Research article

Synthesis, spectral studies, antioxidant and antibacterial evaluation of aromatic nitro and halogenated tetradeptate Schiff bases

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**GRAPHICAL ABSTRACT**

**ABSTRACT**

Herein, we report the synthesis, characterization, and biological properties of eleven (3a-3k) novel Schiff bases. The spectral data of FT-IR, \(^1\)H NMR, \(^13\)C NMR, and LC-MS are associated with these synthesized compounds. From the FT-IR analysis, we confirmed the azomethine (-C\(=\)N-) group and from \(^1\)H NMR data, the phenolic -OH proton is appeared at range \(\delta \) 13.92–14.09 ppm due to hydrogen bonding. The LC-MS analysis agreed with molecular ion peaks of synthesized Schiff bases. To evaluate the antibacterial activity of newly synthesized compounds were screened against \(b. \) licheniformis, \(b. \) species, \(e. \) coli, and \(s. \) aureus. Furthermore, the antioxidant activity was investigated by two methods 2,2-diphenyl-1-picryl hydrazyl (DPPH) and hydroxyl radical scavenging methods. The (-NO\(_2\), -Cl, -Br, -I) substituted compounds have shown good antibacterial activity against tested organisms. Also, these compounds were exhibited higher antioxidant activity by given methods.

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1. Introduction

The Schiff bases synthesized by the condensation of the active carbonyl group and primary amines with azomethine (–C=–N–) linkage may have numerous applications. Some Schiff bases were reported to possess antibacterial [1, 2], antioxidant [1, 2, 3], antifungal [4, 5], anti-HIV [6], anti-tumor [7], anti-inflammatory [8], anticancer [9], antimalarial [10, 11] and antitumor activity [11]. Phenolic Schiff base derivatives with one or more halo groups (–Cl, –Br, –I) or nitro group in the aromatic ring may show special biological activities like antibacterial [12] and antiviral [12] activities. Some isatin Schiff base derivatives were applicable for docking study [13], some Schiff bases had been synthesized and 4-halo/nitro substituted 2,2′-((alkane-1,3-diylbis (azanylylidene))bis(ethan-1-yl-1-ylidene))bis(naphthalen-1-ol) derivatives have been synthesized and characterized by spectral data. Also screened for their biological potential.

2. Experimental

2.1. Chemical material and instrumentation

For the experimental work, the chemicals were purchased by aura, spectrochem & TCI and without further purification. In the laboratory, thin layer chromatography (TLC) was conducted by 0.25-mm merck gel plates (60F-254). Synthesized compounds were dissolved in a minimum amount of acetic acid, spotted on the given TLC plate, and ran through a solution of ethyl acetate and benzene. The melting point determination of compounds was conducted by digital apparatus koefer banc. The elemental analysis of the synthesized compounds was carried out through perkin-elder 240 elemental analyzer. The structure of unknown compounds was agreed upon by different spectral characterization. FT-IR spectrometer was recorded KBr pellets on a perkin-elder 2000 at 8 cm⁻¹ resolution in the region 4000–400 cm⁻¹. 1H NMR spectra were carried out with bruker avance III HD 300/400 operating at 300/400 MHz using CDC13 solution with TMS at internal standard. 13C NMR spectra obtained with bruker avance III HD 300 operating at 300 MHz using CDC13 solution with TMS at internal standard. Mass spectra recorded on LC-MS (ESI) mass spectrometer at 70 ev.

2.2. Synthesis

2.2.1. General synthesis of Schiff base compounds (3a-3k)

Schiff bases had been synthesized by mixing of warm absolute ethanolic solution of substituted 1-(1-hydroxynaphthalen-2-yl)ethan-1-one (2 mmol) with ethane-1,2-diamine (1 mmol) (3a-3e) as well as with propane-1,3-diamine (1 mmol) (3f-3h) and also with pentane-1,3-diamine (1 mmol) (3i-3k). In each reaction mixture catalytic amount of acetic acid (2–3 drops) was added and refluxed for 3–4 h (Scheme-1). The progress of the reaction mixture was monitored on TLC using pet-ether: ethyl acetate (8:2V/V) as eluent. After completion, the reaction mixture was kept overnight at room temperature. The crystalline compound was filtered, washed with cold water, and re-crystallized from absolute ethanol. The purity of the product was checked by using TLC and the physical data were tabulated in Table 1.

