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Research Article

SYNTHESIS, CHARACTERISATION, ANTIOXIDANT AND ANTIMICROBIAL ACTIVITY OF ISATIN DERIVATIVES

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ABSTRACT

Schiff bases are the important class of organic compounds because of their flexibility and structural diversities due to the presence of azomethine group. In the present study some novel Schiff bases of isatin were synthesized by condensation of isatin molecule with different anilines after performing the molecular docking and ADME prediction. Isatin nucleus contains both the keto and lactam moiety in their structure and has attracted researchers to explore its diverse biological and pharmacological properties. Literature survey has also revealed that isatin derivatives exhibit manifold importance in the field of medicinal chemistry. Therefore, some new Schiff bases of isatin have been prepared in order to study the antimicrobial and antioxidant properties. The isatin was synthesized by Sandmeyer method and then its derivatives were synthesized after obtaining significant results from molecular docking and ADME prediction. The structures of the synthesized compounds were confirmed by means of IR, ^{1}H-NMR and elemental analysis. These compounds were screened for antimicrobial and antioxidant activity. The compounds showed broad spectrum of antimicrobial activity. Few of the synthesized compounds also showed good antioxidant activity.

Keywords: Isatin, Schiff bases, antioxidant, antimicrobial, molecular docking, ADME prediction.

INTRODUCTION

Heterocyclic compounds are widely distributed in nature and a large number of synthetic as well as naturally occurring heterocyclic compounds are pharmacologically active and are in clinical use. Isatin or 1H-indole-2, 3-dione is an indole derivative. The synthetic versatility and diverse pharmacological properties[1-4] of this moiety has led to its extensive use in the synthesis of various analogues. Isatin nucleus having both the keto and lactam moiety in their structure has aroused tremendous curiosity due to its diverse biological activities. Biological properties of isatin include a wide range of actions in the brain and it also offers protection against certain types of infections. Isatin moiety shows biological activities like antimicrobial (antibacterial and anti fungal)[5-8], anti-tubercular[9], anthelmintic[10], anticonvulsant[11-14], anti-HIV[15-17], antioxidant[18-21], anti-cancer[22-24], anti-inflammatory, analgesic[25-26], antianxiety[27-29], anti-histaminic[30], anti-diuretic[31] activities. The flexibility of isatin structure and versatility in pharmacological activities motivated us for synthesis of some new isatin derivatives in order to screen their antimicrobial and antioxidant activities.

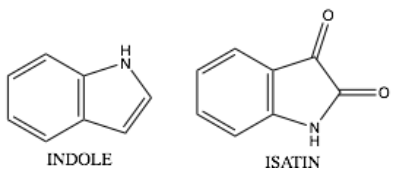


Figure 1

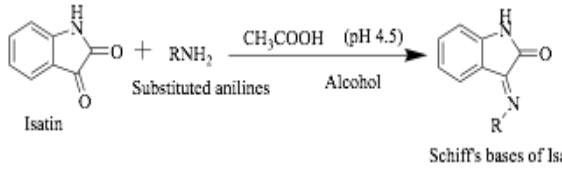
MATERIALS AND METHOD

Materials

The chemicals used were obtained from Sigma Aldrich. The reaction was carried out on the radleys carousel six plate reaction station. TLC was performed using silica gel G as adsorbent and spots were observed by exposure to iodine vapors. Melting points were taken in open glass capillary tube using Lab India visual Melting point apparatus and are uncorrected. IR spectra of compounds were recorded on ATR (Attenuated total reflection). ^{1}H-NMR spectra were recorded on a Bruker 300 MHz NMR. Molecular docking studies were performed on Fujitsu Celsius with quadcore xeon processor, Linux workstation, using Schrodinger Inc. (maestro 9.8, 2014, update 2).

General Procedure for synthesis of Schiff bases of Isatin

Equimolar (0.01 mol) quantity of isatin and substituted anilines were dissolved in alcohol (10 mL) and refluxed for 3 h in presence of few drops of glacial acetic acid using parallel synthesizer. In between TLC was done to confirm the completion of reaction. After completion of reaction, the reaction mixture was left overnight to get the solid product. The product was filtered, dried, and recrystallized from ethanol.



