Experimental protocols

General

Melting points (m.p.) were determined on Mettler FP 51 apparatus (Mettler Instruments, Switzerland) and are uncorrected. They are expressed in degree centigrade (°C). A Nicolet Avatar Model FT-IR spectrophotometer was used to record the IR spectra (4000–400 cm^{-1}). ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker AV 500 (500 MHz (^{1}H) and 125 MHz (^{13}C)) spectrometer using tetramethylsilane (TMS) as an internal reference. The chemical shifts are expressed in parts per million (ppm). Mass spectra (MS) were recorded on Auto Spec EI+ Shimadzu QP 2010 PLUS GC-MS mass spectrometer. Microanalyses were performed on a Vario EL III model CHNS analyzer (Vario, Germany) at the Department of Chemistry, Bharathiar University, Coimbatore - 46, India. The solvent and reagents used for the preparations were of reagent grade and were purified by standard methods, petroleum ether used was of boiling range 60-80°C. Anhydrous sodium sulphate was used to dry the solution of organic extracts. Thin layer chromatography (TLC) was performed using glass plates coated with silica gel-G containing 13% calcium sulphate as binder. Ethyl acetate and petroleum ether were used as developing solvents. A chamber containing iodine vapour was used to locate the spots. Separation and purification of the crude products was carried out using chromatographic columns packed with activated silica gel (60-120 mesh). In the case of mixture of solvents used for elution, the ratio of the mixture is given in brackets.

Synthesis

*Preparation of 4-chloro-2-methylbenzo[h]quinoline (**5**)*

1-Naphthylamine (0.25 mol) and ethylacetoacetate (0.25 mol) were mixed together and to it 1:1 HCl (5 drops) was added and the mixture was shaken well. It was left aside and within a few minutes the mixture became turbid indicating the liberation of water due to the condensation reaction. At this stage the mixture was kept inside in a vacuum dessicator over conc.H_2SO_4 for 2 days to get the corresponding anilide. The anilide was then cyclised using boiling diphenyl ether under 250 °C for half an hour. The reaction mixture was cooled to get white solid. It was washed several times with petroleum ether to get 2-methyl-4-hydroxybenzo[*h*]quinoline. This was treated with $POCl_3$ to get 4-chloro-2-methylbenzo[*h*]quinoline (**5**).

White solid; m.p. 62-64 °C; IR ν_{max} (cm^{-1}): 1581 (C=N), 1537, 1172, 1073; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.80 (s, 3H, C_2-CH_3), 7.48 (s, 1H, C_3-H), 7.68-7.74 (m, 2H, C_8, C_9-H), 7.84 (d, 1H, C_6-

H, *J* = 9.20 Hz), 7.92 (dd, 1H, C_7-H, J_o = 8.80 Hz, J_m = 2.40 Hz), 8.09 (d, 1H, C_5-H, *J* = 9.20 Hz), 9.32 (dd, 1H, C_{10}-H, J_o = 7.60 Hz, J_m = 2.00 Hz); Anal. Calcd. for $C_{14}H_{10}ClN$: C, 73.85; H, 4.43; N, 6.15; Found: C, 73.81; H, 4.45; N, 6.17 %.

*General procedure Preparation of 2-methyl-N-phenylbenzo[h]quinolin-4-amine (**6**)*

Method A (Solvent condition)

An appropriate mixture of 4-Chloro-2-methylbenzo[*h*]quinoline (**5**, 0.004 mol) was reacted with 1-Naphthylamine, (0.004 mol) using CuI and heated in DMSO at 120 °C for an hour. After the reaction completion was indication by the TLC, the reaction mixture was washed with water, dried, adsorbed and purified using silica gel column chromatography and eluted with ethylacetate:methanol (99:1) mixture to get **6** which was then recrystallised using methanol

Method B (Thermal condition)

An appropriate mixture 4-Chloro-2-methylbenzo[*h*]quinoline (**5**, 0.004 mol) was reacted with 1-Naphthylamine, (0.004 mol) was heated under neat condition (without any solvent) at 190 °C for an hour. After the reaction completion was indication by the TLC, the reaction mixture was washed with water, dried, adsorbed and purified using silica gel column chromatography and eluted with ethylacetate:methanol (95:5) mixture to get **6** which was then recrystallised using methanol.