2.2.2. Procedure for antibacterial activity

The given compounds were screened for antibacterial activity against the bacteria bacillus licheniformis, bacillus species, escherichia coli, and staphylococcus aureus by using well diffusion method. The microbial bases had done with spectroscopic techniques (FT-IR, 1H NMR, 13C NMR, and LC-MS). The result of this article will be useful for the upcoming researchers to gain more information about the antibacterial and antioxidant activities of Schiff bases (see Scheme 1).

![Scheme 1. Synthesis of Schiff Bases (3a-3k).](image-url)

| Specifications Table |
|----------------------|
| **Subject area**     | Organic Chemistry |
| **Compounds**        | 4-halo/nitro substituted 2,2′-((alkane-1,3-diylbis (azanylylidene))bis(ethan-1-yl-1-ylidene))bis(naphthalen-1-ol) |
| **Data category**    | Synthesized, Spectral and Biological data. |
| **Data acquisition format** | FT-IR, 1H NMR, 13C NMR, Mass spectra, Elemental analysis |
| **Data type**        | Experimental |
| **Procedure**        | A series of substituted 4-halo/nitro substituted 2,2′-((alkane-1,3-diylbis (azanylylidene))bis(ethan-1-yl-1-ylidene))bis(naphthalen-1-ol) derivatives have been synthesized and characterized by spectral data. Also screened for their biological potential. |
| **Data accessibility** | Data is with this article. |
suspension (100uL) having 108 CFU mL$^{-1}$ of bacteria was carried out with the help of Mueller-Hinton agar (MHA) medium. The plates were incubated at 37°C. Check, and that was put into the well (6 mm). The plates were incubated for 18 h for zone of inhibition. The extract had determined for the bacterial species in zone of inhibition of the extract had determined for the bacterial species in zone sizes around each well. The compounds produced diameters of the zone of inhibition as compared to standard ciprofloxacin [35, 36].

### 2.2.3. Determination of minimum inhibitory concentration (MIC)

The broth dilution method is applicable for the minimum inhibitory concentration of given compounds. The concentration of compounds was prepared 8 mg/mL in the first tube containing 1 mL of broth. The conduits were vortexes to make the initial standard concentration. These were serially diluted to other cannulas. Finally, 1 mL of broth was added to the last tube and prepared the dilution of 0.25, 0.50, 0.75, 1.0 mg/mL. To all these tubes, 0.1 mL of the log phase culture of target microorganisms were added separately and incubated at 37°C for 24–48 h for bacteria. After incubation, the lowest concentration of tube solution with no detectable bacterial growth was considered a minimum inhibitory concentration.

### 2.2.4. Antioxidant activity

#### 2.2.4.1. Procedure for 2, 2-diphenyl-1-Picryl hydrazyl (DPPH) assay

DPPH (2, 2-diphenyl-1-picryl hydrazyl) radical scavenging assay was carried out [37] with slight modifications. The 1 mL ethanol solution had different concentrations of synthesized compounds. It was added with an equal volume of 0.1 mmol ethanol solution of DPPH. The prepared solution settled for incubation at room temperature. The decreases in the concentration of DPPH were measured by noting the absorbance at 517 nm. A similar test was performed with ascorbic acid, as an internal standard, instead of Schiffs base. The percentage scavenging of DPPH free radical for each concentration of test compounds had calculated the absorbance of negative control using Eq. (1).

