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INVESTIGATIONS ON SYNTHESIS, CHARACTERIZATION AND ANTIOXIDANT PROPERTIES OF 2-HYDROXY NAPHTHALDEHYDE BASED SCHIFF BASE DERIVATIVES AS POTENTIAL BIOACTIVE MOTIFS

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ABSTRACT

A series of amine-substituted Schiff base derivatives of 2-hydroxy naphthaldehyde were synthesised via highly efficient catalytic reactions, which have been duly characterised by various spectroscopic methods. These compounds were evaluated for their potential antioxidant activities through DPPH radical scavenging and Ferric Reducing Antioxidant Power (FRAP) assays. All the synthesised compounds exhibited a concentration-dependent enhancement in radical neutralisation efficiency and ferric ion reducing capacity across the investigated concentration range. Derivatives bearing electron-donating and extended π-conjugated amine substituents exhibited comparatively higher electron-transfer capability. The observed variations in activity indicate that modulation of electronic density within the conjugated system significantly enhances antioxidant efficiency. The present investigation contributes to SDG-3 (Good Health and Well-Being) through identification of a new series of Schiff Base derivatives with potential relevance to oxidative stress-associated disorders while simultaneously supporting SDG-4 (Quality Education) through the generation of scientific knowledge, interdisciplinary research and research-oriented learning.

Keywords: Antioxidant, Schiff Base, Radical Scavenging, DPPH, FRAP.

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INTRODUCTION

Oxidative stress is a degenerative state in the body that occurs when endogenous antioxidant defenses are unable to effectively counteract excessive reactive oxygen species (ROS). These species are known as key factors for the onset and progression of degenerative diseases, cardiovascular disorders, neuroinflammation and premature ageing. Excess ROS, including superoxide anion and hydroxyl radical, initiate lipid peroxidation of cellular membranes, leading to loss of membrane integrity and altered permeability, while oxidative modification of proteins results in enzyme inactivation and impaired signal transduction.[1a] In addition, ROS-induced DNA damage, including base modifications, contributes to genomic instability and abnormal cellular function.[1b] At the molecular level, these oxidative events disrupt redox-sensitive pathways involved in inflammation, mitochondrial dysfunction, and glucose metabolism, thereby playing a critical role in the progression of degenerative and metabolic disorders. Consequently, compounds capable of neutralising free radicals or reducing oxidised intermediates are of significant interest, as they may prevent or delay ROS-mediated cellular damage.[1c-d] Therefore, the search for efficient antioxidant agents remains a central theme in medicinal chemistry and biomedical research. While numerous natural and synthetic antioxidants have been investigated to fulfil the need of substrate which can cut down or lower these degenerative diseases but in the development of these species is limited by stability, bioavailability and specificity, necessitating the synthesis of new scaffolds with improved performance and pharmacological characteristics.[2] In this regard, the present work supports Sustainable Development Goal 3 (Good Health and Well-Being) by synthesising and evaluating a new series of Schiff base derivatives as potent antioxidants for future biomedical investigations. Moreover, the study combines synthetic organic chemistry, comprehensive spectroscopic characterisation, and biological screening within a multidisciplinary research framework, thereby supporting Sustainable Development Goal 4 (Quality Education) through research-driven learning and innovation.

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Recently, hydroxynaphthalene and hydroxynaphthoquinone derivatives have emerged as promising candidates owing to their ability to donate hydrogen atoms and stabilise reactive intermediates.[3] Among the diverse members of this class, hydroxy-substituted naphthaldehydes represent a particularly intriguing subgroup, as the presence of both hydroxyl and aldehyde functionalities in conjugation offers additional opportunities for redox modulation. Structurally, the hydroxy-naphthaldehyde framework represents an electronically versatile aromatic system, comprising an extended conjugated π-network spanning the naphthalene ring and the formyl substituent. This conjugation facilitates efficient delocalisation of π-electrons and stabilises radical intermediates generated during redox transformations. The phenolic hydroxyl group can engage in intramolecular hydrogen bonding with the carbonyl oxygen, establishing a quasi-chelated conformation that enforces molecular planarity and enhances electronic communication between the hydroxyl and aldehydic moieties (Fig.-1).[1e-f] Thus, the antioxidant potential of the hydroxy-naphthaldehyde core arises from a synergistic interplay of hydrogen atom transfer (HAT) and single-electron transfer (SET) mechanisms to neutralise free radicals, wherein intramolecular hydrogen bonding and extended π-conjugation collectively facilitate redox stability and radical-scavenging efficiency.[4]

