bacterial and fungal screening have remarked that ligands and complexes were potent against bacterial and fungal strains. Few $\text{Cu}(\text{II})$ complexes have been classified as anticancer agent, in some cases it show higher activity as compared to the clinically used therapeutic agents with excellent DNA binding property. Some of the complexes were active catalyst for polymerization and oxidation of organic species. After studying all sorts of activities. In this review, it has been concluded that acetylacetonate and acetylacetonate derived Schiff base containing metal complex synthesis is an active line of research which has contributed to creating antimicrobial as well as catalytic agents and this review will provide ample references for researchers to further their research in this area and will be profitable to students as well.

REFERENCES

- Ahmed AHA, BenGuzzi SA (2008). Synthesis And Characterization of Some Transition Metals Complexes of Schiff Base Derived From Benzidine and Acetylacetonate. *J. Sci. Appl.* 2(1): 83-90.
- Alexander V (1995). Design and synthesis of macrocyclic ligands and their complexes of lanthanides and actinides. *Chem. Rev.* 95(2): 273-342.
- Amanda LW, Zhuoying C, Jiaqing H, Yimei Z, Nicholas JT, Stephen O'B (2007). Metal Acetylacetonates as General Precursors for the Synthesis of Early Transition Metal Oxide Nanomaterials. *J. Nanomater.* Article ID 14858.
- Anbarasu G, Malathy M, Karthikeyan P, Rajavel R (2017). Silica functionalized $\text{Cu}(\text{II})$ acetylacetonate Schiff base complex: An efficient catalyst for the oxidative condensation reaction of benzyl alcohol with amine. *J. Solid State Chem.* PII: S0022-4596(17)30234-7
- Asraf MA, Ezugwu CI, Zakaria CM, Verpoort F (2019). Homogeneous photochemical water oxidation with metal salophen complexes in neutral media. *Photochem. Photobiol. Sci.* 18(11): 2782-2791.
- Asraf MA, Rahman MM, Kabiraz DC, Ansary RH, Hossen MF, Haque MF (2019). Structural Elucidation, 3D Molecular Modeling and Antibacterial Activity of $\text{Ni}(\text{II})$, $\text{Co}(\text{II})$, $\text{Cu}(\text{II})$ and $\text{Mn}(\text{II})$ Complexes Containing Salophen Ligand. *Asian J. Appl. Chem. Res.* 3(3): 1-15.
- Asraf MA, Younus HA, Ezugwu CI, Mehta A, Verpoort F (2016). Cobalt salophen complexes for light-driven water oxidation. *Catal. Sci. Technol.* 6(12): 4271-4282.
- Asraf MA, Younus HA, Yusubov M, Walter F, Verpoort C (2015). Earth-abundant metal complexes as catalysts for water oxidation; is it homogeneous or heterogeneous? *Catal. Sci. Technol.* 5(11): 4901-4925.
- Babahan I, Coban EP, Biyik H (2013). Synthesis, characterisation and antimicrobial activities of vic-dioxime derivatives containing heteroaromatic hydrazone groups and their metal complexes. *Maejo Int. J. Sci. Technol.* 7(1): 26-41.
- Baltes M, Collart O, Van Der Voort P, Vansant EF (1999). Synthesis of Supported Transition Metal Oxide Catalysts by the Designed Deposition of Acetylacetonate Complexes. *Langmuir.* 15(18): 5841-5845.
- Bingbing L, Zhipeng H, Zhifang J, Rongxian B, Yanlong G (2015). Silica-supported metal acetylacetonate catalysts with a robust and flexible linker constructed by using 2-butoxy-3,4-dihydropyrans as dual anchoring reagents and ligand donors. *Catal. Sci. Technol.* 6: 1810-1820.
- Blahova M, Tumova I, Sokolik J, Gallasova M, Svec P (1994). Anti-inflammatory activity of aqua (aryloxyacetato) copper (II) complexes. *Pharmazie.* 49(5): 373-374.
- Charity WD, Ikechukwu PE, Fanyana MM, Michael JK, Ezekiel DD (2017). Hydrazone Schiff bases of acetylacetonate metal complexes: synthesis, spectroscopic and biological studies. *Int. J. Pharm. Pharm. Sci.* 9(12): 257-267.
