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A review on synthesis and biological activity of Schiff Bases

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Schiff bases are versatile organic compounds, gaining importance day by day due to their wide applications. Schiff bases, containing imines or azomethine functional groups, are prepared by condensation of primary amines with carbonyl compounds or they may occur naturally in plants. They have lots of importance in industry and show numerous biological activities including antibacterial, antifungal, antiviral, anticancer, *etc*. The wide range of biological studies of the Schiff bases are now attracting the attention of researchers which can lead to the identification of promising lead compounds. This review consists of the recent developments and various methodologies to synthesize Schiff base as well as their biological activities covering the last 20 years.

Keywords: Amines, aldehydes, Schiff base, antibacterial, antifungal, antimalarial

Schiff Base (SB), a versatile compound discovered by chemist Hugo Schiff, is formed when condensation of primary amines with carbonyl compounds under specific reaction conditions[1]. They are also termed as imine or azomethine (-C=N-). SB ligands form more readily with aldehydes than ketones. Study on SB has been done due to its very flexible character and different structures. SBs form stable complexes with metal ions[2-3]. At very high temperature and in the presence of moisture many SBs show catalytic activity in various reactions. SB acts as an important intermediate in many enzymatic reactions which involves the interaction of an enzyme with carbonyl or an amino group of the substrate[4-5]. In the field of organic chemistry, SB shows large number of synthetic uses. It is widely used in organic compounds such as pigment, dyes, catalysts, intermediates and polymer stabilizers[6].

Imines group can be found in a variety of natural and synthetic compounds which show diverse biological activities. SB also shows several biological properties including anti-inflammatory, antimalarial, antifungal, antibacterial, antiviral, anti-proliferative and antipyretic, *etc*.[7-36] SBs were showed antibacterial activity against some bacterial strains like *Acinetobacter baumannii*, *Bacillus subtilis*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella Pneumonia*, *M. tuberculosis*, *Micrococcus luteus*, *Micrococcus flavus*, *Mycobacterium phlei*, *Pseudomonas fluorescence*, *Proteus vulgaris*, *Salmonella enteric*, *Staphylococcus aureus*, *Streptococcus epidermidis* and *S. pyogenes*, *etc*.[14-20] SBs were reported to exhibit antifungal activity against fungal strains including *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus niger*, *Candida albicans*, *Candida tropicalis*, *Candida guilliermondii*, *Candida glabrata*, *Cryptococcus neoformans*, *Epidermophyton floccosum*, *Histoplasma capsulatum*, *Microsporum audouinii*, *Microsporum gypseum*, *Penicillium marneffei*, *Trichophyton mentagrophytes* and *Trichophyton rubrum*, *etc*.[21-24]

In our review, we describe the various reported schemes to the synthesized of SBs. We also highlight the biological activities of SBs reported in the literature.

Synthesis of Schiff Bases

Imine was prepared for the first time by Schiff in 19th century. He reported the synthesis of imines under azeotropic distillation. Dehydrating agents such as molecular sieves or magnesium sulphate are used to remove water from the system (Figure 1). Later, numerous methods have been reported for the

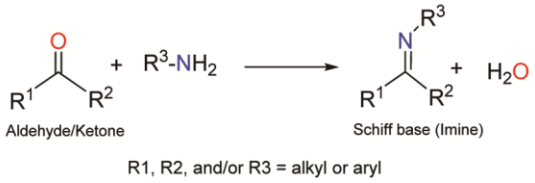
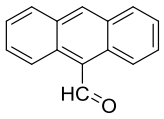
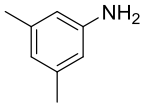
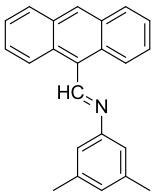
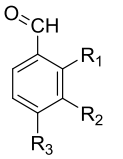
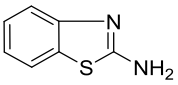
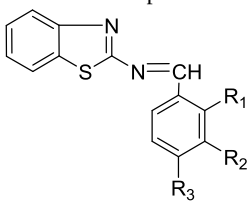
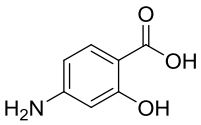
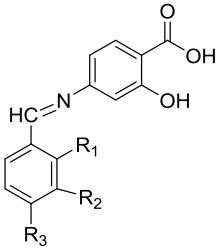
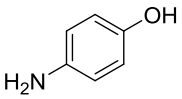
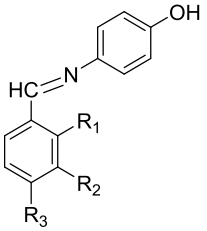
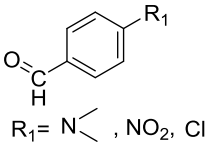
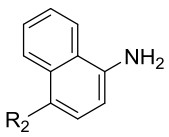
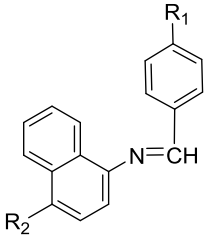