*2-Methyl-N-(naphthalen-1-yl)benzo[h]quinolin-4-amine (**6**)*

Brown solid; m.p. >300 °C; Yield: (75 %); IR ν_{max} (cm^{-1}): 3134 (NH), 1629 (C=N), 1267; ^{1}H NMR (δ, ppm, DMSO-d_6): 2.67 (s, 3H, C_2-CH_3), 6.34 (s, 1H, C_3-H), 7.57-7.97 (m, 7H, C_2'-C_8'-H), 8.13 (d, 2H, C_6, C_7 -H *J* = 8.00 Hz), 8.23-8.26 (m, 2H, C_8, C_9 -H *J* = 9.00 Hz), 8.82 (d, 1H, C_5-H *J* = 8.00 Hz,), 9.45 (d, 1H, C_{10}-H *J* = 9.00 Hz), 11.12 (s, 1H, C_4-NH amino form), 13.70 (bs, 1H, C_1-NH imino form, ratio of amino form : imino form is 1 : 1); ^{13}C NMR (δ, ppm, DMSO-d_6): 20.4 (C_2-CH_3), 103.9 (C_3), 113.9 (C_6'), 119.5 (C_{4a}), 122.6 (C_4'), 123.0 (C_8'), 124.4 (C_{8a}'),125.9 (C_5), 126.3 (C_7'), 127.4 (C_6'), 127.7 (C_3'), 127.9 (C_{10}), 128.5 (C_6), 128.6 (C_9), 129.1 (C_8), 129.2 (C_7), 129.3 (C_5'), 130.7 (C_{4a}'), 133.6 (C_{10a}), 134.8 (C_{6a}) , 134.9 (C_1'), 137.2 (C_{10b}), 154.2 (C_4), 156.4 (C_2); MS: m/z (%) 334 (M^+, 100); Anal. Calcd. for $C_{24}H_{18}N_2$: C, 86.20; H, 5.43; N, 8.38; Found: C, 86.17; H, 5.44; N, 8.40 %.

*General procedure for the synthesis of compound (**7**)*

2-methyl-*N*-(naphthalen-1-yl)benzo[*h*]quinolin-4-amine (**6**, 0.002 mol) and acetic acid (0.0025 mol) were added to polyphosphoric acid (6 g of P_2O_5 in 3 mL of H_3PO_4) and heated at 160 °C for 3 hours. The reaction was monitored by using TLC. After the completion of the reaction, it was poured into ice water, neutralized with saturated sodium bicarbonate solution to remove excess of benzoic acid, extracted with ethyl acetate, purified by column chromatography using silica gel and product eluted with petroleum ether: ethyl acetate (99:1) mixture to get **7** which was recrystallised using methanol.

*6, 7-Dimethyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridine (**7**)*

Pale yellow solid; m.p. 230-232 °C; Yield: (79 %); IR ν_{max} (cm^{-1}) : 1635, 1598 (C=N), 1571, 1469; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.30 (s, 3H, C_6-CH_3), 3.20 (s, 3H, C_7-CH_3) 7.60 - 7.76 (m, 5H, C_8, C_9, C_{10}, C_{11}, C_{12}-H), 7.82 (d, 1H, C_{16}-H J = 8.00 Hz), 7.92-7.98 (m, 3H, C_1, C_2, C_3-H), 9.30 (d, 1H, C_4-H, J = 8.00 Hz), 9.38 (d, 1H, C_{15}-H, J = 9.00 Hz), 9.62 (d, 1H, C_{13}-H, J_o = 9.50 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 19.2 (C_7-CH_3), 31.5 (C_6-CH_3), 120.7 (C_{6a}), 121.8 (2C, C_8 &C_{14b}), 122.0 (C_{13}), 124.6 (C_4), 125.1 (C_{7a}), 126.0 (C_{16}), 126.4 (C_{12}), 126.9 (C_3) 127.3 (C_{10}), 127.4 (C_2), 127.6 (C_{15}), 127.7 (C_9), 127.8 (C_1), 129.4 (C_{11}), 131.0 (C_{4a}), 131.7 (C_{13a}), 133.9 (C_{9a}), 134.4 (C_{16a}), 141.3 (C_{4b}), 143.9 (C_7) 147.0 (C_{14a}), 147.5 (C_{13b}), 157.9 (C_6); MS: m/z (%) 358 (M^+, 100); Anal. Calcd. for $C_{26}H_{18}N_2$: C, 87.12; H, 5.06; N, 7.82; Found: C, 87.16; H 5.04; N, 7.80 %.