R=-COH, -OH, -$COCH_3$, -CO-Ph, -Ph-4-NO_2, -Ph-4-SO_3H, -Ph-2-OH 4-SO_3H, -Ph-3-CH_3 4-CN, -Ph-2-NO_2 4-Cl, -Ph-2-Cl 4-CN, -Ph-2-NO_2, -Ph-4-SO_2NH_2, -Ph-2,4,5-F, -Ph-3-Cl 4-CN, -Ph-3-NO_2, -Ph-2-CH_3 3-CF_3, -Ph-2-Cl 4-NO_2, -Ph-3,5- OCH_3 –Aniline

Scheme

Synthesis of Schiff bases of Isatin

(3Z)-3-[(4-nitrophenyl)imino]-1,3-dihydro-2H-indol-2-one (1a)

M.P: 239-242℃; Yield: 79%; IR (cm^{-1}): 3359 (NH Stret), 1618 (C=N), 1518 (Ar-NO_2); ^{1}H-NMR (DMSO d_6): 6.4-7.1 (m, 6H,Ar-H), 9.82 (s,1H,NH); Anal. Calcd for $C_{14}H_9N_3O_3$:C(62.92), H(3.39), N(15.72); Found: C(62.72), H (3.19), N(15.42).

N-[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]formamide (1b)

M.P: 245-247℃; Yield: 88%; IR (cm^{-1}): 3394 (NH Stret), 1615 (C=N), 1692 (-C=O); ^{1}H-NMR (DMSO d_6): 6.9-7.1 (m, 4H,Ar-H), 11.02 (s,1H,OH); Anal. Calcd for $C_9H_6N_2O_2$: C (62.07), H(3.47), N(16.09); Found: C (61.87), H (3.43), N (15.89).

4-{[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]amino}benzenesulfonicacid (1c)

M.P: 197-199℃; Yield: 90%; IR (cm^{-1}): 3393 (NH Stret), 1610 (C=N), 1201, 1028, 623 (SOOH); ^{1} H-NMR (DMSO d_6): 6.8-7.2 (m, 6H, Ar-H), 11.03 (s, 1H, SO_3H); Anal. Calcd for $C_{14}H_{10}N_2O_4S$: C (55.62), H(3.33), N(9.27); Found: C (55.32), H (3.13), N (9.07).

(3Z)-3-(hydroxyimino)-1,3-dihydro-2H-indol-2-one (1d)

M.P: 251-256℃; Yield: 85%; IR (cm^{-1}): 3393 (NH Stret), 1620 (C=N), 3393 (-OH); ^{1} H-NMR (DMSO d_6): 6.4-6.9 (m, 4H,Ar-H), 10.6 (s,1H,NH), 13.3 (s, 1H, NOH); Anal. Calcd for $C_8H_6N_2O_2$: C(59.26), H(3.73), N(17.28); Found: C (58.96), H (3.53), N (17.08).

3-hydroxy-4-[(2-oxo-2,3-dihydro-1H-indol-3-yl)amino]naphthalene-1-sulfonic acid (1e)

M.P: 229-231℃; Yield: 89%; IR (cm^{-1}): 3394 (NH Stret), 1630 (C=N), 3613 (free Ar-OH), 1158, 1027 (SOOH); ^{1}H-NMR (DMSO d_6): 6.3-7.0 (m, 8H,Ar-H), 1.94-1.97 (s,1H,OH alcohol) 7.04-7.09 (t,1H,Ar-H); Anal. Calcd for $C_{18}H_{12}N_2O_5$ S: C (58.37), H (3.81), N (7.56); Found: C (58.17), H (3.61), N (7.26).

2-methyl-4-{[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]amino}benzonitrile (1f)

M.P: 234-236℃; Yield: 81%; IR (cm^{-1}): 3364 (NH Stret), 1616 (C=N), 2217(C≡N), 1467 (CH_3); ^{1}H-NMR (DMSO d_6): 6.6-7.2 (m, 7H,Ar-H), 11.0(s, 1H, NH); Anal. Calcd for $C_{16}H_{11}N_3O$:C (73.55), H(4.24), N(16.08), O(6.12); Found: C (73.25), H (3.94), N (15.88).

N-[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]acetamide (1g)

M.P: 213-217℃; Yield: 76%; IR (cm^{-1}): 3393 (NH Stret), 1612 (C=N); ^{1}H-NMR (DMSO d_6): 6.6-7.0 (m, 4H,Ar-H), 11.02 (s, IH, NH), 2.4 (s, 1H, $COCH_3$); Anal. Calcd for $C_{10}H_8N_2O_2$: C (63.82), H(4.28), N(14.89), O(17.00); Found: C (63.62), H (3.98), N (16.80).