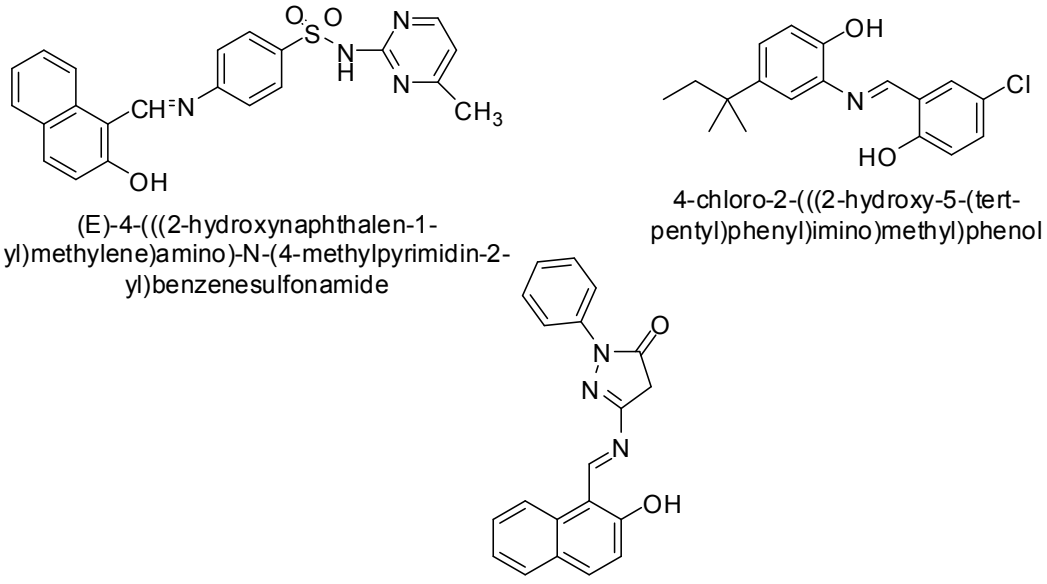


Fig.-1: Structural Features Associated with Antioxidant Activity

Hydroxy-naphthaldehyde and derivatives of this scaffold have been documented to exhibit a wide spectrum of activities, including antioxidant[5a], antimicrobial[5b], antifungal[5c], anti-inflammatory[5d], enzyme inhibitory[5e] and anticancer[6] properties. The antioxidant potential arises from the hydrogen-donating capacity of the compound and the ability to delocalize unpaired electrons, thereby stabilising reactive oxygen species (ROS). These diverse biological effects highlight the significance of the hydroxy-naphthaldehyde framework in medicinal chemistry. Several naturally occurring hydroxynaphthalene and hydroxynaphthoquinone derivatives exemplify the intrinsic redox potential of this molecular class. 4,8-dihydroxy-5-methoxy-2-naphthaldehyde, isolated from *Diospyros kaki* and naphthoquinone derivatives found in *Diospyros nigrescnes* exhibited significant radical-scavenging activity in vitro.[6a-b] A fungal polyketide intermediate, 1,8-dihydroxynaphthalene is identified for its capacity to stabilise ROS through peri-hydroxylation. Sea urchins are a natural source of polyhydroxylated naphthoquinone pigment, recognised for its significant reactive oxygen species (ROS) scavenging activity.[7] Terrestrial plants also yield a notable number of compounds: lawsone (2-hydroxy-1,4-naphthoquinone), a natural pigment of *Lawsonia inermis* (henna), demonstrates good antioxidant capacity,[8] while juglone (5-hydroxy-1,4-

naphthoquinone) from walnut husks shows pronounced radical-scavenging behavior.[9] These natural representatives (Fig.-2) collectively emphasise how subtle changes in substitution around the hydroxynaphthalene core modulate antioxidant responses and biological activity.[7]

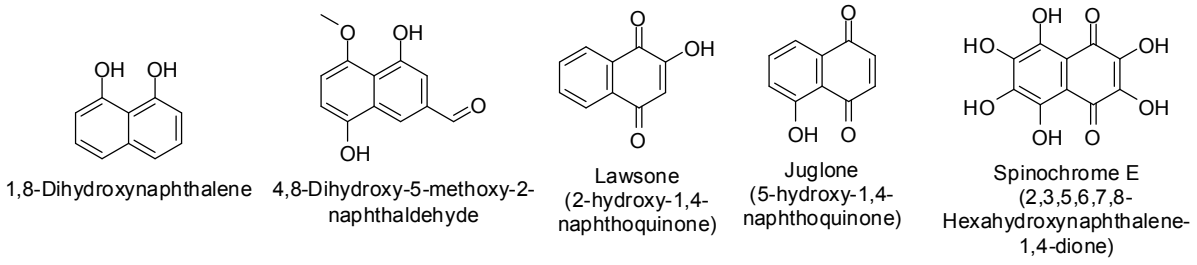


Fig.-2: Natural Hydroxynaphthalene and Hydroxynaphthoquinone Derivatives

In view of this potential, numerous synthetic derivatives of hydroxy-naphthaldehyde (Fig.-3) have been explored for antioxidant efficiency. Bis-lawsone derivatives, such as 3,3′-(aryl-methylene)bis(2-hydroxy-1,4-naphthoquinones), demonstrated enhanced DPPH radical scavenging relative to the monomer.[10,16-17]