*General procedure for the synthesis of compound (**8-20**)*

2-methyl-*N*-(naphthalen-1-yl)benzo[*h*]quinolin-4-amine (**6**, 0.002 mol) and various aromatic carboxylic acids and hetero carboxylic acids (0.0025 mol) were added to polyphosphoric acid (6 g of P_2O_5 in 3 mL of H_3PO_4). The reaction time, temperature maintained and various acid used for the synthesis of respective product are mention in the **Table 2**. The reaction was monitored by using TLC. After the completion of the reaction, it was poured into ice water, neutralized with saturated sodium bicarbonate solution to remove excess of carboxylic acids, extracted with ethyl acetate, purified by column chromatography using silica gel and product eluted with petroleum ether:ethyl acetate (97:3) mixture to get **8-20** which was recrystallised using methanol.

*6-Methyl-7-phenyldinaphtho[1,2-b:1',2'-h][1,6] naphthyridine (**8**)*

Yellow prisms; m.p. 270-272 °C; Yield: (83 %); IR ν_{max} (cm^{-1}) : 1566, 1536 (C=N), 1494, 1438; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.52 (s, 3H, C_6-CH_3), 7.41 (d, 1H, C_9-H J = 9.00 Hz), 7.48-7.69

(m, 6H, C_2', C_3', C_4', C_5', C_6' & C_8-H), 7.72-7.85 (m, 3H, C_{10}, C_{11}, C_{12})7.89-7.93 (m, 2H, C_2, C_3-H), 8.07 (d, 1H, C_{16}-H, *J* = 8.00 Hz), 8.16 (d, 1H, C_1-H, *J* = 9.00 Hz), 9.42 (d, 1H, C_4-H, *J* = 8.80 Hz), 9.65 (d, 1H, C_{15}-H, *J* = 9.00 Hz), 9.85 (d, 1H, C_{13}-H, *J* = 8.50 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.5 (C_6-CH_3), 120.6 (C_{6a}), 121.0 (C_8), 121.5 (C_{14b}), 122.2 (C_{13}), 124.7 (C_4), 125.3 (C_{7a}), 126.1 (C_{16}), 126.5 (C_{12}), 126.8 (C_3), 127.1 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.5 (C_2' & C_6'), 128.6 (C_3', C_4' & C_5'), 129.3 (C_{11}), 130.0 (C_1') 131.1 (C_{4a}), 131.4 (C_{13a}), 133.8 (C_{9a}), 134.1 (C_{16a}), 141.1 (C_{4b}), 143.8 (C_7) 147.1 (C_{14a}), 147.9 (C_{13b}), 159.0 (C_6); MS: m/z (%) 420 (M^+, 100); Anal. Calcd. for $C_{31}H_{20}N_2$: C, 88.55; H, 4.79; N, 6.66; Found: C, 88.52; H 4.80; N, 6.68 %.

*6-Methyl-7-tolyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridine (**9**)*

Pale yellow solid; m.p. 249-251 °C; Yield: (86 %); IR ν_{max} (cm^{-1}): 1650, 1602 (C=N), 1441; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.43 (s, 3H, C_6-CH_3), 2.57 (s, 3H, C_6'-CH_3), 7.42 (d, 1H, C_9-H *J*= 9.00 Hz), 7.44-7.82 (m, 8H, C_8, C_{10}, C_{11}, C_{12}, C_2', C_3', C_5' & C_6'-H), 7.85-7.90 (m, 2H, C_2, C_3-H), 8.07 (d, 1H, C_{16}-H, *J* = 7.20 Hz), 8.12 (d, 1H, C_1-H, *J* = 8.80 Hz), 9.39 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.61 (d, 1H, C_{15}-H, *J* = 8.80 Hz), 9.81 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 21.5 (C_4'-CH_3), 29.6 (C_6-CH_3), 120.5 (C_{6a}), 121.3 (C_8), 121.7 (C_{14b}), 122.1 (C_{13}), 124.8 (C_4), 125.4 (C_{7a}), 126.2 (C_{16}), 126.7 (C_{12}), 126.9 (C_3), 127.2 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.4 (C_2' & C_6'), 128.8 (C_3' & C_5'), 129.1 (C_{11}), 130.3 (C_1') 131.4 (C_{4a}), 131.6 (C_{13a}), 133.7 (C_{9a}), 134.2 (C_{16a}), 135.6 (C_4'), 141.0 (C_{4b}), 143.6 (C_7), 147.3 (C_{14a}), 148.0 (C_{13b}), 159.5 (C_6); MS: m/z (%) 434 (M^+, 100); Anal. Calcd. for $C_{32}H_{22}N_2$: C, 88.45; H, 5.10; N, 6.45; Found: C, 88.43; H, 5.09; N, 6.48 %.