Figure 1 — General pathway for synthesis of a Schiff base

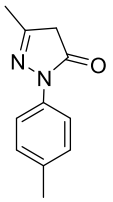
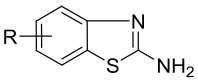
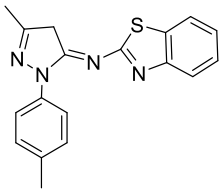
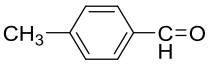
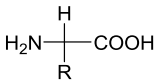
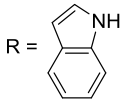
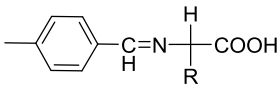
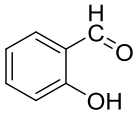
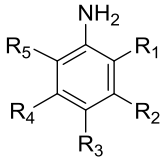
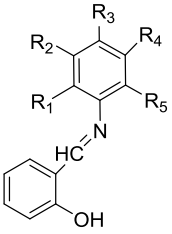
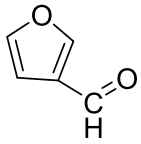
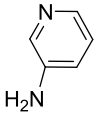
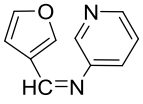
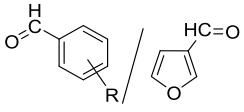
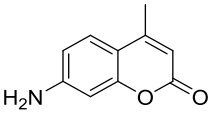
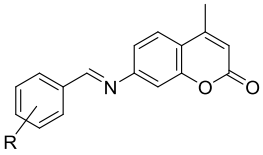
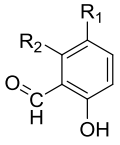
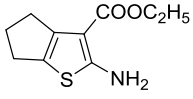
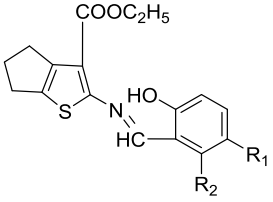
synthesis of imines. According to Chakraborti *et al*. 2004, the carbonyl compounds should be highly electrophilic and amines should be strongly nucleophilic for efficiency of the methods for synthesis of SB. A SB is formed when an aldehyde or ketone react with an amine by acid or base catalysis, or upon heating with the removal of water. Due to the presence of effective conjugation, aromatic aldehydes form stable SBs in comparison to aliphatic aldehydes. Various techniques including microwave irradiation[38–41], water suspension medium, solid-state synthesis, infrared irradiation and ultrasonication[42-46] have been reported. The different schemes of synthesis of SBs are listed in Table I.

Table I — The various Schiff bases

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E1			Aldehyde: Amine at 1:1 molar ratio; Hot ethanol; Reflux at 70°C; 6-8 h.	 1 example	A novel SB was synthesized at reflux condition.	3
E2	 R_1 = H, OH, Cl R_2 = H, OCH_3 R_3 = H, OH, Cl		Aldehyde: Amine at 1:1 molar ratio; Ethanol (25 mL); Reflux (2 h)	 5 examples (59-72%)	Three substituted SBs were synthesized. The SBs containing chloro group showed significant antibacterial activity while compounds containing benzthiazole moiety showed antifungal activity.	47
			Similar condition	 2 examples (61 & 74%)		
			Similar condition	 5 examples (57-74%)		
E3	 R_1= N<, NO_2, Cl	 R_2 = H, $-SO_3H$	Aldehyde: Amine at 1:1 molar ratio; Absolute Ethanol; Stirring 2h and (5-10 h); 60-70°C; NaOH	 6 examples (51-85%)	The preparation of SBs have been carried out by stirring at 60-70°C.	48

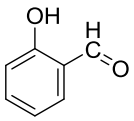
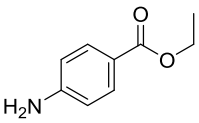
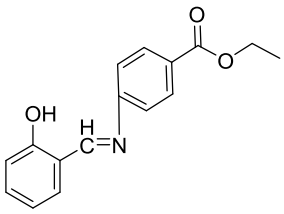
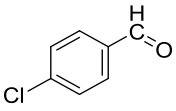
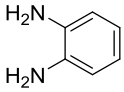
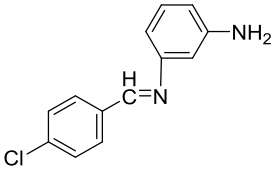
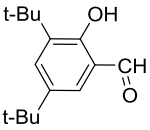
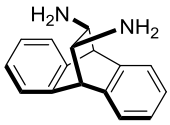
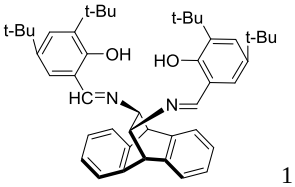
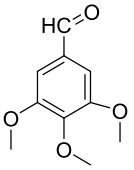
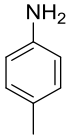
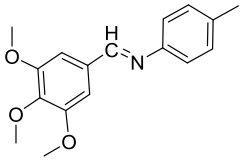
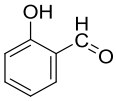
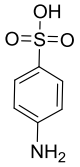
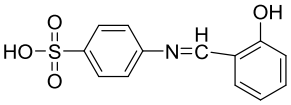
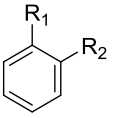
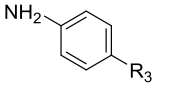
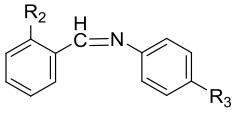
(*Contd*.)

Table I — The various Schiff bases (*Contd*.)

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E4		 R= 6-NO_2, 6-SO_3H, 6-CH_3, 6-OH, 4-OCH_3, 6-Cl, 4,6-$(NO_2)_2$, 6-OCH_3, 4-NO_2, 6-$NHCOCH_3$	a) Aldehyde: Amine at 1:1 molar ratio; CH_3OH; Reflux (5-6 h) b) Aldehyde: Amine at 1:1 molar ratio; CH_3OH; M.W. (2-3 min).	 10 examples (60-75%)	The SBs preparation have been carried out by conventional and microwave methods. In conventional method, the reaction took 5-6h, whereas by microwave irradiation it took only 2-3min.	60
E5		 R = H 	Aldehyde (1.0 mmol): Amine (1.2 mmol); KOH; Methanol; Reflux; 8 h.	 2 examples (60-75%)	The SBs were prepared in alkali absolute methanol.	49
E6		 R_1=H, R_2= H, R_3= X R_4= H, R_5= H X = F, Cl, Br	a) Aldehyde: Amine at 1:1 molar ratio; Water; 1-2 h b) Aldehyde: Amine at 1:1 molar ratio; Microwave/ 50-80°C; 30 sec to 2 min.	 5 examples (90-96%)	The SBs preparation have been carried out by conventional and microwave methods. In microwave, the best yield was obtained at 70°C.	50
E7			Aldehyde: Amine at 1:1 molar ratio; Reflux 1h; Ethanol; Pouring in ice	 1 example (60%)	The condensation of SB was performed in reflux condition by taking equimolar amounts of furan-3-carboxaldehyde and 3-amino pyridine.	51
E8	 R = H, 2-OH, 3-OCH_3, 3-NO_2, 2,4-Cl, 4-OCH_3 3-methylfuran, 4-$N(CH_3)_2$, 4-F, 4-CH_3, 4-OH		Aldehyde: Amine at 1:5 molar ratio; Absolute ethanol; Acetic anhydride; Reflux	 11 examples (42-75%)	SBs showed antimicrobial activity against six microbes at a concentration of 100 µg/mL compared with standard antibiotics.	61
E9	 R_1 = R_2 = H R_1 = Cl, R_2 = H R_1= Br, R_2 = H R_1= R_2= -$(CH)_4$-		Aldehyde: Amine at 1:1 molar ratio; Reflux 2-3 h; Ethanol	 4 examples (76-87%)	The condensation of *o*-hydroxyl aldehyde with Ethyl 2-amino-4,5,6,7-tetrahydrobenzo(β)thiophene 3-carboxylate in 1:1 molar ratio to form SB.	52