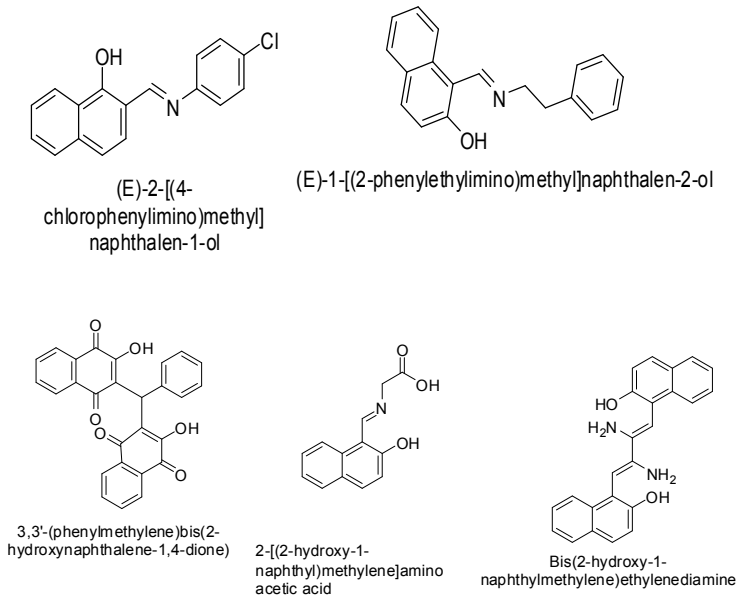


Fig.-3: Synthetic Derivatives of hydroxy-1-naphthaldehyde

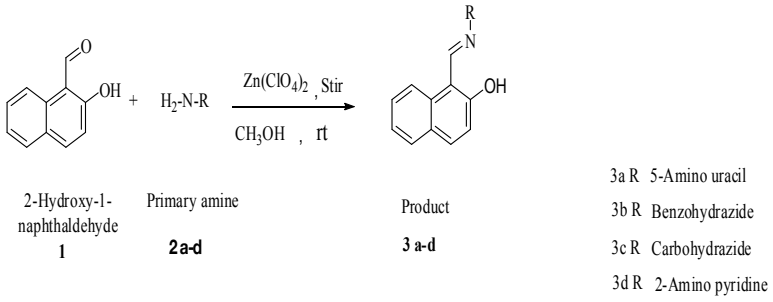
From a structural perspective, imine (C=N) frameworks are well recognised in medicinal chemistry due to their ease of synthesis, structural versatility and ability to participate in redox-related biological interactions. In this context, several azomethine derivatives have been recorded for possessing significant antioxidant potential. Hydroxy-naphthaldehyde-derived imine conjugates with benzohydrazones exhibited potent radical-scavenging activity, which is as high as that of ascorbic acid, a naturally occurring antioxidant.[11] Several studies have highlighted the influence of structural modifications on the antioxidant activity of imine-based compounds. Substituted phenylethylamine-derived imines demonstrated that the presence of electron-withdrawing groups enhances radical-quenching efficiency.[8,11,14-15] Similarly, isonicotinoyl hydrazone derivatives exhibited measurable antioxidant responses, further supporting the role of functional group variation in modulating activity.[12] In addition, halogenated imines synthesised from hydroxy-naphthaldehyde emphasised the impact of electronic effects on hydrogen-donation ability.[13] Collectively, these findings demonstrate that the hydroxy-naphthaldehyde scaffold provides a versatile

platform for targeted structural modifications aimed at optimising antioxidant potential.[16,18-23] However, despite these advances, a systematic exploration of how substitution patterns and electronic modulation within the hydroxy-naphthaldehyde core directly correlate with radical-scavenging activity has not yet been systematically addressed.[24-26.] This gap provides an opportunity to clarify structure–activity relationships and to design derivatives with enhanced antioxidant activities.

EXPERIMENTAL

General Synthetic Procedure for Schiff Base Derivatives

2-Hydroxy-1-naphthaldehyde (1.0 eq.) was dissolved in 30 mL of anhydrous methanol, and then the respective amine (1.0 eq.) was added along with a catalytic amount of zinc perchlorate, $Zn(ClO_4)_2$. The reaction was allowed to proceed at room temperature with continuous stirring under an inert atmosphere of nitrogen. After completion of the reaction (TLC), the residual solvent was evaporated using rotatory evaporator under reduced pressure to get the crude product, which was subsequently recrystallised from dichloromethane (DCM) to afford the desired product in quantitative yields.



Scheme-1: Synthesis of 2-hydroxy-1-naphthaldehyde Derivatives (3a-d)

(E)-6-(((2-hydroxynaphthalen-1-yl)methylene)amino)pyrimidine-2,4(1H,3H)-dione (3a)

Orange crystalline solid; Yield: 78%; M.P.: 258-260 °C; FTIR (ATR, cm^{-1}): 3270 (N-H), 3185 (O-H), 1654 (C=O), 1612 (C=N), 1262 (C-O), 1146 (C-N); ^{1}H-NMR (500 MHz, DMSO-d_6) (δ, ppm): 15.22 (s, 1H, OH), 11.54 (s, 1H, NH), 11.29 (s, 1H, NH), 9.87 (s, 1H, CH=N), 8.30 (d, *J*=8.0Hz, 1H, Ar-H), 7.87-7.78 (m, 5H, Ar-H), 7.33 (s, 1H, C6-H pyrimidine); ^{13}C-NMR (125 MHz, DMSO-d_6) (δ, ppm): 163, 161, 160 (C=O), 154 (C-6), 150, 149 (CH=N), 135, 133, 132, 128, 127, 126, 123, 121, 119 (naphthyl CH), 108; MS (ESI^+, m/z): $[M+H]^+$ calc. for $C_{15}H_{11}N_3O_3$: 282.28; Elemental Analysis (CHN) %: calc. for $C_{15}H_{11}N_3O_3$: C 64.05, H 3.94, N 14.94; found: C 63.90, H 3.90, N 14.89

(E)-N′-[(2-hydroxynaphthalen-1-yl)methylene]benzohydrazide (3b)

Yellow solid; Yield: 82%; M.P.: 240-242 °C; FTIR (ATR, cm^{-1}): 3270 (N-H), 3185 (O-H), 1654 (C=O, amide), 1608 (C=N, azomethine), 1262 (C-O, phenolic), 1145 (C-N); ^{1}H-NMR (500 MHz, DMSO-d_6) (δ, ppm): 12.81 (s, 1H, OH), 12.22 (s, 1H, NH, amide), 9.52 (s, 1H, CH=N), 8.22 (d, *J* = 8.5 Hz, 1H, Ar-H), 8.01 (d, *J* = 8.0 Hz, 2H, Ar-H), 7.90-7.87 (m, 2H, Ar-H), 7.66-7.55 (m, 4H, Ar-H), 7.40 (t, *J* = 7.5 Hz, 1H, Ar-H), 7.23 (d, *J* = 7.8 Hz, 1H, Ar-H); ^{13}C-NMR (125 MHz, DMSO-d_6) (δ, ppm): 162 (C=O, amide), 157 (C=N, azomethine), 146, 134, 133, 132, 131, 130, 129, 128, 127, 123, 120, 118, 108; MS (ESI^+, m/z):$[M+H]^+$ calc. for $C_{18}H_{14}N_2O_2$: 291.33; Elemental Analysis (CHN) %: calc. for $C_{18}H_{14}N_2O_2$: C 74.47, H 4.86, N 9.65; found: C 74.40, H 4.90, N 9.60.