*6-Methyl-7-(2'-chlorophenyl)dinaphtho[1,2-b:1',2'-h][1,6] naphthyridine (**10**)*

Yellow solid; m.p. 221-223 °C; Yield: (77 %); IR ν_{max} (cm^{-1}): 1663, 1567 (C=N), 1535, 1434; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.49 (s, 3H, C_6-CH_3), 7.33 7.84 (m, 11H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_2', C_3', C_5' & C_6'-H), 7.98 (d, 1H, C_{16}-H, *J* = 7.20 Hz), 8.21 (d, 1H, C_1-H, *J* = 8.80 Hz), 9.33 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.56 (d, 1H, C_{15}-H, *J* = 8.80 Hz), 9.75 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.9 (C_6-CH_3), 120.8 (C_{6a}), 121.1 (C_8), 121.4 (C_{14b}), 122.3 (C_{13}), 124.9 (C_4), 125.2 (C_{7a}), 126.3 (C_{16}), 126.6 (C_{12}), 126.8 (C_3), 127.3 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.1 (C_6'), 128.7 (C_3', C_4' & C_5'), 129.0 (C_{11}), 130.1 (C_1') 131.3 (C_{4a}), 131.5 (C_{13a}), 133.6 (C_{9a}), 134.4 (C_{16a}), 135.7 (C_2') 141.2 (C_{4b}), 143.7 (C_7), 147.2 (C_{14a}),

147.7 (C_{13b}), 159.6 (C_6); MS: m/z (%) 454 (M^+, 100), 456 (M^{+2}, 100) ; Anal. Calcd. for $C_{31}H_{19}ClN_2$: C, 81.84; H, 4.21; N, 6.16; Found: C, 81.78; H, 4.26; N, 6.10 %.

*6-Methyl-7-(4'- methoxyphenyl)dinaphtho[1,2-b:1',2'-h][1,6]naphthyridine (**11**)*

Pale yellow solid; m.p. 262-264 °C; Yield: (71 %); IR ν_{max} (cm^{-1}): 1597, 1521 (C=N), 1445, 1402; ^{1}H NMR (δ, ppm, $CDCl_3$): 2.44 (s, 3H, C_6-CH_3), 4.00 (s, 3H, C_4'-OCH_3), 7.32-7.82 (m, 11H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_2', C_3', C_5' & C_6'-H), 8.06 (d, 1H, C_{16}-H, *J* = 8.00 Hz), 8.22 (d, 1H, C_1-H, *J* = 8.80 Hz), 9.38 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.62 (d, 1H, C_{15}-H, *J* = 8.80 Hz), 9.84 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.8 (C_6-CH_3), 55.6 (OCH_3), 120.9 (C_{6a}), 121.4 (C_8), 121.9 (C_{14b}), 122.2 (C_{13}), 124.6 (C_4), 125.1 (C_{7a}), 126.0 (C_{16}), 126.7 (C_{12}), 126.9 (C_3), 127.4 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.2 (C_2' & C_6'), 128.9 (C_3' & C_5'), 129.4 (C_{11}), 130.5 (C_1'), 131.2 (C_{4a}), 131.7 (C_{13a}), 133.9 (C_{9a}), 134.5 (C_{16a}), 135.9 (C_4'), 141.5 (C_{4b}), 143.5 (C_7), 147.4 (C_{14a}), 148.1 (C_{13b}), 159.7 (C_6); MS: m/z (%) 450 (M^+, 100);Anal. Calcd. for $C_{32}H_{22}N_2O$: C, 85.31; H, 4.92; N, 6.22, Found: C, 85.35; H, 4.90; N, 6.27 %.

*6-Methyl-7-(3'-nitrophenyl)dinaphtho[1,2-b:1',2'-h][1,6] naphthyridine (**12**)*

Dark yellow solid; m.p. 282-284 °C; Yield: (68 %); IR ν_{max} (cm^{-1}): 1591, 1590 (C=N), 1513 (asym NO_2), 1472, 1341 (sym NO_2); ^{1}H NMR (δ, ppm, $CDCl_3$): 2.41 (s, 3H, C_6-CH_3), 7.39-7.90 (m, 11H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_2', C_4', C_5' & C_6'-H), 7.90 (d, 1H, C_{16}-H, *J* = 7.20 Hz), 8.30 (d, 1H, C_1-H, *J* = 8.00 Hz), 9.31(d, 1H, C_4-H, *J* = 8.00 Hz), 9.63 (d, 1H, C_{15}-H, *J* = 8.80 Hz), 9.86 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.8 (C_6-CH_3), 120.4 (C_{6a}), 121.1 (C_8), 121.5 (C_{14b}), 122.4 (C_{13}), 124.7 (C_4), 125.3 (C_{7a}), 126.1 (C_{16}), 126.7 (C_{12}), 126.8 (C_3), 127.1 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.0 (C_5'), 128.4 (C_4'), 128.5 (C_4'), 129.1 (C_{11}), 129.9 (C_2'), 130.3 (C_1'), 131.4 (C_{4a}), 131.8 (C_{13a}), 133.7 (C_{9a}), 134.3 (C_{16a}), 136.0 (C_3'), 141.6 (C_{4b}), 144.0 (C_7), 147.5 (C_{14a}), 147.8 (C_{13b}), 159.3 (C_6); MS: m/z (%) 465 (M^+, 100); Anal. Calcd. for $C_{31}H_{19}N_3O_2$: C, 79.99; H, 4.11; N, 9.03; Found: C, 80.05; H, 4.07; N, 9.09 %.