\[
\% \text{ scavenging} = \frac{\text{absorbance of control} - \text{absorbance of test sample}}{\text{absorbance of control}} \times 100
\]

#### 2.2.4.2. Procedure for hydroxyl radical scavenging assay

Hydroxyl radical scavenging activities of given compounds were determined by using the earlier reported method [37]. The reaction cocktail included 60 μL of 1 mm FeCl$_3$, 90 μL of 1 mm 1,10 phenanthroline, 2.4 mL of 0.2 M phosphate buffer (pH 7.8), 150 μL of 0.17 M H$_2$O$_2$, and 1.5 mL of various concentrations of each compound. The prepared solutions of given compounds were kept at room temperature for 5 min incubation, and absorbance was measured at 560 nm with the help of spectrophotometer. The α-tocopherol was used as the reference compound for hydroxyl radical scavenging assay.

### 3. Result and discussion

All the synthesized Schiff bases are in different colors and they are stable in air and moisture at room temperature. They are soluble in methanol, dimethyl sulphoxide, dimethylformamide, dichloromethane, and partially soluble in ethanol. The spectral data of FT-IR, H NMR, 13C NMR, and LCMS confirmed their structure.

### 3.1. FT-IR analysis

FT-IR spectra of given compounds performed with the KBr pellet technique, and the observed results are in Table 2. The stretching bands are observed at 3444-3403 cm$^{-1}$ due to the phenolic –OH group and 1665-1622 cm$^{-1}$ due to the (C=O) stretching mode of the imine group. The IR absorption peak at 1278–1263 cm$^{-1}$ shows the phenolic (C–O) group with the presence of the keto-amine group having (N=O–H) intramolecular hydrogen bonding only in the solid-state [38]. The Schiff bases have shown two C–X stretching vibrations in the range of 794–760 cm$^{-1}$ which confirms that the halogen groups are presented at the para position to the aromatic –OH group [38, 39]. Even two stretching vibrations have been observed in the range 1573–1523 cm$^{-1}$ and

### Table 1. Physical properties of Schiff bases (3a-3k).

| compound | molecular formula | color     | yield% | M.P. (°C) |
|----------|-------------------|-----------|--------|-----------|
| 3a       | C$_{20}$H$_{24}$O$_2$N$_2$ | yellow    | 88     | 128–130   |
| 3b       | C$_{20}$H$_{24}$O$_2$NCl$_2$ | yellow   | 85     | 158–160   |
| 3c       | C$_{20}$H$_{24}$O$_2$NBr$_2$ | brown    | 90     | 172–174   |
| 3d       | C$_{20}$H$_{24}$O$_2$NI$_2$ | pale yellow | 92     | 182–184   |
| 3e       | C$_{20}$H$_{24}$O$_2$NSe$_2$ | yellow  | 82     | 205–207   |
| 3f       | C$_{20}$H$_{24}$O$_2$NBr$_2$ | brown    | 92     | 135–137   |
| 3g       | C$_{20}$H$_{24}$O$_2$NCl$_2$ | yellow  | 88     | 195–199   |
| 3h       | C$_{20}$H$_{24}$O$_2$NCl$_2$ | green    | 78     | 220–222   |
| 3i       | C$_{20}$H$_{24}$O$_2$NBr$_2$ | yellow  | 90     | 192–194   |
| 3j       | C$_{20}$H$_{24}$O$_2$NBr$_2$ | brown    | 81     | 235–237   |