(E)-N′-[(2-hydroxynaphthalen-1-yl)methylene]carbohydrazide (3c)

Green solid ; Yield: 79%; M.P.: 169-171°C; FTIR (ATR, cm^{-1}): 3280 (O-H, broad), 3195 (N-H), 1660 (C=O, amide), 1615 (C=N, azomethine), 1248 (C-O, phenolic), 1145 (C-N); ^{1}H-NMR (500 MHz, DMSO-d_6) (δ, ppm)**:** 16.23 (s, 1H, phenolic OH), 10.82 (s, 1H, CONH), 9.81 (br-s, 1H, NH-NH), 9.16 (s, 1H, azomethine CH=N), 8.95-7.10 (m, 12H, Ar-H), 6.78 (d, *J* = 8.2 Hz, 1H, Ar-H), 6.55 (d, *J* = 8.2 Hz, 1H, Ar-H); ^{13}C-NMR (125 MHz, DMSO-d_6) (δ, ppm):163 (C=O, CONH), 158, 156 (C=N), 148, 146, 138, 136, 134, 132, 131, 129, 128, 127, 125, 122, 120, 119, 116, 114, 112, 109;

MS(ESI$^+$, m/z): $[M+H]^+$ calc. for $C_{23}H_{18}N_4O_3$: 415.43; Elemental Analysis (CHN)% calc. for $C_{23}H_{18}N_4O_3$: C 69.34, H 4.55, N 14.06; found: C 69.33, H 4.79, N 13.97.

(E)-1-((pyridin-2-ylimino)methyl)naphthalen-2-ol (3d)

Yellow solid; Yield: 85%; M.P.: 174-175 °C; FTIR (ATR, cm^{-1}): 3265 (O-H stretching, phenol), 1610 (C=N, azomethine), 1586 (C=C aromatic), 1152 (C-N); ^{1}H-NMR (500 MHz, DMSO-d_6) (δ, ppm):11.83 (br-s, 1H, phenolic OH), 8.95 (dd, *J* = 7.9, 1.6 Hz, 1H, pyridyl H-6), 8.63 (s, 1H, CH=N), 7.90-7.30 (m, 6H, naphthyl Ar–H), 7.22 (dd, *J* = 7.9, 1.6 Hz, 1H, pyridyl H-3), 7.10-7.04 (m, 1H, pyridyl H-4), 6.92-6.86 (m, 1H, pyridyl H-5); ^{13}C-NMR (125 MHz, DMSO-d_6) (δ, ppm): 160 (C=N), 155, 150, 149, 145, 139, 136, 132, 131, 130, 128, 127, 126, 125, 122, 120; MS (ESI$^+$, m/z): $[M+H]^+$ calc. for $C_{16}H_{12}N_2O$: 249.10; Elemental Analysis (CHN) % calc. for $C_{16}H_{12}N_2O$: C 77.40, H 4.87, N 11.29; found: C 77.35, H 4.90, N 11.20.

IN VITRO ANTIOXIDANT EVALUATION

DPPH Radical Scavenging Assay

The radical-quenching efficiency of the synthesised derivatives was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method, an assay employed to measure the capacity of compounds to donate electrons or hydrogen atoms for radical neutralisation. Interaction of antioxidants with the DPPH radical results in a reduction of its deep violet chromophore[27] (Fig.-4), producing a quantifiable decrease in absorbance at the radical's maximum wavelength (λ_{max}) 517nm.

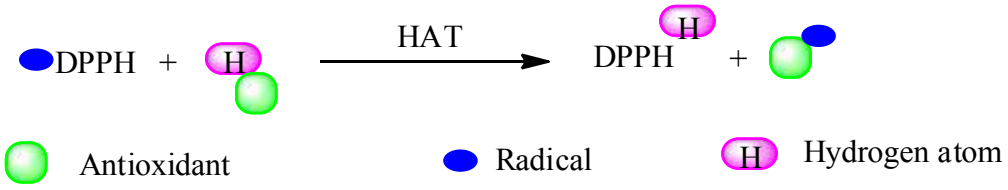


Fig.-4: Scavenging Activity of DPPH (free radical) by Antioxidant

For the complete antioxidant assay, λ_{max} was determined by performing a complete UV-Vis spectral scan of a 0.01 mM DPPH solution in DMSO. The λ_{max} observed was subsequently used for all absorbance measurements. For the assay, 1.0 mL of freshly prepared DPPH solution (0.01 mM) was mixed with 4.0 mL of test compound solutions at concentrations of 10, 20, 40, 60 and 80 ppm in DMSO. The reaction mixtures were maintained at ambient temperature in the dark for 30 min to ensure completion of the redox interaction. A control comprising 1 mL DPPH in 4 mL DMSO was prepared under identical conditions, while ascorbic acid was used as the reference antioxidant standard. Radical scavenging efficiency (% inhibition) was calculated according to the equation:

$$\% \text{ Inhibition} = [A_{(control)} - A_{(sample)} / A_{(control)}] \times 100$$

Where $A_{(control)}$ and $A_{(sample)}$ are the absorbance values corresponding to the control and test samples, respectively.[28] To assess the antioxidant potential of synthesised compounds, a variable concentration of compounds was prepared, and the antioxidant potential was determined using the DPPH assay, and results were compared with those of ascorbic acid as a reference antioxidant (Table-1).