- chohan ZH, Arif M, Akhtar MA, Supuran CT (2006). Metal-based antibacterial and antifungal agents: synthesis, characterization and in vitro biological evaluation of $\text{Co}(\text{II})$, $\text{Cu}(\text{II})$, $\text{Ni}(\text{II})$ and $\text{Zn}(\text{II})$ complexes with amino acid derived compounds. *Bioinorganic Chemistry Applications.* DOI 10.1155/BCA/2006/83131.
- Chohan ZH, Sumrera SH, Youssoufi MH, Hadda TB (2010). Metal based biologically active compounds: Design, synthesis, and antibacterial/antifungal/cytotoxic properties of triazole-derived Schiff bases and their oxovanadium (IV) complexes. *Eur. J. Med. Chem.* 45(7): 2739-2747.
- Da Silva C, Da Silva D, Modolo L, Alves R, De Resende M, Martins C, De Fátima Á (2011). Schiff bases: A short review of their antimicrobial activities. *J. Adv. Res.* 2(1): 1-8.
- Divya K, Pinto GM, Pinto AF (2017). Application of metal complexes of Schiff bases as an antimicrobial drug: a review of recent works. *Int. J. Curr. Pharm. Res.* 9(3): 27-30.
- Ejidike IP, Ajibade PA (2015). Synthesis, characterization and biological studies of metal (II) complexes of (3E)-3-[(2-((E)-[1-(2, 4-dihydroxyphenyl) ethylidene] amino) ethyl) imino]-1-phenylbutan-1-one Schiff base. *Mol.* 20(6): 9788-9802.
- El-Tabl AS, El-Waheed MMA, Wahba MA, El-Fadl NAEA (2015). Synthesis, Characterization, and Anticancer Activity of New Metal Complexes Derived from 2-Hydroxy-3-(hydroxyimino)-4-oxopentan-2-ylidene)benzohydrazide. *Bioinorg. Chem. Appl.* Article ID 126023.
- Gaowen Y, Xiaoping X, Huan T, Zhao C (1995). Synthesis and Antitumor Activity of Schiff Base Coordination Compounds. *Chinese J. Appl. Chem.* 12: 13-7.
- Gupta K, Sutar AK (2008). Catalytic activities of Schiff base transition metal complexes. *Coord. Chem. Rev.* 252(12-14): 1420-1450.
- Hanna WG, Moawad MM (2001). Synthesis, characterization and antimicrobial activity of $\text{Co}(\text{II})$, $\text{Ni}(\text{II})$ and $\text{Cu}(\text{II})$ complexes with new assymetrical schiffs base ligands derived from 7-formylanil-substitued diamine sulfoxide and acetylacetonate. *Transit. Met. Chem.* 26(6): 644-651.
- Jafaria M, Salehia M, Kubickib M, Khaleghian A (2018). Crystal Structures and Biological Studies Two Novel Zinc Complexes Derived from para-Vanillin and Acetylacetonate. Two New Precursors for Preparation ZnO Nanoparticles. *Russ. J. Coord. Chem.* 44(1): 21-31.
- Jarrahpour A, Khalili D, Clercq ED, Salmi C, Brunel JM (2007). Synthesis, antibacterial, antifungal and antiviral activity evaluation of some new bis-Schiff bases of isatin and their derivatives. *Mol.* 12(8): 1720-1730.
- Karem LKA, Waddai FY, Karam NH (2018). Schiff base complexes of some drug substances. *J. Pharm. Sci. Res.* 10(8): 1912-1917.
- Khojasteh RR, Matin SJ (2015). Synthesis, Characterization, and Antibacterial Activities of Some Metal Complexes of Heptadentate Schiff Base Ligand Derived from Acetylacetonate. *Russ. J. Appl. Chem.* 88(6): 921-925.
- Kumar S, Dhar DN, Saxena P (2009). Applications of metal complexes of Schiff bases-A review. *J. Sci. Ind. Res.* 68: 181-187.

- Mohammed AS, Abubakar F, Aye AE (2017). Synthesis, Characterization and Antifungal Activity of Cobalt (II) Complex with Schiff Base Derived from Acetylacetone and Leucine. *IOSR J. Appl. Chem. (IOSR-JAC)*. 10(1): 68-71.
- Murakami S, Akutsu Y, Habaue S, Haba O, Higashimura H (2010). Oxidative coupling polymerization of p-alkoxyphenols with Mn(acac)₂-ethylenediamine catalysts. *Nat. Sci.* 2(8):803-808.