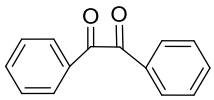
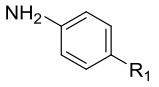
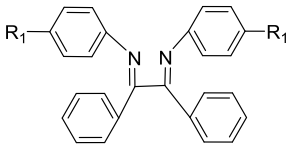
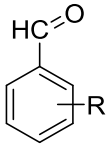
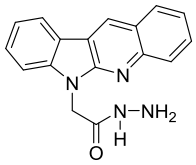
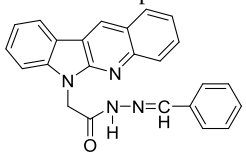
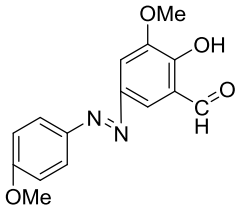
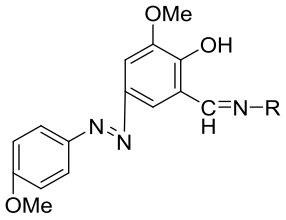
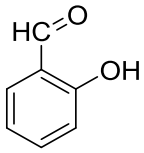
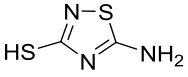
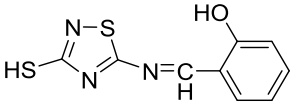
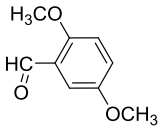
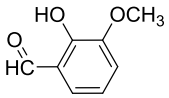
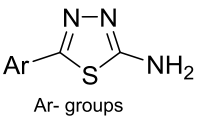
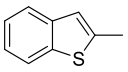
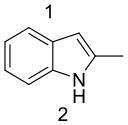
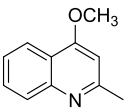
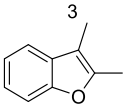
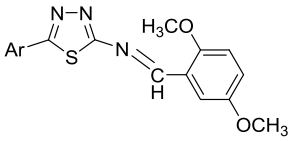
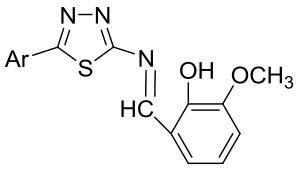
(*Contd*.)

Table I — The various Schiff bases (*Contd.*)

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E10			Aldehyde: Amine at 1:1 molar ratio; Reflux, 3 h glacial CH_3COOH	 1 example	The condensation of SB was performed in reflux condition with glacial acetic acid.	53
E11			Aldehyde: Amine at 1:1 molar ratio; a) Microwave irradiation; b) reflux; c) Stirring; d) Grinding; Ethanol; NaOH	 1 example	Among the methods including Microwave, Reflux, Stirring and Grinding for SB preparation, microwave irradiation requires the least time and greatest yield (80%).	54
E12			Aldehyde: Amine at 1:1 molar ratio; $NaSO_4$, $CHCl_3$; Reflux 24 h	 1 example	A novel chiral SB of (R,R)-11,12-diamino-9,10-dihydro-9,10-ethanonanthracene was synthesized	62
E13			Aldehyde: Amine at 1:1 molar ratio; a) Reflux, Benzene b)Microwave Irradiation neutral alumina (1g) CH_2Cl_2 (2 mL) c) Reflux Anhydrous $MgSO_4$ DCM	 3 examples	SBs were synthesized in three reaction conditions.	56
E14			Aldehyde: Amine at 1:1 molar ratio; stirred, RT ethanol acetic acid		The condensation of SB was performed in reflux condition by taking equimolar amounts of 2-hydroxybenzaldehyde and 4-aminobenzenesulfonic acid	55
E15	 R1 = -CHO, -CH=CH-CHO R2 = -OH, H	 R_3 = H, CH_3	Aldehyde: Amine at 1:1 molar ratio; CH_3COOH; Stirred. 1.15- 2.00 h	 2 examples	The SBs are yellow coloured solid with sharp melting point and insoluble in organic solvents.	5