*6-Methyl-7-(4'-hydroxyphenyl)dinaphtho[1,2-b:1',2'-h][1,6] naphthyridine (**13**)*

Pale Brown solid; m.p. 272-274 °C; Yield: (32 %); IR ν_{max} (cm^{-1}): 3431 (OH), 1631, 1591 (C=N); ^{1}H NMR (δ, ppm, $CDCl_3$): 2.45 (s, 3H, C_6-CH_3), 5.36 (bs, 1H, C_4'- OH), 7.35-7.88 (m,

11H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_2', C_3', C_5' & C_6'-H), 8.00 (d, 1H, C_{16}-H, *J* = 8.50 Hz), 8.15 (d, 1H, C_1-H, *J* = 8.00 Hz), 9.35 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.66 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.83 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (*δ*, ppm, $CDCl_3$): 28.8 (C_6-CH_3), 120.3 (C_{6a}), 121.2 (C_8), 121.9 (C_{14b}), 122.0 (C_{13}), 124.9 (C_4), 125.6 (C_{7a}), 126.3 (C_{16}), 126.7 (C_{12}), 126.8 (C_3), 127.1 (C_{10}), 127.4 (C_2), 127.6 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.0 (C_2' & C_6'), 128.7 (C_3' & C_5'), 129.2 (C_{11}), 130.4 (C_1'), 131.3 (C_{4a}), 131.5 (C_{13a}), 133.6 (C_{9a}), 134.2 (C_{16a}), 135.3 (C_4'), 141.4 (C_{4b}), 144.0 (C_7), 147.4 (C_{14a}), 148.0 (C_{13b}), 159.9 (C_6); MS: m/z (%) 436 (M^+, 100); Anal. Calcd. for $C_{31}H_{20}N_2O$: C, 85.30; H, 4.62; N, 6.42; Found: C 85.27; H 4.67; N 6.46 %.

*2-(6-methyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridin-7-yl)aniline (**14**)*

Yellow spongy solid; m.p. 263-265 °C; Yield: (61 %); IR ν_{max} (cm^{-1}): 3326, 3273 (NH_2), 1630, 1600 (C=N); ^{1}H NMR (*δ*, ppm, $CDCl_3$): 2.50 (s, 3H, C_6-CH_3), 5.65 (s, 2H, C_2'-NH_2), 7.43 (d, 1H, C_9-H *J*= 9.00 Hz), 7.50-7.70 (m, 5H, C_3', C_4', C_5', C_6' & C_8-H), 7.74-7.86 (m, 3H, C_{10}, C_{11}, C_{12}), 7.90-7.96 (m, 2H, C_2, C_3-H), 8.03 (d, 1H, C_{16}-H, *J* = 8.00 Hz), 8.20 (d, 1H, C_1-H, *J* = 9.00 Hz), 9.40 (d, 1H, C_4-H, *J* = 8.50 Hz), 9.59 (d, 1H, C_{15}-H, *J* = 9.00 Hz), 9.77 (d, 1H, C_{13}-H, *J* = 8.50 Hz);^{13}C NMR (*δ*, ppm, $CDCl_3$): 28.9 (C_6-CH_3), 120.1 (C_{6a}), 121.0 (C_8), 121.6 (C_{14b}), 122.3 (C_{13}), 124.6 (C_4), 125.7 (C_{7a}), 126.0 (C_{16}), 126.6 (C_{12}), 126.9 (C_3), 127.1 (C_{10}), 127.4 (C_2), 127.6 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.2 (C_6'), 128.8 (C_3', C_4' & C_5'), 129.0 (C_{11}), 130.1 (C_1'), 131.2 (C_{4a}), 131.2 (C_{13a}), 133.7 (C_{9a}), 134.4 (C_{16a}), 138.6 (C_2'), 141.0 (C_{4b}), 144.0 (C_7), 147.6 (C_{14a}), 147.5 (C_{13b}), 158.7 (C_6); MS: m/z (%) 435 (M^+, 100); Anal. Calcd. for $C_{31}H_{21}N_3$: C, 85.49; H, 4.86; N, 9.65; Found: C, 88.52; H, 4.81; N, 6.67 %.