Table-1: Data for Free Radical % Scavenging Activity of 2-hydroxy-1-naphthaldehyde Derivatives (3a-d) at 10, 20, 40, 60 and 80ppm

Entry	3a	3b	3c	3d	Ascorbic acid
10ppm	10.2	13.5	16.2	18.6	21.4
20ppm	22.6	29	32.8	36.5	41.7
40ppm	39.4	51.7	58.1	61.8	70.3
60ppm	55.1	64.5	71.4	77.3	84.5
80ppm	68.7	75.1	81.9	86.4	91.2

The in vitro antioxidant evaluation of compounds 3a-d revealed a distinct hierarchy in DPPH radical-scavenging activity, with 3d exhibiting the highest efficiency, followed by 3c, 3b, and 3a. At 80 ppm, the scavenging percentages were 86.4%, 81.9%, 75.1%, and 68.7%, respectively, approaching the standard ascorbic acid value of 91.2% (Fig.-5).

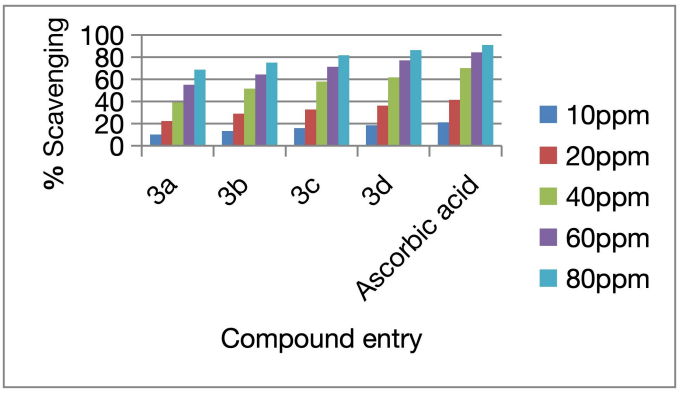


Fig.-5: Comparative Absorbance Profiles of Compounds (3a-3d) and Ascorbic Acid at Varying Concentrations

The absorption plot of concentration for the different compounds shows a significant change in their absorption behaviour. Upon calculating the oxidative potential of all the synthesised compounds, it was observed that all the compounds show significant antioxidant properties at 60ppm concentration. When the results were compared with the ascorbic acid solution at 60 ppm concentration, it showed a similar trend in the antioxidant potential (Fig.-6).

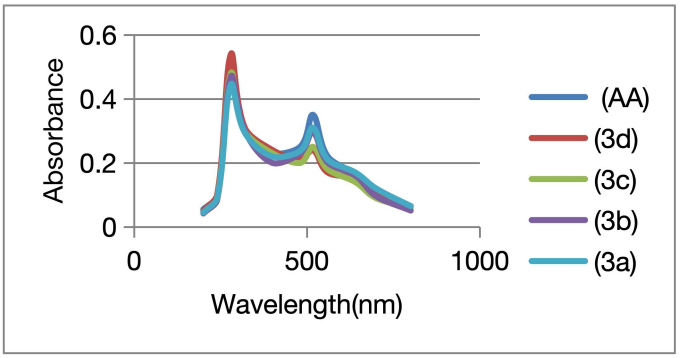


Fig.-6: Relative Absorption Behaviour of Various Derivatives of 2-Hydroxy-1-Naphthaldehyde (3a-D) At 60ppm And Their Comparison with Ascorbic Acid Solution

Ferric Reducing Antioxidant Power (FRAP) Assay

The electron-donating ability of the synthesized derivatives was investigated using FRAP assay.[29] The FRAP reagent was freshly prepared by mixing sodium acetate-acetic acid buffer (300 Mm, Ph 3.6), 2,4,6-Tripyridyl-S-Triazine (TPTZ, 10 Mm in 40 Mm hydrochloric acid), and ferric chloride hexahydrate ($Fecl_3 \cdot 6H_2O$, 20 Mm) in the ratio of 10:1:1. Test solutions of each compound (10-80 Ppm In DMSO) were blended with 3.0 Ml of the FRAP reagent and incubated for 30 min at 37°C. The absorption values for all the compounds were recorded using ascorbic acid as the reference compound at a wavelength of 593nm (Table-2).

Table-2: Data For Ferric Ion Reducing Activity (% Reducing Power) of Compounds (3a-D) at 10, 20, 40, 60, and 80ppm Relative to Ascorbic Acid

Entry	3a	3b	3c	3d	Ascorbic acid
10ppm	10	12.1	16.5	14.4	17.5
20ppm	19.2	24	33.4	28.3	32.8
40ppm	36.4	46.2	59.7	52.2	60.9
60ppm	50.7	64.3	73.6	72.3	79.8
80ppm	64.1	81.9	83.7	92.20	100