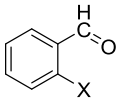
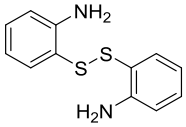
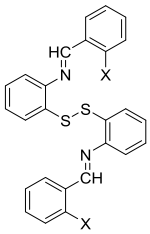
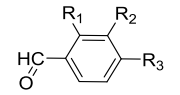
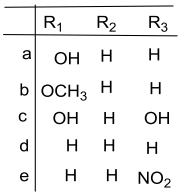
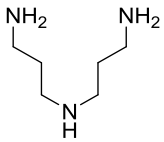
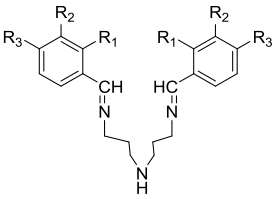
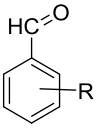
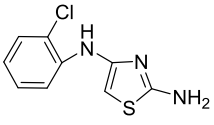
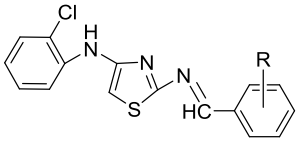
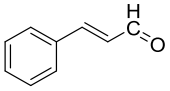
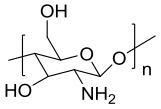
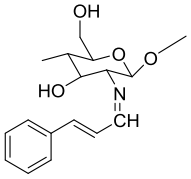
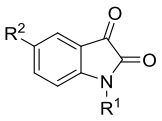
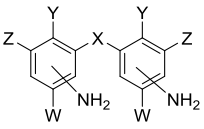
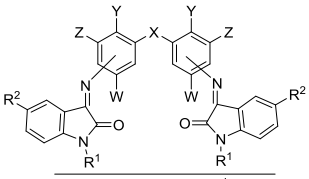
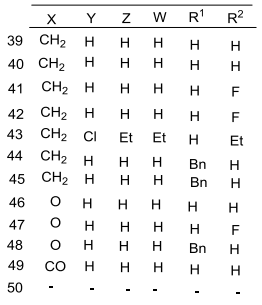
(*Contd.*)

Table I — The various Schiff bases (*Contd*.)

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E16		 R_1 = H, CH_3	Aldehyde: Amine at 1:2 molar ratio; CH_3COOH; Stirred. 1.30-1.45 h	 2 examples	The SBs are yellow coloured solid with sharp melting point and insoluble in organic solvents.	5
E17	 R = H, 3-NO_2, Furfural, -CH_3, 4-OH, 4-$N(CH_3)_2$, 2-Cl, 4-OH, 3-OCH_3, 4-OCH_3, 2-OH		Aldehyde: Amine at 1:2 molar ratio; CH_3COOH CH_2OH, M.W.	 10 examples (61-82%)	SBs were synthesized under conventional and microwave heating.	57
E18		RNH_2	Aldehyde: Amine at 1:2 molar ratio; H_2O			58
E19			Aldehyde: Amine at 1:2 molar ratio; Reflux; Absolute EtOH			59
E20	 	 Ar- groups  1  2  3  4	Aldehyde: Amine at 1:1 molar ratio; THF; Acetic acid (*p*H = 4-5); reflux 24 h.	 4 examples (56-78%)  4 examples (64-78%)	SBs were reported as two pairs, one of which was synthesized by 2,3-dimethoxybenzaldehyde and 2-amino-1,3,4-thiadiazole couple while the other was synthesized by *o*-vanillin and 2-amino-1,3,4-thiadiazole couple.	2

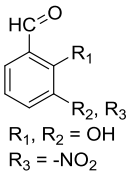
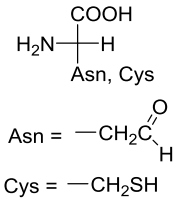
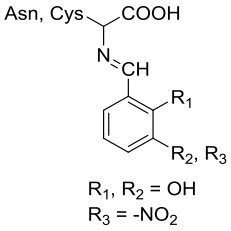
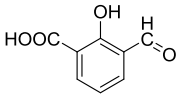
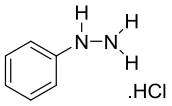
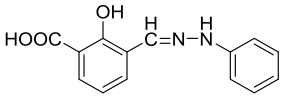
(*Contd*.)

Table I — The various Schiff bases (*Contd.*)

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E21	 X = F, Cl, Br		Aldehyde: Amine at 1:1 molar ratio; Reflux	 3 examples (85-93%)	The fluorine containing SB exhibited higher antimicrobial activity than bromine and chlorine containing SBs.	20
E22	 		Aldehyde: Amine at 1:2 molar ratio; Reflux (4 h) Absolute EtOH	 5 examples (80-93%)	SBs exhibited Antimicrobial activity.	21
E23	 R = 4-NO_2, 2-NO_2, 4-Cl, 2-Cl, 4-F, 4-OH, 2,3,4-$(OCH_3)_3$, 3,4,5-$(OCH_3)_3$, 4-$CH(CH_3)_2$, 3,4-$(OCH_3)_2$		Aldehyde: Amine at 1:1 molar ratio; Reflux (4 h) Dil HCl, CH_3OH/Na	 10 examples (43-91%)	A novel series of SBs 2-amino-4-(o-chloroanilino)-1,3-thiazole were synthesized. SBs exhibited promising antibacterial activity.	32
E24			Aldehyde: Amine at 1:1 molar ratio; 2% acetic acid; RT (6 h); 10 mL EtOH	 1 example (91%)	Five different molar ratios of Chitosan-Cinnamaldehyde were prepared. It was found that increasing the cinnamaldehyde ratio to chitosan increases the formation of SB.	26
E25			Aldehyde: Amine at 1:1 molar ratio; Reflux (7 h) warm ethanol (20 mL); glacial acetic acid in EtOH	  12 examples (70-99%)	Twelve new bis-SBs of isatin, benzylisatin and 5-fluoroisatin were synthesized.	31

(*Contd.*)

Table I — The various Schiff bases (*Contd*.)