- Nath M, Yadav R, Gielen M, Dalil H, De-Vos D, Eng G (1997). Synthesis, Characteristic Spectral Studies and in vitro Antimicrobial and Antitumour Activities of Organotin(IV) Complexes of Schiff Bases Derived from Amino-acids. *Appl. Organomet. Chem.* 11(9): 727-736.
- Parashar R, Sharma R, Mohan G (1989). Biological activity of some Schiff bases and their metal complexes. *Biol. Trace Elem. Res.* 23(1): 145-150.
- Patil AR, Donde K, Raut S, Patil VR, Lokhande R (2012). Synthesis, characterization and biological activity of mixed ligand Co (II) complexes of schiff base 2-amino-4-nitrophenol-n-salicylidene with some amino acids. *J. Chem. Pharm. Res.* 4(2): 1413-1425.
- Paul BC, Sarkhel P, Poddar RK (1995). Synthesis and catalytic activity of ruthenium(II) complexes containing acetylacetonate. *J. Coord. Chem.* 36(4): 267-272.
- Paulpandiyar R, Arunadevi A, Raman N (2017). Role of Knoevenagel condensate pyrazolone derivative Schiff base ligated transition metal complexes in biological assay and cytotoxic efficacy. *Appl. Organometal. Chem.* 31: e3792.
- Prasad AVGS, Trinagaraju K, Rao BG, Usha Y, Reddy PS, Rao PV (2013). Synthesis, Characterization And Biological Activity Of Schiff Bases Of Acetylacetone. *Int. J. Innov. Res. Dev.* 2: 39-43.
- Qiu M, Liu G, Yao X, Guo M, Pan G, Zheng ZC (2001). Copper(II)-Schiff base complexes as catalysts for asymmetric cyclopropanation of styrene. *Chin. J. Catal.* 22(1): 77-80.
- Quiroga AG, Ranninger CN (2004). Contribution to the SAR field of metallated and coordination complexes: studies of the palladium and platinum derivatives with selected thiosemicarbazones as antitumoral drugs. *Coord. Chem. Rev.* 248(1-2): 119-133.
- Reddy KK, Rao S, Rao BS (2015). Synthesis and characterization and biological activities of hydrazones. *Int. J. Innov. Res. Sci. Eng. Technol.* 4(1): 18944-18952.
- Rehman M, Imran M, Arif M (2013). Synthesis, Characterization and in vitro Antimicrobial studies of Schiff-bases derived from Acetylacetone and amino acids and their oxovanadium (IV) complexes. *Am. J. Appl. Chem.* 1(4): 59-66.
- Rong M, Liu C, Han J, Sheng W, Zhang Y, Wang H (2008). Catalytic Oxidation of Alcohols by a Novel Copper Schiff Base Ligand Derived from Acetylacetonate and L-Leucine in Ionic Liquids. *Catal. Lett.* 125: 52-56.
- Sachse A, Mosch-Zanetti N, Lyashenko G, Wielandt JW, Most K, Magull J, Dall'Antonia F, Pal A, Herbst-Irmer R (2007). Rhenium(V) Oxo Complexes with Acetylacetone Derived Schiff Bases: Structure and Catalytic Epoxidation. *Inorg. Chem.* 46(17): 7129-7135.
- Salavati-Niasaria M, Banitaba SH (2003). Alumina-supported Mn(II), Co(II), Ni(II) and Cu(II) bis(2-hydroxyanil)acetylacetone complexes as catalysts for the oxidation of cyclohexene with tert-butylhydroperoxid. *J. Mol. Catal. A: Chem.* 201: 43-54.
- Salehi M, Galini M, Kubicki M, Khaleghian A (2019). Synthesis and characterization of new Co(III) and Ni (II) complexes derived from acetylacetone and 2-Aminopyridine: A New Precursor For Preparation Of Nanoparticles. *Russ. J. Inorg. Chem.* 64(1): 18-27.
- Santos JE, Dockal ER, Cavalheiro ET (2005). Synthesis and characterization of Schiff bases from chitosan and salicylaldehyde derivatives. *Carbohydrate Polymers.* 60(3): 277-282.
- Sarker D, Reza Y, Haque M, Zamir R, Asraf A (2019). Copper (II) Complex of Salicylaldehyde Semicarbazone: Synthesis, Characterization and Antibacterial Activity. *Asian J. Chem. Sci.* 4(4): 1-8.