(3Z)-3-[(4-chloro-2-nitrophenyl)imino]-1,3-dihydro-2H-indol-2-one (1h)

M.P: 262-265℃; Yield: 90%; IR (cm^{-1}): 3394 (NH Stret), 1625 (C=N), 1514, 1332 (Ar-NO_2), 737(Ar-Cl); ^{1}H-NMR (DMSO d_6): 6.6-7.2 (m, 7H,Ar-H), 9.6 (s,1H,NH); Anal. Calcd for $C_{14}H_8ClN_3O_3$: C(55.74), H(2.67), N(13.93); Found: C (55.44), H (2.47), N (13.73).

3-chloro-4-{[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]amino}benzonitrile (1i)

M.P: 251-256℃; Yield: 88%; IR(cm^{-1}): 3357 (NH Stret), 1631(C=N), 2220(C≡N), 676(Ar-Cl); ^{1}H-NMR (DMSO d_6): 6.7-7.0 (m, 7H,Ar-H), 11.02 (s,1H, NH); Anal. Calcd for $C_{15}H_8ClN_3O$:C(63.96), H(2.86), N(14.92); Found: C (63.66), H (2.56) N (14.62).

(3Z)-3-[(2-nitrophenyl)imino]-1,3-dihydro-2H-indol-2-one (1j)

M.P: 226-229℃, Yield: 78%, IR (cm^{-1}): 3400 (NH Stret), 1617(C=N), 1515, 1392 (Ar-NO_2), ^{1}H-NMR (DMSO d_6): 6.5-7.1 (m, 7H,ArH), 11.04 (s,1H,NH), Anal, Calcd for $C_{14}H_9N_3O_3$: C(62.92), H(3.39), N(15.72); Found: C (62.72), H (3.09), N (15.52).

4-{[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]amino}benzenesulfonamide (1k)

M.P: 264-266℃; Yield: 83%; IR (cm^{-1})): 3364 (NH Stret), 1628 (C=N), 1394, 1159($SONH_2$); ^{1}H-NMR (DMSO d_6): 6.7-7.1 (m, 6H,Ar-H), 9.6 (s,1H,NH), 7.23 (s, 1H, NH_2); Anal. Calcd for $C_{14}H_{11}N_3O_3S$:C(55.80), H(3.68), N(13.95); Found: C (55.50), H (3.48), N (13.65).

N-[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]benzamide (1l)

M.P: 242-245℃; Yield: 87%; IR (cm^{-1}): 3393 (NH Stret), 1612 (C=N); ^{1}H-NMR (DMSO d_6): (aromatic CH Bend), 6.3-6.9 (m, 7H,Ar-H), 9.4 (s,1H,NH); Anal. Calcd for $C_{15}H_{10}N_2O_2$: C(71.99), H(4.03), N(11.19); Found: C (71.69), H (3.73), N (10.99).

(3Z)-3-[(2,4,5-trifluorophenyl)imino]-1,3-dihydro-2H-indol-2-one
(1m)

M.P: 219-222℃; Yield: 76%; IR (cm^{-1}): 3392 (NH Stret), 1629 (C=N), 1026(Ar-F); ^{1}H-NMR (DMSO d_6): 6.5-7.2 (m, 7H,Ar-H), 11.03 (s,1H,NH) ; Anal. Calcd for $C_{14}H_7F_3N_2O$:C(60.88), H(2.55), N(10.14); Found: C (60.68), H (2.35), N (9.84).

2-chloro-4-{[(3Z)-2-oxo-1,2-dihydro-3H-indol-3-ylidene]amino}benzonitrile
(1n)

M.P: 227-229℃; Yield: 79%; IR (cm^{-1}): 3358 (NH Stret), 1616(C=N), 2220(C≡N), 666(Ar-Cl); ^{1}H-NMR (DMSO d_6): 6.3-6.7 (m, 7H,Ar-H), 11.6 (s,1H,NH) ; Anal. Calcd for $C_{15}H_8ClN_3O$: C(63.96), H(2.86), N(14.92); Found: C (63.66), H (2.66), N (14.62).

(3Z)-3-[(3-nitrophenyl)imino]-1,3-dihydro-2H-indol-2-one
(1o)

M.P: 238-243℃; Yield: 84%; IR (cm^{-1}): 3394 (NH Stret), 1630(C=N), 1518, 1346(Ar-NO_2); ^{1}H-NMR (DMSO d_6): 6.3-6.9 (m, 9H,Ar-H), 10.09 (s,1H,NH) ; Anal. Calcd for $C_{14}H_9N_3O_3$: C(62.92), H(3.39), N(15.72); Found: C (62.72), H (3.09), N (15.52).