Entry	Aldehyde/ketone	Amine	Conditions	Products	Comments	Refs
E26			Aldehyde: Amine at 1:1 molar ratio; 8 h at RT; methanol	 3 examples	SBs showed antibacterial activity against the tested Gram positive and Gram negative organisms.	22
E27			Aldehyde: Amine at 1:1 molar ratio; water bath (8h); Ethanol	 1 example	SB is found active against all tested fungi.	63

Biological activities of Schiff bases

Antibacterial activity

SBs have been reported to exhibit as significant antibacterial agents[2]. There are several synthetic or plant produced Schiff bases possess antibacterial activity. Shi *et al*., 2007 studied antimicrobial activity of synthesized 5-chlorosalicylaldehyde Shiff base derivatives (**1-10**) against *P. fluorescence*, *E. coli*, *B. subtilis* and *S. aureus*. Compounds (**1-10**) were found most active against *P. fluorescence* with MIC values 2.5-5.2 µg/mL, whereas reference drug kanamycin showed MIC value 3.9 µg/mL. The Schiff bases **1**, **2**, **4**–**6** and **9**-**10** showed antibacterial activity against *E. coli* with MIC value 1.6–5.7 µg/mL. Compound **9** showed antibacterial activity against *B. subtilis* (MIC value 1.8 µg/mL) whereas compounds **1** and **2** exhibited activity against *S. aureus* with MIC values 3.1 and 1.6 µg/mL respectively[14]. Pandeya *et al*., 1999a, 1999b reported antibacterial activity of Isatin-derived Schiff base **11** against twenty-eight pathogenic bacteria compared with sulfamethoxazole as reference drug. According to Hearn *et al*., 2004 the isoniazid-derived Schiff base **12** exhibited antibacterial activity against *M. tuberculosis* H37Rv with MIC value of 0.03 mg/L. Panneerselvam *et al*., 2005 tested antibacterial activity of morpholine-derived Schiff bases (**13**–**15**) against *S. aureus, M. luteus, S. epidermidis, B. cereus* and *E. coli*. They reported that compound **13** showed activity *S. aureus, M. luteus* with MIC values 20 and 32 µg/mL, respectively. Compound **14** exhibited activity against *S. epidermidis* with MIC value 17 µg/mL. Moreover, compound **15** reported inhibition against *B. cereus* and *E. coli* with MIC values 21 and 16 µg/mL, respectively. According to Karthikeyan *et al*., 2006, Schiff bases with a 2,4-dichloro-5-fluorophenyl compounds (**16**–**19**) were reported to hinder the bacterial growth against *S. aureus*, *E. coli*, *P. aeruginosa*, and *K. pneumonia* with MIC values from 6.3 to 12.5 µg/mL, compared with reference drug Ciprofloxacin. The compounds are depicted in Figure 2.

The dimeric disulphide Schiff base derivatives **20-22** were studied for antimicrobial activity against *A. baumannii*, *E. coli*, *K. pneumaniae*, *S. aureus*, *C. tropicalis*, *C. guilliermondii*, *C. albicans* and *C. glabrata* by Disc diffusion method compared with standard Cefotaxime, Amoxicillin/clavulanic acid for antibacterial and Posaconazole for antifungal. SB (**20**) exhibited more inhibition against bacteria as compared to other SBs in which *K. pneumaniae* is the most sensitive bacterium. The fluorine containing SBs exhibited higher antimicrobial activity than bromine and chlorine containing SBs[20]. SBs (**23-27**) were studied for antimicrobial activity against pathogenic microorganisms by disc diffusion method with test sample 250 µg/disc. The results showed zones of inhibition for the SBs ranged from 0.9 to 3 cm for Gram positive bacteria, from 0.7 to 2.5 cm for gram-negative bacteria and from 0.6 to 2.4 cm for *Candida* which indicate better effect against gram positive bacteria than against gram negative and *Candida*[21]. A novel series of SBs 2-amino-4-(*o*-chloroanilino)-1,3-thiazole (**28-37**) exhibited promising antibacterial activity against *S. aureus*, *B. subtilis*, *E. coli* and *K. pneumaniae*. Cinnamyl chitosan SB was (**38**) showed to have antimicrobial activity against *S. aureus*, *S. pyogenes*, *P. aeruginosa*, *P. vulgaris* and *Shigella*. Salihovic *et al*., 2018 studied the *in vitro* antimicrobial activity of SBs (**39-41**) against bacteria *S. aureus*, Methicillin-resistant *S. aureus*: MRSA, *B. subtilis*, *E. faecalis*, *S. enteric*, *P. aeruginosa*,