- Shamsipur M, Ghiasvand AR, Sharghi H, Naeimi H (2000). Solid phase extraction of ultra trace copper (II) using octadecyl silica membrane disks modified by a naphthol-derivative Schiff's base. *Anal. Chim. Acta.* 408(1-2): 271-277.
- Siraj IT, Sadiq IA (2016). Synthesis, Characterization and Antimicrobial Activities of a Schiff Base Derived from Phenylalanine and Acetylacetone and its Mn(II), Ni(II) and Cu(II) Complexes. *ChemSearch J.* 7(2): 34-39.
- Stănilă A, Braicu C, Stănilă S, Popi RM (2011). Antibacterial activity of copper and cobalt amino acids complexes. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca.* 39(2): 124-129.
- Sudo A, Hirayama S, Endo T (2009). Highly Efficient Catalysts-Acetylacetonato Complexes of Transition Metals in the 4th Period for Ring-Opening Polymerization of 1,3-Benzoxazine. *Inc. J. Polym. Sci. Part A: Polym. Chem.* 48(2): 479-484.
- Sumathi RB, Halli MB (2014). Metal (II) Complexes Derived from Naphthofuran-2-carbohydrazide and Diacetylmonoxime Schiff Base: Synthesis, Spectroscopic, Electrochemical, and Biological Investigation. *Bioinorg. Chem. Appl.* 1: 942162.
- Sumathi S, Anitha C, Tharmaraj P, Sheela CD (2011). Spectral, NLO, Fluorescence and Biological Activity of Knoevenagel Condensate of β -Diketone Ligands and Their Metal(II) Complexes. *Int. J. Inorg. Chem.* Article ID 154326.
- Suslova DS, Bykova MV, Kuzminb AV, Abramovc PA, Kravchenkoa OV, Pakhomovaa MV, Rokhina MV, Ushakove IA, Tkacha VS (2018). Cationic acetylacetonate palladium complexes/boron trifluoride etherate catalyst systems for polymerization of 5-methoxycarbonylnorbornene. *Catal. Commun.* 106(5): 30-35.
- Tai AW, Lien EJ, Lai MM, Khwaja TA (1984). Novel N-hydroxyguanidine derivatives as anticancer and antiviral agents. *J. Med. Chem.* 27(2): 236-238.
- Tanaka S, Adachi K (2019). A novel efficient catalyst for water-crosslinking reaction of silane-grafted polyolefin system: Specific influence of axially coordinated n-alkylamine ligand on catalytic abilities of metal acetylacetonate complex. *Mater. Today Commun.* 21: 100584.
- Tyagi M, Chandra S (2012). Synthesis, characterization and biocidal properties of platinum metal complexes derived from 2,6-diacetylpyridine (bis thiosemicarbazone). *Open J. Inorg. Chem.* 2: 41-48.
- Ur Rehman M, Imran M, Arif M (2013). Synthesis, Characterization and in vitro Antimicrobial studies of Schiff-bases derived from Acetyl acetone and Amino acids and their Oxovanadium(IV) complexes. *Am. J. Appl. Chem.* 1(4): 59-66.
- Wang T, Guo Z (2006). Copper in medicine: homeostasis, chelation therapy and antitumor drug design. *Curr. Med. Chem.* 13(5): 525-537.
- West DX, Liberta AE, Padhye SB, Chikate RC, Sonawane PB, Kumbhar AS, Yerande RG (1993). Thiosemicarbazone complexes of copper (II): structural and biological studies. *Coord. Chem. Rev.* 123(1-2): 49-71.
- Yang ZH, Wang LX, Zhou ZH, Zhou QL, Tang CC (2001). Synthesis of new chiral Schiff bases and their application in the asymmetric trimethylsilylcyanation of aromatic aldehydes. *Tetrahedron: Asymmetry.* 12(11): 1579-1582.
- Zhang P, Wang C, Chenb Z, Li H (2011). Acetylacetone-metal catalyst modified by pyridinium salt group applied to the NHPI-catalyzed oxidation of cholesteryl acetate. *Catal. Sci. Technol.* 1: 1133-1137.

Cite this article as:

Islam R, Uddin E, Ashrafuzzaman, Bitu NA, Asraf A, Hossen F, Haque M, Mannan A, Zahan KE (2020). Recent advances in biological and catalytic activities of schiff base containing acetylacetone and their metal complexes-a short overview. *Acad. J. Sci. Res.* 8(10): 320-332.

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