*2-(6-methyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridin-7-yl)-4-nitroaniline (**15**)*

Yellow solid; m.p. 285-287 °C; Yield: (68 %); IR ν_{max} (cm^{-1}): 1632, 1602 (C=N), 1520 (asym NO_2), 1349 (sym NO_2); ^{1}H NMR (*δ*, ppm, $CDCl_3$): 2.43 (s, 3H, C_6-CH_3), 5.17 (s, 2H, NH_2), 7.42-7.89 (m, 10H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_3', C_4' & C_6' -H), 8.01 (d, 1H, C_{16}-H, *J* = 8.50 Hz), 8.10 (d, 1H, C_1-H, *J* = 8.00 Hz), 9.35 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.57 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.70 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (*δ*, ppm, $CDCl_3$): 28.5 (C_6-CH_3), 119.5 (C_3'), 120.3 (C_{6a}), 121.1 (C_8), 121.5 (C_{14b}), 122.4 (C_{13}), 124.7 (C_4), 125.5 (C_{7a}), 126.1 (C_{16}), 126.7 (C_{12}), 126.8 (C_3), 127.3 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.0 (C_6'), 128.3 (C_4'), 129.1 (C_{11}), 130.3 (C_1'), 131.4 (C_{4a}), 131.6 (C_{13a}), 133.9 (C_{9a}), 134.5 (C_{16a}), 137.6 (C_5'), 138.3 (C_2'), 141.3 (C_{4b}), 143.6 (C_7), 147.7 (C_{14a}), 148.1 (C_{13b}), 158.5 (C_6); MS: m/z (%)

480 (M^+, 100); Anal. Calcd. for $C_{31}H_{20}N_4O_2$: 77.49; H, 4.20; N, 11.66;; Found: C, 77.46; H, 4.23; N, 11.61 %.

*2-(6-methyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridin-7-yl) benzenethiol (**16**)*

Yellow prisms; m.p. 267-269 °C; Yield: (66 %); IR ν_{max} (cm^{-1}): 1628, 1596 (C=N), 2547 (S-H); ^{1}H NMR (δ, ppm, $CDCl_3$): 2.47 (s, 3H, C_6-CH_3), 3.61 (s, 1H, C_2'- SH), 7.42 (d, 1H, C_9-H(*J*= 9.00 Hz)), 7.50-7.94 (m, 7H, C_2, C_3, C_8, C_3', C_4', C_5' & C_6' -H), 8.00 (d, 1H, C_{16}-H, *J* = 8.00 Hz), 8.19 (d, 1H, C_1-H, *J* = 9.00 Hz), 9.42 (d, 1H, C_4-H, *J* = 8.80 Hz), 9.65 (d, 1H, C_{15}-H, *J* = 9.00 Hz), 9.87 (d, 1H, C_{13}-H, *J* = 8.50 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.9 (C_6-CH_3), 120.6 (C_{6a}), 121.4 (C_8), 121.8 (C_{14b}), 122.3 (C_{13}), 124.9 (C_4), 125.5 (C_{7a}), 126.1 (C_{16}), 126.9 (C_{12}), 126.9 (C_3), 127.3 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.0 (C_6'), 128.7 (C_3', C_4' & C_5'), 129.0 (C_{11}), 130.2 (C_1'), 131.3 (C_{4a}), 131.5 (C_{13a}), 133.5 (C_{9a}), 134.6 (C_{16a}), 136.9 (C_2'), 141.5 (C_{4b}), 143.9 (C_7), 147.4 (C_{14a}), 147.6 (C_{13b}), 158.2 (C_6); MS: m/z (%) 452 (M^+, 100); Anal. Calcd. for $C_{31}H_{20}N_2S$: C, 82.27; H, 4.45; N, 6.19; S, 7.09; Found: C, 82.22; H, 4.49; N, 6.24; S, 7.05 %.