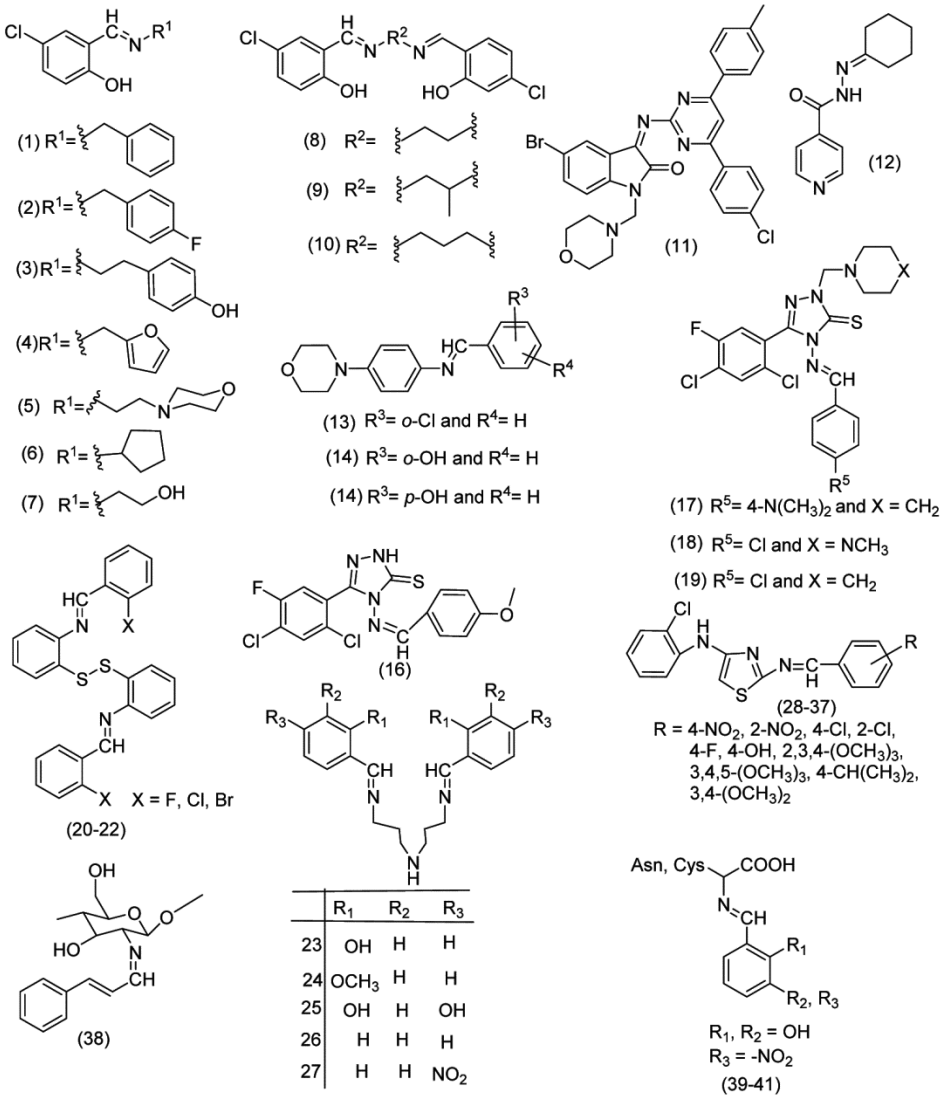


Figure 2 — Structures of synthetic antibacterial Schiff bases

E. coli, and one yeast *C. albicans* by Agar Well Diffusion Method. SB (**39**) showed maximum inhibition against the microorganisms.

Madura hydroxylactone SBs (**42**–**47**) (Figure 3) isolated from *Actinomadura rubra* inhibited bacterial growth of *B. subtilis*, *M. flavus*, *Sa. lutea*, and *S. aureus*, with MIC values 0.2-3.1 µg/mL. They also showed very low activity against *M. phlei* or *P. vulgaris* with MIC value 50.0 µg/mL[23-24].

Antifungal activity

Both synthetic and naturally occurring Schiff bases reported promising antifungal activity (Figure 4). 2,4-dichloro-5-fluorophenyl Schiff bases (**16**, **48**–**51**) inhibit the growth of fungi against *Aspergillus fumigatus*, *Aspergillus flavus*, *Penicillium marneffei*, and *Trichophyton mentagrophytes* with MIC values range of 6.3–12.5 µg/mL, compared with reference fluconazole[19].

According to Echevarria *et al*., 1999, Piperonyl-derived Schiff bases (**52**–**57**) repressed the growth of fungi *Trichophyton rubrum* and *Epidermophyton floccosum* with MIC values 820–980 µM and 200–930 µM, respectively. The isatin-derived Schiff bases (**11**, **58**–**68**) were found to have antifungal activity against *Microsporuma udouinii* and *Microsporum gypseum* with MIC values ranging from 2.4-9.7 µg/mL and 1.2-9.7 µg/mL, repectively[15]. Further, compounds (**11**, **58**–**68**) also showed inhibition against *Aspergillus niger*, *Candida albicans*, *Cryptococcus neoformans*, *E. floccosum*, *Histoplasma capsulatum* and *T. mentagrophytes* at

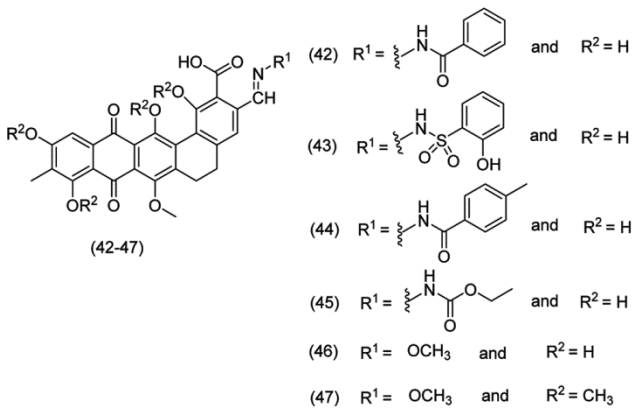


Figure 3 — Structures of some antibacterial Schiff bases derived from plant

MIC values 10-79 µg/mL[16]. Compounds **14** and **69** exhibited antifungal activity against *C. albicans* and *A. niger* conceded by treatment at 20 and 30 µg/mL, repectively. Compound **70**, a natural product derived Schiff base reported antifungal activity against *C. albicans* and *C. neoformans* at 20 µg/mL, whereas for free nystatin required a concentration of 10 µg/mL. SB (**25**) showed moderate activity against *Candida* (24 µg/mL) and could be a promising anti microbial agent[21]. The SBs 2-amino-4-(*o*-chloroanilino)-1,3-thiazole (**28**-**37**) exhibited promising antifungal activity against *C. albicans* and *A. niger*[26]. The hydrazone SB (**71**) synthesized by Pawaiya *et al*., 2014 exhibited antifungal activity against *C. albicans*, *A. niger*, and *Penicillium* sp.