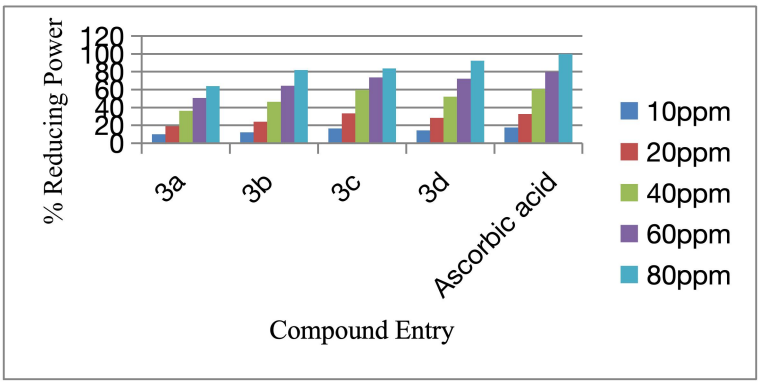


Fig.-7: Comparative Absorbance Data of the Compounds (3a-d) and Ascorbic Acid in FRAP Assay at different Concentrations

RESULTS AND DISCUSSION

The successful synthesis of the proposed compounds was unequivocally confirmed through comprehensive spectroscopic and analytical characterisations, which relates to SDG-4(Quality Education). FTIR-attenuated reflectance spectra give a characteristic band in the range of 1600-1640 cm^{-1} are indicative for azomethine (C=N) linkage, as well as bands consistent with hydroxyl (-OH), aromatic C-H, and other substituent-specific functional groups.[30] The formation of imine derivatives was confirmed by characteristic azomethine (C=N) stretching in the range 1608- 1615 cm^{-1}, along with the disappearance of aldehydic C=O bands of the starting material. The presence of phenolic -OH and amide N-H functionalities was supported by broad absorptions in the 3200-3300 cm^{-1} region. In the ^{1}H-NMR spectra, formation of the imine was indicated by the azomethine proton resonating as a singlet in the range δ 8.6-9.9 ppm, consistent with conjugation to the aromatic system, while the phenolic and amide protons appeared downfield due to intramolecular hydrogen bonding, at δ 11.8-16.2 ppm. The compounds bearing amide or hydrazide groups (3b, 3c) displayed NH resonance between δ 10.8-12.5ppm, slightly broadened due to slow spin relaxation. Aromatic protons were observed between δ 6.8-8.9ppm as doublets, doublets of doublets or multiplets with *J* values in the range of 7.5-8.5 Hz, typical of ortho-coupled aromatic systems. The ^{13}C-NMR spectra further supported imine formation by signals in the δ 155–165 ppm region attributable to C=N and carbonyl carbons, consistent with reported literature values. Aromatic carbons were observed consistent with substituted naphthalene and heteroaromatic scaffolds.[31-35]

In-vitro Antioxidant Evaluation

On comparing the recorded antioxidant data of (3a-d), it was observed that these derivatives exhibit a significant radical scavenging potential due to their capacity to release H-radical. The analysis of all the absorption values and subsequent calculation of antioxidant capacity in terms of the DPPH assay shows that the synthesised compounds possess a significant antioxidant potential, which is very much comparable with the antioxidant potential of ascorbic acid, a well-established natural antioxidant. The established sequence of antioxidant potential of the synthesised compounds can be drawn as: 3d > 3c > 3b > 3a. The superior radical scavenging activity of compounds 3d and 3c can be rationalised by the synergistic influence of extended π-conjugation, the presence of electron-rich hydroxyl groups and the hydrazone (-CH=N-NH-) linkage, which collectively promote electron delocalisation and stabilise the resultant radical species. In compound 3d, the conjugative interplay between the naphthol functionality and the heteroatomic pyridine ring through the imine linkage is likely to enhance resonance stabilisation of the radical intermediate, accounting for its enhanced antioxidant performance. Structural variations across the series provide critical insights into structure–activity relationships (SAR). The incorporation of electron-rich, planar aromatic frameworks was observed to augment radical quenching efficiency, whereas electron-deficient motifs, exemplified by the uracil-based 3a, exhibited comparatively attenuated activity. These findings suggest that the combined influence of electronic effects and molecular topology modulates the antioxidant potential of hydroxy-naphthaldehyde Schiff base derivatives, offering a rational basis for the design of optimised radical scavengers. To complement the DPPH assay, the FRAP assay was employed to evaluate the reducing potential through electron-donating capacity of the synthesised

Schiff base derivatives of 2-hydroxy naphthaldehyde. Among the synthesised derivatives, 3d exhibited the highest reducing potential as shown in (Fig.-6), attributable to the synergistic effect of its phenolic hydroxyl groups and extended π-conjugation established between the naphthol moiety and the heteroatomic pyridine ring, which facilitates efficient electron delocalisation and transfer during the reduction of Fe^{3+} to Fe^{2+}. Compounds 3c and 3b displayed moderate reducing capacities, influenced by the presence of hydrazide linkages and aromatic scaffolds, which contribute to the resonance stabilisation and electron donation, although to a lesser extent than 3d. In contrast, compound 3a showed the lowest FRAP value, likely due to limited conjugation and fewer electron-donating substituents. The descending trend of reducing capacity was observed as: 3d > 3c > 3b > 3a. This order correlates well with the electronic characteristics of each scaffold, including the distribution of electron density, the number and type of donor groups (-OH, -NH, -C=O), and the overall extent of π-conjugation. Schiff bases featuring multiple electron-donating functionalities, planar aromatic frameworks, and extended conjugative bridges exhibited superior FRAP values, reinforcing established structure–activity relationships for redox-active molecules. These findings suggest that Schiff bases bearing heterocyclic systems such as pyridine in **3d** or hydrazide linkages in **3c** enhance antioxidant behaviour due to better electron delocalisation and redox capability. Overall, the antioxidant performance mirrored the structural features, where conjugation, electron-rich centres, and heteroaromatic substituents contributed significantly to the radical scavenging and reducing power of the molecules. The consistency observed between DPPH and FRAP results supports the reliability of the antioxidant evaluation, and hence the work establishes a valuable contribution to SDG-3 (Good Health and Well-Being).