*6-methyl-7-(naphthalen-1-yl)dinaphtho[1,2-b:1',2'-h][1,6] naphthyridine (**17**)*

Pale orange solid; m.p. 267-269 °C; Yield: (73 %); IR ν_{max} (cm^{-1}): 1632, 1598 (C=N); ^{1}H NMR (δ, ppm, $CDCl_3$): 2.42 (s, 3H, C_6-CH_3), 7.31-7.92 (m, 14H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_2', C_3', C_4', C_5', C_6', C_7' & C_8'-H), 8.00 (d, 1H, C_{16}-H, *J* = 8.50 Hz), 8.16 (d, 1H, C_1-H, *J* = 8.00 Hz), 9.36 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.58 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.76 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (δ, ppm, $CDCl_3$): 29.0 (C_6-CH_3), 119.1 (C_2'), 120.1 (C_{6a}), 121.3 (C_8), 121.6 (C_{14b}), 122.2 (C_{13}), 124.7 (C_4), 125.3 (C_{7a}), 126.3 (C_{16}), 126.8 (C_{12}), 126.7 (C_3), 127.4 (C_{10}), 127.3 (C_2), 127.6 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.1 (C_8'), 128.2 (C_3') 128.6 (C_4' & C_6'), 128.7 (C_6' & C_7'), 129.2 (C_{11}), 130.1 (C_1'), 131.4 (C_{4a}), 131.0 (C_{13a}), 132.6 (C_{8a}'), 133.6 (C_{9a}), 134.4 (C_{16a}), 135.0 (C_{4a}'), 141.0 (C_{4b}), 143.7 (C_7), 147.3 (C_{14a}), 148.3 (C_{13b}), 159.1 (C_6); MS: m/z (%) 470 (M^+, 100); Anal. Calcd. for $C_{35}H_{22}N_2$: C, 89.34; H, 4.71; N, 5.95; Found: C, 89.39; H, 4.70; N, 5.91 %.

*6-methyl-7-(pyridin-3-yl)dinaphtho[1,2-b:1',2'-h][1,6]naphthyridine (**18**)*

Pale orange solid; m.p. 278-280 °C; Yield: (59 %); IR ν_{max} (cm^{-1}): 1608, 1598, 1590 (C=N); ^{1}H NMR (δ, ppm, $CDCl_3$): 2.42 (s, 3H, C_6-CH_3), 7.45 (t, 1H, C_5'-H, *J* = 5.5 Hz) 7.70- 8.09 (m,

9H, C_1, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{16} - H), 8.31 (d, 1H, C_6'-H, *J* = 5.00 Hz), 8.51 (s, 1H, C_2'-H), 8.44 (d, 1H, C_4'-H, *J* = 5.00 Hz), 9.40 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.51 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.73 (d, 1H, C_{13}-H, *J* = 7.50 Hz); ^{13}C NMR (*δ*, ppm, $CDCl_3$): 29.1 (C_6-CH_3), 120.0 (C_{6a}), 121.2 (C_8), 121.5 (C_{14b}), 122.4 (C_{13}), 124.6 (C_4), 125.5 (C_{7a}), 126.0 (C_{16}), 126.6 (C_{12}), 126.9 (C_3), 127.3 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.7 (C_5'), 129.0 (C_{11}), 131.3 (C_{4a}), 131.2 (C_{13a}), 133.1 (C_{9a}), 133.9 (C_3'), 134.5 (C_{16a}), 135.3 (C_4'), 142.0 (C_{4b}), 144.1 (C_7), 147.0 (C_{14a}), 147.5 (C_2') 148.5 (C_{13b}), 149.0 (C_6') 159.2 (C_6); MS: m/z (%) 421 (M^+, 100); Anal. Calcd. for $C_{30}H_{19}N_3$: C, 85.49; H, 4.54; N, 9.97; Found: C, 85.52; H, 4.52; N, 9.96 %.

*4-(6-methyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridin-7-yl) quinolin-2-ol (**19**)*

Pale yellow solid; m.p. 277-279 °C; Yield: (39 %); IR ν_{max} (cm^{-1}): 3420 (OH), 1627, 1611, 1590 (C=N); ^{1}H NMR (*δ*, ppm, $CDCl_3$): 2.40 (s, 3H, C_6-CH_3),5.32 (bs, 1H, C_2'-H), 6.54 (s, 1H, C_3'- H), 7.28-7.95 (m, 10H, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_6', C_7' & C_8'-H), 8.05 (d, 1H, C_{16}-H, *J* = 8.50 Hz), 8.22 (d, 1H, C_1-H, *J* = 8.00 Hz), 8.67 (d, 1H, C_5'-H, *J* = 8.50 Hz), 9.37(d, 1H, C_4-H, *J* = 8.00 Hz), 9.64 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.80 (d, 1H, C_{13}-H, *J* = 8.00 Hz); ^{13}C NMR (*δ*, ppm, $CDCl_3$): 29.3 (C_6-CH_3), 110.3 (C_3'), 117.6 (C_{4a}'), 120.7 (C_{6a}), 121.2 (C_8), 121.8 (C_{14b}), 122.7 (C_{13}), 124.6 (C_4), 125.1 (C_{7a}), 126.2 (C_{16}), 126.6 (C_{12}), 126.6 (C_3), 127.2 (C_{10}), 127.5 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 128.5 (C_5'), 128.6 (C_6'), 129.0 (C_{11}), 129.9 (C_8'), 130.1 (C_1'), 131.4 (C_{4a}), 131.6 (C_{13a}), 133.5 (C_{9a}), 134.4 (C_{16a}), 136.1 (C_7'), 141.9 (C_{4b}), 143.4 (C_7), 147.2 (C_{14a}), 147.7 (C_{13b}), 148.3 (C_{8a}'), 151.0 (C_4'), 157.1 (C_2'), 159.5 (C_6); MS: m/z (%) 487 (M^+, 100); Anal. Calcd. for $C_{34}H_{21}N_3O$: C, 83.76; H, 4.34; N, 8.62; Found: C, 83.80, H, 4.39, N, 8.57 %.