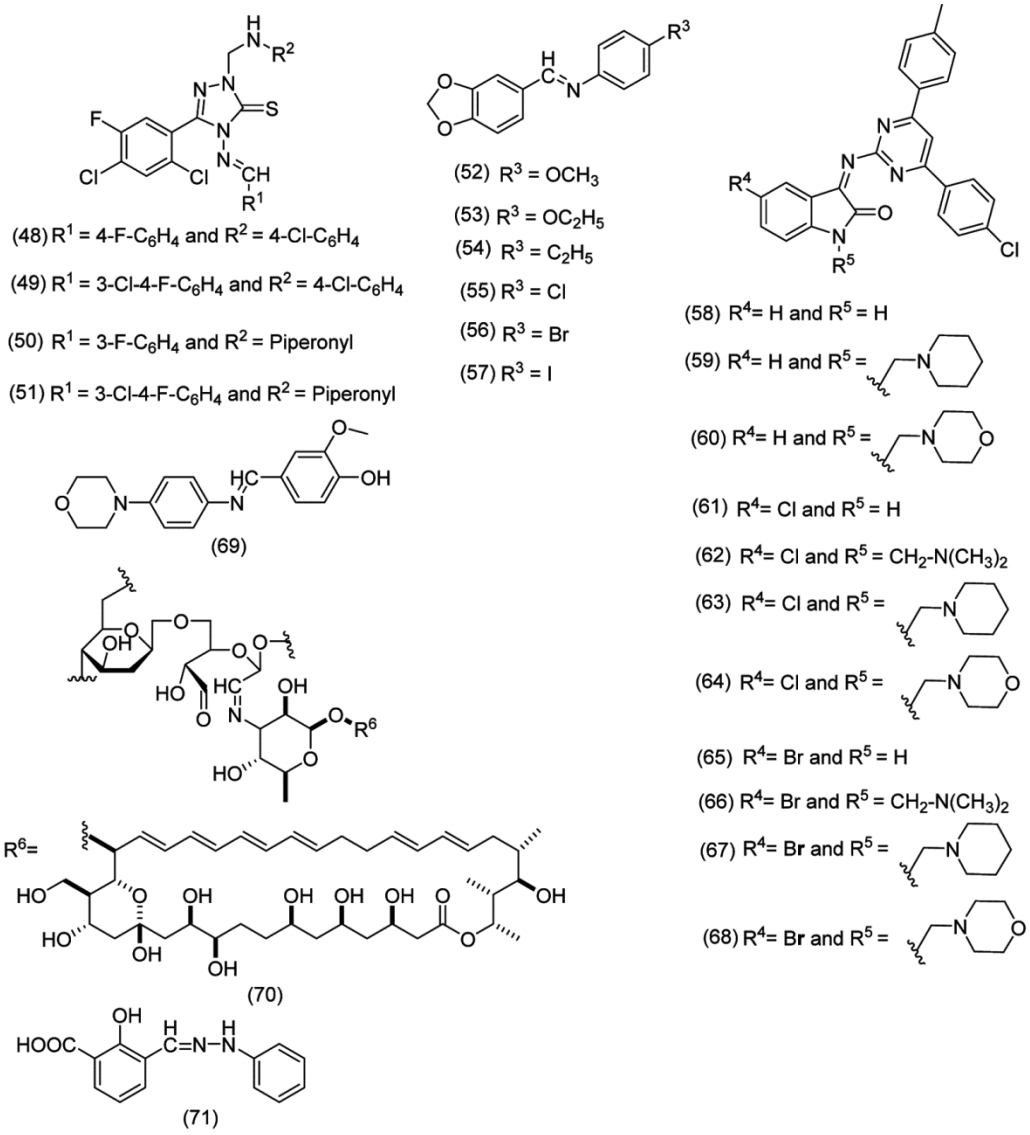


Figure 4 — Structures of some antifungal Schiff bases

Antimalarial activity

A series of fifteen SBs derived from aromatic sulphonamides were tested as inhibitors of *Plasmodium falciparum* carbonic anhydrase enzyme compared with clinical drug acetazolamide (Figure 5). SBs **72-77** inhibited parasite activity with an affinity constant (KI) ranging from 0.54-1.23 µg/mL against carbonic anhydrase enzyme[27-28]. SBs **78-80** exhibited good antimalarial activity against the tested 3D7 strain with IC_{50} values ranging from 19.69 to 25.38 µg/mL. SBs **81-86** exhibited antimalarial activity inhibiting the growth of this parasite (IC_{50}, 2.28 - 26.9 µg/mL[29].

Antiviral activity

A 1-amino-3-hydroxyguanidine tosylate derived SB (**87**) was reported to exhibit antiviral activity against mouse hepatitis virus (MHV), by 50% inhibition in growth at concentrations of 3.2 µM[30] (Figure 6). Further, according to Sriram *et al*., 2006