CONCLUSION

Present investigations on synthesis, characterisation, and studies on antioxidant properties related to Schiff base derivatives of 2-hydroxy naphthaldehyde provide an insight into the role of various amine-substituted derivatives for their active participation in the radical scavenging activities. The results demonstrate that the conjugation of the π-electron system plays a critical role in entrapping the free radical thus generated. The rate of radical scavenging depends on the ease of the system. This methodology can be conveniently utilised to study the role of various types of conjugated systems in electron entrapment, and the method provides ease of the access for detailed study related to the methodology of radical scavenging. This provides a lead towards studying the role of naphthol derivatives as a potential candidate for the antioxidant properties, which can be induced in biological systems, hence contributing to SDG-3 (Good Health and Well-Being) and the research work with scientific innovation supports SDG-4 (Quality Education).

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The present work is related to *SDG-3: Good Health and Well-being*. All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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REFERENCES

1. (a) Y. A. Hajam, R. Rani, S. Y. Ganie, T. A. Sheikh, D. S. S. Qadri, S. Pramodh, A. Alsulimani, M. F. Alkhanani, A. Hussain, S. Haque and M. S. Reshi, *Cells*, **11**, 1(2022), https://doi.org/10.3390/cells11030552 (b) J. Yang, J. Luo, X. Tian, Y. Zhao, Y. Li and X. Wu, *Antioxidants*, **13**, 1(2024), https://doi.org/10.3390/antiox13040394 (c) X. Chen, N. Xie, L. Feng, Y. Huang, Y. Wu, H. Zhu, J. Tang and Y. Zhang, *Chinese Medical Journal*, **138**, 15(2025), https://doi.org/10.1097/cm9.0000000000003230 (d) S. Thelakkadan and M. B. Ummathur, *Rasayn Journal of Chem*istry, **19**, 348(2026), http://doi.org/10.31788/RJC.2026.1918560 9 (e) N. M. Abdalsahib and L. K. A. Karem, *International Journal of Drug Delivery Technology*, **13**, 290(2023), https://doi.org/10.25258/ijddt.13.1.47 (f) P. Barwa, S. Asija, Y. Deswal, N. Kumar, A. Kumar and J. Devi, *Research on Chemical Intermediates*, **49**, 3411(2023), https://doi.org/10.1007/s11164-023-05053-z
2. E. A. Abourashed, *Antioxidants*, **2,** 309(2013), https://doi.org/10.3390/antiox2040309
3. T. B. Santos, L. G. C. de Moraes, P. A. F. Pacheco, D. G. dos Santos, R.M. de Assis C. Ribeiro, C. dos Santos Moreira and D. R. da Rocha, *Pharmaceuticals*, **16**, 1(2023), https://doi.org/10.3390/ph16111577
4. V. Lino, P. Manini, M. Galeotti and M. Salamone, *ChemplusChem,* **88**, 1(2023), https://doi.org/10.1002/cplu.202200449
5. (a) Md. S. Rana, N. Md. A. R. Rayhan, Md. S. H. Emon, Md. T. Islam, K. Rathry, Md. M. Hasan, Md. M. I. Mansur, B. C. Srijon, Md. S. Islam, A. Ray, Md. A. Rakib, A. I. Md. K. Zahan, Md. F. Hossen and Md. A. Asraf, *Royal Society of Chemistry Advances,* **14**, 33094(2024), https://doi.org/10.1039/d4ra04375h (b) M. Dalal, J. Devi, N. Antil, B. Kumar, Y. K. Verma, S. Kumar, M. Wati and S. Garg, *Applied Organometallic Chemistry*, **38**, 1(2023), https://doi.org/10.1002/aoc.7338 (c) Z. H. Chohan and H. A. Shad, *Journal of Enzyme Inhibition and Medicinal Chemistry,* **23**, 58(2012), https://doi.org/10.3109/14756366.2011.574623 (d) M. Todorova, R. Bakalska, M. F. Dehnayebi, G. Md. Ziarani, M. Pencheva, K. Stojnova, M. Milusheva, P. Nedialkov, E. Cherneva, T. Kolev and S. Nikolova, *Applied Sciences*, **15**, 1(2025), https://doi.org/10.3390/app15010284 (e) H. Shirinnzadeh and E. Dilek, *Journal of Molecular Structure,* **1220**, 12857(2020), https://doi.org/10.1016/j.molstruc.2020.128657
6. (a)Y. Matsushita, I. C. Jang, T. Imai, K. Fukushima, J. M. Lee, H. R. Park and S.C. Lee, *Journal of Wood Science*, **57**, 161(2011), https://doi.org/1007/s10086-010-1147-9 (b) R. D. Popeta and G. A. Thakur, *Rasayan Journal of Chemistry*, **19**, 48(2026), http://doi.org/10.31788/RJC.2026.1919526
7. L. Brasseur, E. Hennebert, L. Fievez, G. Caulier, L. Tafforeau, P. Flammang, P. Gerbaux and I. Eeckaut, *Marine Drugs*, **15**, 1(2017), https://doi.org/10.3390/md15060179
8. R. Song, B. Yu, D. Friedrich, J. Li, H. Shen, H. Krautscheid, S. D. Huang and M. H. Kim, *Communications Biology*, **3**, 1(2020), https://doi.org/10.1038/s42003-020-01261-0
9. T. Ahmad and Y. J. Suzuki, *Antioxidants*, **8**, 1(2019), https://doi.org/10.3390/antiox8040091
10. M. T. Riaz, M. Yaqub, Z. Shafiq and A. T. Asraf, *Bioorganic Chemistry*, **114,** 105069(2021), https://doi.org/10.1016/j.bioorg.2021.105069
11. R. R. Kotha, F. S. Tareq, E. Yildiz and D. L. Luthria, *Antioxidants*, **11**, 1(2022), https://doi.org/10.3390/antiox11122388
12. M. Hermes-Lima, M. S. Goncalves and R. G. Andrade Jr., *Molecular and Cellular Biochemistry*, **228**, 73(2001), https://doi.org/10.1023/A:1013348005312
13. S. D. Oladipo, R. C. Luckay and K. A. Olofinsan, *Scientific Reports*, **14**, 1(2024), https://doi.org/10.1038/s41598-024-78460-w
14. Y. M. Ahmed, M. A. Elgandi, Md. M. Omar, G.G. Mohamad, and R. G. Degandi, *Journal of Molecular Structure*, **1326**, 141076(2025), https://doi.org/10.1016/j.molstruc.2024.141076
15. M. G. Balamon, E. A. El-Bordany, A. E. Swilem, N. F. H. Mahmoud and A. A. Hamed, *Scientific Reports,* **14**, 1(2024), https://doi.org/10.1038/s41598-024-74275-x
16. N. Żurek, K. Pycia, A. Pawłowska and I. T. Kapusta, *Molecules*, **28**, 1(2023), https://doi.org/10.3390/molecules28041989