### Table 2. FT-IR values of Schiff bases (3a-3k).

| compound | μ(0–H) cm$^{-1}$ | μ(–C–N–) cm$^{-1}$ | μ(C=C) cm$^{-1}$ | μ(C–N–C) cm$^{-1}$ | μ(C–X) cm$^{-1}$ | μ(N–O) cm$^{-1}$ |
|----------|-----------------|-------------------|-----------------|-------------------|-----------------|-----------------|
| 3a       | 3434            | 1629              | 1452            | 1018              | –               | –               |
| 3b       | 3444            | 1640              | 1457            | 1076              | 788,761         | –               |
| 3c       | 3419            | 1630              | 1440            | 1068              | 788,763         | –               |
| 3d       | 3440            | 1646              | 1457            | 1070              | 794,760         | –               |
| 3e       | 3413            | 1636              | 1467            | 1081              | –               | 1573, 1413      |
| 3f       | 3403            | 1622              | 1450            | 1072              | 790,765         | –               |
| 3g       | 3407            | 1635              | 1450            | 1076              | 790,765         | –               |
| 3h       | 3417            | 1650              | 1455            | 1076              | –               | 1527, 1384      |
| 3i       | 3444            | 1640              | 1452            | 1078              | 790,769         | –               |
| 3j       | 3440            | 1647              | 1457            | 1018              | 786, 760        | –               |
| 3k       | 3430            | 1630              | 1450            | 1027              | –               | 1523, 1388      |
1413–1384 cm\(^{-1}\) due to the \(-\text{NO}_2\) group. Table 2 and the supplementary file (Fig. No. S1 to S11) represents spectroscopic data (IR) of given Schiff bases (3a-3k) (see Table 3).

### 3.2. \(^1\text{H} \text{ NMR analysis}\)

\(^1\text{H} \text{ NMR spectral data of Schiff bases analyzed in CDCl}_3 \) solvent, from the data, the presence of multiplets at \(\delta\) value between 6.78–8.53ppm is due to aromatic protons. The appearance of the singlet at \(\delta 165.1\) ppm due to a C\(_{-}\)OH proton having (N-O--H) intramolecular hydrogen bonding. In compounds (3a-3h)--CH\(_2\) groups have shown singlet at range \(\delta 2.45–2.49\)ppm of 6H indicating that they are symmetrically equivalent. The compounds (3i, 3j, 3k),--CH\(_3\) groups have shown two singlets at range \(\delta 2.44–2.47\)ppm, which indicates that they are symmetrically non-equivalent. The spectral data of \(^1\text{H} \text{ NMR}\) is represented in the supplementary file (Fig. No.S12 to S22) of synthesized Schiff bases (3a-3k).

### 3.3. \(^{13}\text{C} \text{ NMR analysis}\)

In \(^{13}\text{C} \text{ NMR spectra, the peaks are observed at the range of } \delta \text{ value from 105 to 140ppm is due to aromatic and olefinic carbon. The signal present at } \delta 175.1–175.5\)ppm confirms azomethine (C=N--) group, and the phenolic C\(_{-}\)OH carbon atom showed a sharp peak at \(\delta 170.6–171.7\)ppm. The Schiff bases (3e, 3h, 3k) display signal at \(\delta 165.1–164.5\)ppm due to a C\(_{-}\)-NO\(_2\) bond. Schiff bases (3b-d, 3f, 3g, 3i, 3j) have exhibited a peak at \(\delta 132.1–135.0\)ppm stipulates the presence of a C\(_{-}\)-X bond and the signal present at \(\delta 14.3–14.6\)ppm due to \(-N=CH-\) group. The spectral data of \(^{13}\text{C} \text{ NMR}\) is represented in the supplementary file (Fig. No. S23 to S33) of given Schiff bases (3a-3k).

### 3.4. LC-MS analysis

The LC-MS spectra of the Schiff bases exhibited different fragmentation patterns as expected, and results were getting to be in good agreement with their molecular formulae. --Cl and --Br containing Schiff bases gave different molecular ion peaks due to its isotopic effect. The molecular ion peak of the Schiff bases is displayed at \([M + H]^+\) peak. Especially the aromatic nitro Schiff bases (3e, 3h, 3k) lose \(-\text{NO}_2\) radical and give molecular ion peak (M – \text{NO}_2) [39]. The spectral analysis (FT-IR, \(^1\text{H} \text{ NMR}, \(^{13}\text{C} \text{ NMR}, \) and LC-MS) confirmed that the synthesized compounds are Schiff bases. The mass spectrometry data of synthesized Schiff bases (3a-3k) is represented in the supplementary file (Fig. No. S34 to S44).