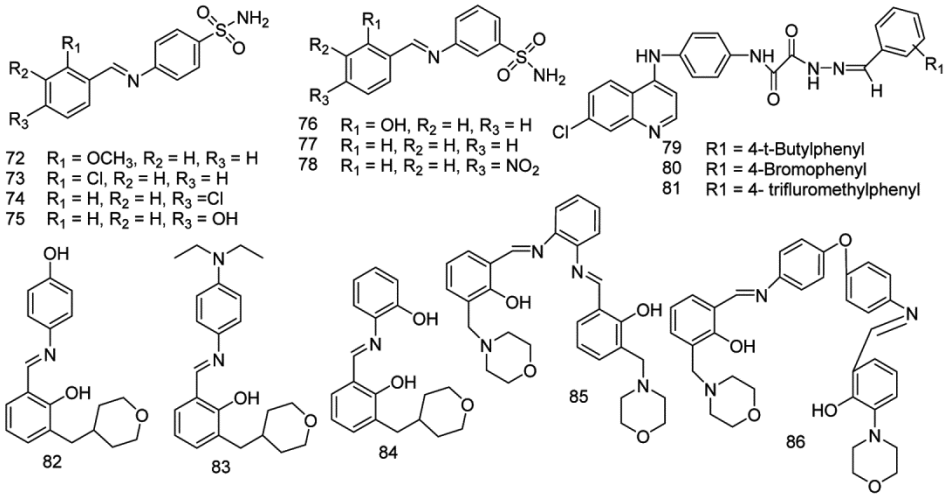


Figure 5 — Structures of some antimalarial Schiff bases

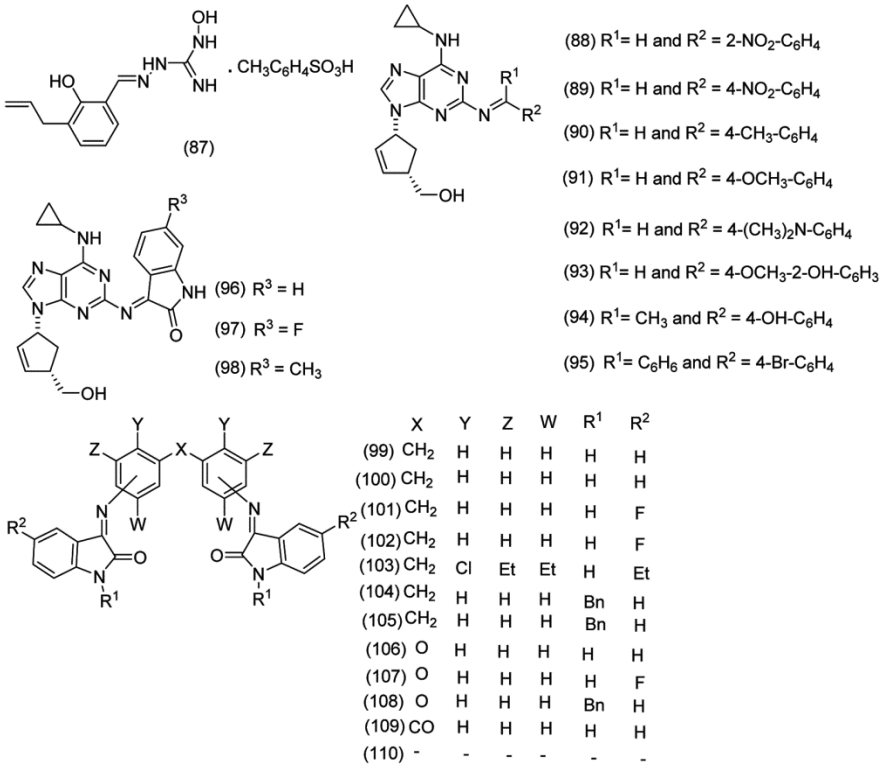


Figure 6 — Structures of some antiviral Schiff bases

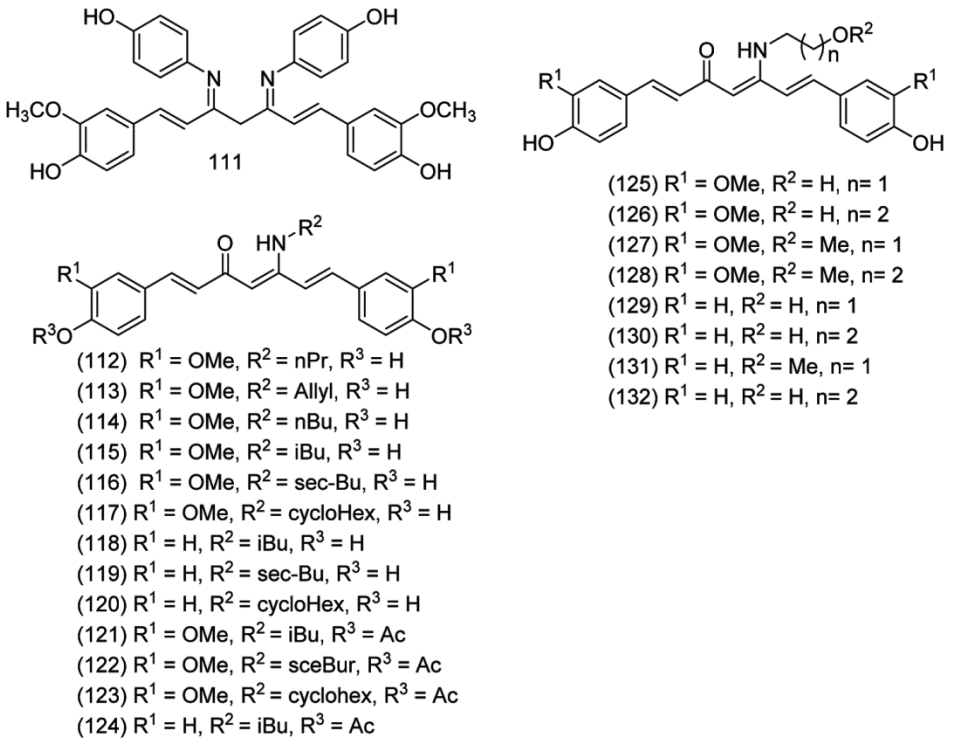


Figure 7 — Structures of some antioxidant Schiff bases

the abacavir-derived Schiff bases (**88**–**98**) showed significant antiviral activity against HIV-1 in which compound **90** was the most potent Schiff base, being effective at 50 nM, could be a principal compound for new anti-HIV-1 (Figure 6). The new bis-Schiff bases of isatin, benzylisatin and 5-fluoroisatin (**99-110**) were reported having antiviral activity in human embryonic lung (HEL) and human epithelial (HeLa) cells and African green monkey kidney (Vero) cells[31].

Antioxidant activity

The SB (**111**) bearing N,N-dimethylamino benzaldehyde and 4-hydroxy benzaldehyde showed antioxidant activity with IC_{50} value 50 mM compared with curcumin using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay[32] (Figure 7). Vreese *et al*., 2016 studied antioxidant activity of thirteen new derivatives (**112-124**) bearing a β-enaminone by DPPH and the ferric reducing ability of plasma (FRAP) assays. SBs showed antioxidant activity by both tests (0.08–0.13% inhibition per mM by DPPH assay and 0.83–1.29 Trolox equiv. per mM by FRAP assay) compared with curcumin (0.15% inhibition per mM by DPPH assay and 1 Trolox equiv. per mM by FRAP assay)[33-34]. The new enaminone analogues (**125-132**) exhibited antioxidant activities comparable to curcumin[35-36].

Conclusion

This article summarizes the working procedures of preparation of Schiff base since they have many important applications in organic chemistry. In this article we have also highlighted various biological activities of Schiff base.

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