17. S. A. Malak, J. D. Rajput and M. Sharif, *European Journal of Chemistry*, **14**, 466(2023), https://doi.org/10.5155/eurchem.14.4.466-472.2468
18. M. Dalal, A. Dubey, A. Tufail, N. Antil, N. Sehrawat and S. Garg, *Journal of Molecular Structure*, **1287**, 1(2023), https://doi.org/10.1016/j.molstruc.2023.135590
19. L. Lv, T. Zheng, L. Tang, Z. Wang and W. Liu, *Coordination Chemistry Reviews*, **525**, 327(2025), https://doi.org/10.1016/j.ccr.2024.216327
20. M. Dalal, J. Devi and N. Antil, *Applied Organometallic Chemistry*, **38**, 739(2024), https://doi.org/10.1002/aoc.7338
21. N. Housas, S. Chafaa, N. Chafai, S. Ghedjati, M. Djenane and S. Kitouni, *Journal of Molecular Structure*, **1247**, 32(2022), https://doi.org/10.1016/j.molstruc.2021.13132
22. C. E. Satheesh, P. K. Raghavendra, P. A. Suchetn, H. Rajanaika and S. Foro, *Inorganica Chimica Acta,* **515**, 17(2021), https://doi.org/10.1016/j.ica.2020.120017
23. S. Aytac, O. Gundogdu, Z. Bingoi and I. Gulcin, *Pharmaceutics*, **15**, 1(2023), https://doi.org/10.3390/pharmaceutics15030779
24. C. Majee, R. Mazumder, A. N. Choudhary and Salahuddin, *Mini-Reviews in Medicinal Chemistry*, **23**, 131(2023), https://doi.org/10.2174/1389557522666220602141142
25. N. C. Charlton, M. Mastyugin, B. Torok and M. Torok, *Molecules*, **28**, 1(2023), https://doi.org/10.3390/molecules28031057
26. A. Lu, S-Meng Yuan, H. Xiao, D-song Yang, Z-qiong, Q. Y. Li, Y. Zhao, Z-zhi Chen and X-mei Wu, *Scientific Reports*, **12**, 7860(2022), https://doi.org/10.1038/s41598-022-11925-y
27. V. Mittapelli, N. R. Parine and R. Merugu, *Rasayan Journal of Chemistry*, **19**, 583(2026), http://doi.org/10.31788/RJC.2026.1919578
28. I. Gulcin, *Journal Archives of Toxicology*, **94**,651(2020), https://doi.org/10.1007/s00204-020-02689-3
29. I. F. F Benzie and J. J. Strain, *Analytical Biochemistry,* **239**, 70(1996), https://doi.org/10.1006/abio.1996.0292
30. D. T. Sakhare, *International Journal of Science and Research,* **14**, 1345(2025), https://doi.org/10.21275/MS25222083442
31. H. Kargar, A. A. Ardakani, M. N. Tahir, M. Asfaq and K. S. Munnawar, *Journal of Molecular Structure*, **1229**, 554(2021), https://doi.org/10.1016/j.molstruc.2020.129842
32. Y. S. Li, A. Ba and M. S. Mahmood, *Spectrochimica Acta A: Molecular and Biomolecular Spectroscopy***, 72**, 605(2009), https://doi.org/10.1016/j.saa.2008.10.055
33. P. M. Thakor, R. J. Patel, R. Kr. Giri, S. H. Chaki, A. J. Khimani, Y. H. Vadiya, P. Thakor, A. B. Thakkar and J. D. Patel, *American Chemical Society Omega*, **8**, 33069(2023), https://doi.org/10.1021/acsomega.3c05254
34. G. Venktesh, P. Vennila, S. Kaya, S. B. Ahmed, V. Siva, P. Rajendran and C. Kamal, *American Chemical Society Omega*, **9**, 8123(2024), https://doi.org/10.1021/acsomega.3c08526
35. S. Slassi, M. Aarjane and A. Amine, *Journal of Molecular Structure*, **1225**, 457(2021), https://doi.org/10.1016/j.molstruc.2020.129079

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