### 3.5. Antibacterial activity

The experimental details and zone of inhibition of Schiff bases concerning the antibacterial activity against the bacterial strains is illustrated in table no.3. Among the eleven Schiff bases, the compound 3i has more potent against tested all four micro-organisms. The Schiff bases 3b, 3d, 3k are more effective against b. Lichenifermis and the compounds 3b, 3e, 3j show the higher activity against e. coli. Also, the compounds 3f, 3j are more potent against Bacillus sp., and compounds 3f, 3h give promising activity against s. aureus. The synthesized Schiff bases with the electron-withdrawing group such as [\(-\text{Cl}, -\text{Br}, -\text{I}, \) and \(-\text{NO}_2\)] and extended carbon chain of diamines suggest more potent in antibacterial activities. The impact of electronegative groups like \(-\text{Cl},-\text{Br},\) and \(-\text{NO}_2\) is more effective than the \(-\text{H}\) and \(-\text{I}\) group on synthesized compounds. The antibacterial activity of these compounds is represented graphically in Figure 1.

The minimum inhibitory concentration was done at 0.25, 0.50, 0.75, and 1.0 mg/mL; the observed results are presented in Table 4. The Schiff base 3i has a good inhibition character at minimum concentration against referred microorganisms. It indicates the \(-\text{Cl}\) group and extended carbon chain of diamine which gives more potent biological activity. The Schiff bases 3b, 3d, 3k have shown good inhibition against b. Lichenifermis (gram-positive), and compounds 3f, 3h, 3k show high potent against b. species (gram-positive). The compounds 3e, 3j against e. coli (gram-negative) strain, and compounds 3f, 3h against s. aureus (gram-positive) organisms have conveyed good inhibition at a minimum concentration (0.25 mg/mL).

### Table 3. Antibacterial activity of Schiff bases (in mm) (3a-3k).

| sample | B. Lichenifermis | Bacillus Sp. | E.coli | S.aureus |
|--------|-----------------|-------------|--------|---------|
| 3a     | 08              | 07          | 07     | 08      |
| 3b     | 24              | 19          | 16     | 20      |
| 3c     | 17              | 20          | 11     | 21      |
| 3d     | 23              | 13          | 09     | 16      |
| 3e     | 09              | 16          | 18     | 20      |
| 3f     | 10              | 22          | 10     | 27      |
| 3g     | 16              | 12          | 11     | 13      |
| 3h     | 19              | 25          | 08     | 26      |
| 3i     | 25              | 23          | 19     | 28      |
| 3j     | 12              | 15          | 17     | 19      |
| 3k     | 26              | 24          | 10     | 18      |
| ciprofloxacin | 27          | 26          | 20     | 30      |
| DMSO   | 00              | 00          | 00     | 00      |
| average| 17.18           | 17.81       | 12.36  | 19.63   |

### Table 4. MIC of Schiff bases (in Mg/mL) (3a-3k).

| sample | bacterial pathogens |
|--------|---------------------|
|        | B.Lichenifermis Mg/mL | Bacillus sp. Mg/mL | E.coli Mg/mL | S.aureus Mg/mL |
| 3a     | 0.638              | 0.792              | 0.792       | 0.653       |
| 3b     | 0.172              | 0.261              | 0.267       | 0.256       |
| 3c     | 0.267              | 0.272              | 0.272       | 0.291       |
| 3d     | 0.229              | 0.642              | 0.690       | 0.667       |
| 3e     | 0.531              | 0.267              | 0.192       | 0.269       |
| 3f     | 0.639              | 0.218              | 0.609       | 0.235       |
| 3g     | 0.351              | 0.739              | 0.752       | 0.761       |
| 3h     | 0.279              | 0.162              | 0.713       | 0.169       |
| 3i     | 0.149              | 0.140              | 0.149       | 0.138       |
| 3j     | 0.632              | 0.275              | 0.172       | 0.329       |
| 3k     | 0.153              | 0.158              | 0.571       | 0.269       |
| ciprofloxacin | 0.107          | 0.107              | 0.097       | 0.112       |
| average| 0.367273           | 0.356909           | 0.470818    | 0.367       |