(3Z)-3-{[2-methyl-3-(trifluoromethyl)phenyl]imino}-1,3-dihydro-2H-indol-2-one
(1p)

M.P: 266-269℃; Yield: 75%; IR (cm^{-1}): 3394 (NH Stret), 1632 (C=N), 2879 (CH_3 Stret), 1390 (CH_3 Bend), 1206 (Ar-F); ^{1}H-NMR (DMSO d_6): 6.1-6.6 (m, 8H, Ar-H), 2.4 (s,1H, Ar-H); Anal. Calcd for $C_{16}H_{11}F_3N_2O$:C (63.16), H(3.64), N(9.21); Found: C (62.96), H (3.34), N (9.01).

(3Z)-3-[(2-chloro-4-nitrophenyl)imino]-1,3-dihydro-2H-indol-2-one
(1q)

M.P: 214-217℃; Yield: 83%; IR (cm^{-1}): 3393 (NH Stret), 1612 (C=N), 1513, 1321 (Ar-NO_2), 697(Ar-Cl); ^{1}H-NMR (DMSO d_6): 6.8-7.0 (m, 7H, Ar-H), 11.02 (s,1H,NH); Anal. Calcd for $C_{14}H_8ClN_3O_3$: C (55.74), H(2.67), N(13.93); Found: C (55.54), H (2.37), N (13.73).

(3Z)-3-[(3,5-dimethoxyphenyl)imino]-1,3-dihydro-2H-indol-2-one
(1r)

M.P: 247-249℃; Yield: 78%; IR (cm^{-1}): 3392 (NH Stret), 1634 (C=N), 1261(C-O), 2929(CH_3 Stret), 1375(CH_3 Bend); ^{1}H-NMR (DMSO d_6):6.5-6.9 (m, 4H,Ar-H), 11.02 (s, 1H,NH), 3.4 (s, 1H, OCH_3); Anal. Calcd for $C_{16}H_{14}N_2O_3$: C(68.07), H(5.00), N(9.92); Found: C (67.77), H (4.80), N (9.62).

Antimicrobial activity (Zone of inhibition)

The zone of inhibition was determined by paper disc diffusion method[32]. Amoxicillin and Clotrimazole at concentration 100 microgram/ml were used as standard drug for antibacterial activity and anti fungal activity respectively. Results were presented in terms of diameter (mm) of zone of inhibition.

Anti oxidant activity

The ability of test compounds to scavenge hydrogen peroxide was determined according to the method of Sanchez[33] and Famey[34]. The percentage of H_2O_2 scavenging of test and standard compounds was calculated by: % scavenged [H_2O_2] = [(A control –A sample)/ A control] ×100

Results were expressed as IC_{50} values i.e. concentration of test compound required to scavenge 50% free radical.

Molecular docking

Protein and ligand preparation

The procedure starts with a protein and its co-crystallized ligand. It finishes with a partially optimized protein-ligand complex to which hydrogens have been added, subject to adjustment of protonation states for ionisable residues, modification of tautomeric forms for histidine residues and repositioning of reorient-able hydrogens (e.g. Side chain hydroxyl hydrogens). The first step is to prepare the co-crystallized ligand by making sure that the multiple bonds are defined correctly, and hydrogens are properly added. Second step is to neutralise residues that do not participate in salt bridges and that are more than a specified distance from the nearest ligand atom; by default, it chooses the value between 1 and 2 nm. The third step is to post process the peripheral receptor. This is necessary because the judgments made by the preparation procedure will not always be correct. Step four ads structural waters if any are to be kept. Fifth step adds hydrogens to the protein, to any cofactors and to any added structural waters, and the final step carries out a series of restrained minimization on the protein-ligand complex. Ligand preparation was done in Lig Prep, Maestro 9.8, using force field OPLS2005.

Grid Generation

Grid was generated with respect to the co-crystallized ligand 5-imino-4-(3trifluoromethylphenylazo)-5H-pyrazol-3-ylamine.

Validation

Co-crystallized ligand was extracted and prepared in Ligprep. The ligand was docked in generated grid of 2GG2. The RMSD value of newly docked pose and earlier co-crystallized docked pose was found to be 0.2.

Ligand Docking

Docking studies were done in extra precision mode, by defining 10 as maximum number of poses.

ADME prediction

The synthesized compounds were sketched and prepared using Ligprep 2.3. Using Quik Prop 3.2 module of Schrödinger the ADME properties were calculated using fast mode. The desirable properties were screened from the overall output and considered for further analysis.

Table 1: Comparative Study of the Docking Score, Glide Energy and H-Bond Interactions for all the Synthesized Compounds

Ligand	Glide Score (Kcalmol$^{-1)}$	Glide Energy	H-bonding Residues in e-MetAP
1a	-4.7	-35.1	HIE 79
1b	-4.9	-27.3	No interaction
1c	-4.3	-31.5	CYS169
1d	-6.3	-31.5	THR99
1e	-4.6	-31.0	CYS169
1f	-5.4	-36.4	HIE79
1g	-4.6	-31.8	CYS169
1h	-5.2	-36.9	HIE79
1i	-5.1	-36.2	HIE79
1j	-4.5	-34.9	HIE79
1k	-4.8	-34.9	No interaction
1l	-5.1	-40.0	GLU204
1m	-4.6	-30.3	HIE79
1n	-5.4	-36.5	HIE79
1o	-4.7	-35.0	HIE79
1p	-5.6	-36.6	HIE79
1q	-5.0	-37.3	HIE79
1r	-5.2	-38.3	HIE79

Table 2: ADME Profile of synthesized compounds

Molecule	MW	QPPCaco	CNS	QlogKhsa	#metab	%Absorption	QPlogPo/w
1a	267.243	198.077	-2	-0.102	1	78.254	1.742
1b	174.159	208.519	-1	-0.786	0	67.634	-0.14
1c	302.304	23.443	-2	-0.658	0	57.787	1.08
1d	162.148	286.576	-1	-0.688	0	71.271	0.059
1e	302.304	23.443	-2	-0.658	0	57.787	1.08
1f	261.282	401.171	-1	-0.077	1	85.383	2.023
1g	302.304	23.816	-2	-0.659	0	57.96	1.088
1h	301.688	341.506	-1	-0.012	1	86.091	2.357
1i	281.701	392.458	-1	-0.118	0	85.966	2.151
1j	267.243	341.633	-1	-0.122	1	83.237	1.869
1k	301.319	79.496	-2	-0.527	0	62.767	0.309
1l	250.256	796.976	0	-0.288	0	89.718	1.852
1m	276.217	1784.101	1	0.048	0	100	3.091
1n	281.701	384.505	-1	-0.113	0	85.956	2.177
1o	267.243	203.071	-2	-0.104	1	78.451	1.743
1p	304.271	2055.308	1	0.284	2	100	3.615

1q	301.688	221.361	-2	-0.005	1	81.754	2.192
1r	282.298	1747.192	0	-0.04	2	100	2.663

Table 3: Antimicrobial activity (Paper Disc Diffusion) zone of inhibition (MM)

Compounds	ANTI BACTERIAL ACTIVITY				ANTIFUNGAL	ACTIVITY
	S. aureus	*E. faecalis*	*E. coli*	*P. aeruginosa*	*C. albicans*	*C. cocii*
1a	21	18	20	9	22	19
1b	19	24	15	12	19	16
1c	25	20	19	10	26	23
1d	20	19	13	10	21	21
1e	17	14	18	11	29	18
1f	24	11	20	8	18	15
1g	26	23	11	10	25	20
1h	16	15	19	6	27	21
1i	14	26	14	9	27	15
1j	25	19	13	7	26	20
1k	12	11	18	12	26	21
1l	29	21	12	8	21	18
1m	15	19	17	10	29	21
1n	14	13	21	9	28	17
1o	27	15	19	9	19	23
1p	22	25	16	11	27	21
1q	13	23	12	10	23	15
1r	19	21	15	9	21	19
Amoxycillin	40	35	25	18	-	-
Clotrimazole	-	-	-	-	34	28

Table 4: Antioxidant activity (H_2O_2method) IC_{50}

Compounds	Substituent's	IC_{50} µg/ml
1a	1-NO_2	48.63
1b	1-COH	66.71
1c	1-SOOH	51.09
1d	1-OH	73.45
1e	1-SOOH,1-OH	56.39
1f	1-CH_3. 1-C≡N	65.43
1g	1-$COCH_3$	69.70
1h	1-NO_2,1-Cl	45.14
1i	1-Cl,1-C≡N	60.04
1j	1-NO_2	47.49