**Figure 1.** Antibacterial activity of Schiff bases (3a-3k) against gram positive and gram negative error bars represents the standard deviation of triplicate measurements.
Table 5. Antioxidant activity of Schiff bases (3a-3k).

| sample | DPH (%) | OH (%) |
|--------|---------|--------|
| 3a     | 55.89 ± 0.55 | 62.93 ± 0.25 |
| 3b     | 75.19 ± 0.15  | 72.50 ± 0.15  |
| 3c     | 72.99 ± 0.15  | 56.12 ± 0.51  |
| 3d     | 59.91 ± 0.89  | 47.90 ± 0.76  |
| 3e     | 62.89 ± 0.55  | 61.93 ± 0.15  |
| 3f     | 52.24 ± 0.03  | 57.17 ± 0.53  |
| 3g     | 78.56 ± 0.45  | 73.28 ± 0.17  |
| 3h     | 78.28 ± 0.36  | 77.77 ± 0.91  |
| 3i     | 67.99 ± 0.51  | 78.25 ± 0.21  |
| 3j     | 72.29 ± 0.45  | 70.55 ± 0.78  |
| 3k     | 79.28 ± 0.36  | 73.77 ± 0.31  | ascorbic acid | 85.42 ± 0.78 | – |
|        |          |          | α-tocopherol | 82.50 ± 0.84 | – |
| average | 68.68 | 66.55 |

3.6. Antioxidant activity

The antioxidant activity is one of the prime activities for the Schiff bases by using DPPH and hydroxyl radical scavenging assay. Ascorbic acid is used as a control compound for the DPPH method whereas α-tocopherol is used for the hydroxy method; the observed results are illustrated in Table 5. The compounds (3b, 3g, 3h, 3k) containing an electron-withdrawing group at the para position to phenolic–OH group were shown more potent with antioxidant activity by both methods. The results of both techniques reveal that the electron-withdrawing substitution with an extended carbon chain of diamines perform alternating antioxidant activity. The obtained data of compounds is mean graphically in Figure 2.

3.7. Spectral data

\[ \text{[E-2,2'-(ethane-1,2-diylbis(azanylylidene))bis(ethan-1-yl-1-ylidene)] bis(naphthalen-1-ol) (3a)} \]

Yield – 349.53 mg, 88%, Color - Yellow, M.P. 128–130 °C. FT-IR (KBr, cm\(^{-1}\)) : 3434 (OH), 1629 (C = N), 1452 (C = C), 1018 (C–N–C).

\[ \text{1}^1\text{H NMR (400MHz,CDCl}_3\text{)}: \delta \ 14.02 (s,2H,Ar-OH), 8.48–6.82 \text{ (m,12H, Ar-H)}, 4.05 (s,4H,CH\(_2\)), 2.49 (s,6H,CH\(_3\)). \]

\[ \text{13}^1\text{C NMR (300MHz,CDCl}_3\text{)}: \delta \ 175.2 (C=O), 137.1–108.1 (Ar-C), 14.5 (N=C=CH\(_3\)). \]

ESIMS (m/z): 397.40.