1k	1-$SOONH_2$	57.23
1l	1-COC_6H_5	68.13
1m	3-F	63.27
1n	1-Cl,1-C≡N	59.85
1o	1-NO_2	47.26
1p	1-CH_3,3-F	65.79
1q	1-Cl,1-NO_2	44.56
1r	2-OCH_3	75.18
Ascorbic Acid	Standard	5.84

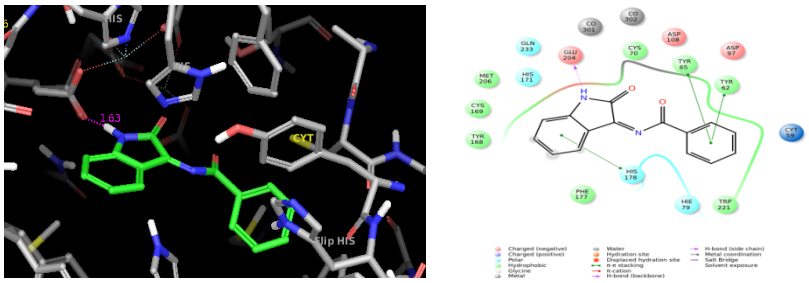


Figure 2: Interaction of Compound 1m with e-MetAP in 3-d and 2-D

RESULTS AND DISCUSSION

Chemistry

The schiff bases of isatin were synthesized as presented in the above scheme by reacting equimolar quantities of isatin with substituted anilines in good yield (75-90%). The analytical and spectral data of all the synthesized compounds were in full agreement with the proposed structures. The IR spectra of synthesized compounds under study were recorded in the solid state using attenuated transmission reflectance. The IR spectra of compounds (1a-1r) showed the appearance of characteristic C=N bands within 1610-1635 cm^{-1} region and NH spectra within 3350-3400 cm^{-1} region. The ^{1}H-NMR spectra of synthesized compounds showed characteristic peak between 6.3-7.2 for the aromatic hydrogens and NH leads to a singlet equivalent to one hydrogen at 9.4-11.6. For compounds 1c and 1d the characteristic peak was observed at δ11.02 (s, 1H, SO_3H), 13.3 (s,1H, NOH) respectively. For compounds, 1g and 1r the characteristic peak was observed at δ3.4 (s, 1H, OCH3), 2.4 (s, 1H, $COCH_3$) respectively.

Molecular Docking

All the compounds (1a-1r) were subjected to molecular docking. A comparative study of glide energy and hydrogen bond (Table 1) interaction in Methionine amino peptidase in *E. coli* (eMetAP) was performed which revealed that all the compounds showed good to moderate interaction with the receptor. The synthesized ligands interacted with the receptor e-Methionine amino peptidase in *E. coli* (*Escherichia coli*) by forming hydrogen bonds with this receptor. The H-boning interaction of the synthesized ligands and the receptor includes bonding with THR99, GLU204, CYS169 and HIE79. The ligands 1l and 1b did not show interaction through H-bonding. Compound 1m showed good interaction with e-MetAP (Figure 2).

ADME Prediction

The ADME profile (Table 2) of all the synthesized compounds was analyzed to be optimum to show a drug able behavior. All the ligands have satisfied the molecular weight criteria as per Lipinski's rule. QPP Caco parameter of the ligands had shown optimum result except four ligands having QPP Caco value less than 25. The CNS activity parameter of the ligands is -2 to 1 depicting negligible CNS activity in case of ligands having value between 0 to -2. All the rest parameters have the optimum result for the synthesized ligands except QPlogPo/w parameter for some of the ligands.

Antimicrobial activity and Antioxidant activity

Antimicrobial activity of synthesized compounds was compared against the standard drug Amoxicillin for antibacterial activity and Clotrimazole for anti fungal activity. The synthesized compounds 1j, 1m, 1b, 1l, 1o, 1c, 1e, 1n, 1p showed broad spectrum of activity as shown in Table 3. The antioxidant activity of the synthesized compounds was performed by H_2O_2 method. Their activity was compared against the standard Ascorbic acid. The synthesized compound 1q showed potent activity as antioxidant as shown in Table 4.

CONCLUSION

Several isatin derivatives were synthesized on the basis of results obtained from molecular docking and ADME studies. The synthesized compounds were characterized by ^{1}H-NMR and IR spectra. The compounds were studied for their antimicrobial and antioxidant activities which have shown good to moderate results. Molecular docking studies of compounds 1d, 1m and 1n were also carried out and they showed good interaction with the e-Methionine amino peptidase (e-MetAP)

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