Anal. Cal. For C\(_{26}\)H\(_{24}\)O\(_2\)N\(_2\): C 78.78, H 6.60, N 7.07; found C 78.60, H 6.82, N 7.72.

\[ \text{[E-2,2'-(ethane-1,2-diylbis(azanylylidene))bis(ethan-1-yl-1-ylidene)] bis(4-chloronaphthalen-1-ol) (3b)} \]

Yield – 395.34 mg, 85%, Color - Yellow, M.P. 158–160 °C. FT-IR(KBr, cm\(^{-1}\)) : 3444 (OH), 1640 (C = N), 1457 (C = C), 1076 (C–N–C), 788 (C=Cl), 761 (C-Cl) cm\(^{-1}\).

\[ \text{1}^1\text{H NMR (300MHz,CDCl}_3\text{)}: \delta \ 13.93 (s,2H,Ar-OH), 8.50–6.79 \text{ (m,10H, Ar-H)}, 4.09 (s,4H,CH\(_2\)), 2.49 (s,6H,CH\(_3\)). \]

\[ \text{13}^1\text{C NMR (300MHz,CDCl}_3\text{)}: \delta \ 175.3 (C=O), 137.1–108.2 (Ar-C), 13.93 (s,2H,Ar-OH), 14.5 (N=C=CH\(_3\)). \]

ESIMS (m/z): 566.40.

Anal. Cal. For C\(_{26}\)H\(_{24}\)O\(_2\)N\(_2\)Cl\(_2\): C 57.04, H 4.25, N 4.92; found C 56.04, H 4.51, N 5.09.

\[ \text{[E-2,2'-(ethane-1,2-diylbis(azanylylidene))bis(ethan-1-yl-1-ylidene)] bis(4-bromonaphthalen-1-ol) (3c)} \]

Yield – 583.44 mg, 88%, Color - Yellow, M.P. 195–197 °C. FT-IR (KBr, cm\(^{-1}\)) : 3407 (OH), 1635 (C = N), 1450 (C = C), 1076 (C–N–C), 790 (C=Br), 765 (C-Br) cm\(^{-1}\).

\[ \text{1}^1\text{H NMR (400MHz,CDCl}_3\text{)}: \delta \ 14.02 (s,2H,Ar-OH), 8.45–7.26 \text{ (m,10H, Ar-H)}, 3.81 (t,4HJ = 4.5Hz,CH\(_2\)), 2.47 (s,6H,CH\(_3\)), 2.32 (s,2HJ = 4.5Hz,CH\(_2\)). \]

Figure 2. Antioxidant activity of Schiff bases (3a-3k) error bars represents the standard deviation of triplicate measurements.
The current study describes the synthesis of new eleven Schiff bases having an electronegative group (-Cl, -Br, -I, and –NO2) located at para position to the phenolic –OH group. They are confirmed by using instrumental techniques viz. FT-IR, 1H NMR, 13C NMR, and LCMS analysis, also evaluated biologically by antibacterial and antioxidant activities. From the FT-IR analysis, we confirm the azomethine (C=N−) group, and the 1H NMR peaks of the phenolic –OH proton are shown at δ 13.92–14.09 ppm due to hydrogen bonding. The LC-MS analysis agrees with molecular ion peaks of synthesized Schiff bases. The screening data for antibacterial activity shows that electronegative-substituted Schiff bases are more potent against the tested gram-positive and gram-negative bacteria. Among these Schiff bases, compound 3i shows the best Antibacterial activity against all tested pathogens. From this, it is concluded that the influence of the –Cl group and extended carbon chain of diamines on synthesized compounds is more effective than other substituent's. The comparative determination of the total antioxidant capacity also shows the highest value for the electronegative Schiff bases with an extended carbon chain of diamines by DPPH and the hydroxyl radical scavenging method.

Declarations

Author contribution statement

Bhagwat Vhanale: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Digambar Kadam: Analyzed and interpreted the data.

Avinash Shinde: Conceived and designed the experiments.

Digambar Kadam: Analyzed and interpreted the data.

Avinash Shinde: Conceived and designed the experiments.

Avinash Shinde: Contributed reagents, materials, analysis tools or data.

Avinash Shinde: Wrote the paper.

Avinash Shinde: Supervised the project.

Avinash Shende: Revised the manuscript.
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