*3-(6-methyldinaphtho[1,2-b:1',2'-h][1,6]naphthyridin-7-yl) pyrazin-2-amine (**20**)*

Pale orange solid; m.p. 271-273 °C; Yield: (55 %); IR ν_{max} (cm^{-1}): 3420, 3332, 1635, 1509 (C=N); ^{1}H NMR (*δ*, ppm, $CDCl_3$): 2.42 (s, 3H, C_6-CH_3), 5.46 (s, 2H, C_2'-NH_2), 7.65- 8.17 (m, 9H, C_1, C_2, C_3, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{16} -H), 8.40 (2d, 2H, C_4' & C_5'-H, *J* = 5.50 Hz), 9.43 (d, 1H, C_4-H, *J* = 8.00 Hz), 9.55 (d, 1H, C_{15}-H, *J* = 8.50 Hz), 9.78 (d, 1H, C_{13}-H, *J* = 7.50 Hz); ^{13}C NMR (*δ*, ppm, $CDCl_3$): 28.1 (C_6-CH_3), 120.1 (C_{6a}), 121.5 (C_8), 121.9 (C_{14b}), 122.9 (C_{13}), 124.7 (C_4), 125.0 (C_{7a}), 126.1 (C_{16}), 126.7 (C_{12}), 126.9 (C_3), 127.3 (C_{10}), 127.6 (C_2), 127.7 (C_{15}), 127.8 (C_9), 127.9 (C_1), 129.5 (C_{11}), 131.2 (C_{4a}), 131.5 (C_{13a}), 132.0 (C_5'), 133.9 (C_{9a}), 134.0 (C_{16a}), 136.0 (C_3'), 141.7 (C_{4b}), 143.2 (C_7), 144.3 (C_6'), 147.0 (C_{14a}), 147.5 (C_{13b}), 152.5 (C_2'), 159.8

(C_6); MS: m/z (%) 437 (M^+, 100); Anal. Calcd. for $C_{29}H_{19}N_5$: C, 79.61; H, 4.38; N, 16.01; Found: C, 85.52; H, 4.52; N, 9.96 %.

ANTIOXIDANT ACTIVITY

Radical scavenging activity using DPPH$^\bullet$ method

The DPPH$^\bullet$ radical scavenging activity of synthesized compounds was measured according to the literature method[36]. The concentration of compound necessary to decrease initial concentration of DPPH by 50% (IC_{50}) under the specified experimental condition was calculated.

Total antioxidant activity assay using radical cation (ABTS$^{\bullet+}$)

The total antioxidant activity measured by the ABTS$^{\bullet+}$ radical cation decolourization assay involving preformed ABTS$^{\bullet+}$ radical cation. ABTS was dissolved in water to a 7 mM concentration. ABTS radical cation (ABTS$^{\bullet+}$) was produced by reacting ABTS stock solution with 2.45 mM potassium persulfate (final concentration) and allowing the mixture to stand in the dark at room temperature for 12-16 h before use. Prior to assay, the solution was diluted in ethanol (about 1:89 v/v) and equilibrated to 30 ºC to give an absorbance at 734 nm of 0.70 ± 0.02 in a 1 cm cuvette[37]. The concentrations of compounds that produced between 20-80% inhibition (50-150 µg/mL) of the blank absorbance was determined and adapted. After the addition of 1 mL of diluted ABTS$^{\bullet+}$ solution to various concentrations of compound, OD was taken at 30 ºC exactly 30 min after the initial mixing.

Hydroxyl radical scavenging activity

The scavenging activity of synthesised compounds on hydroxyl radical was measured according to the literature method[38]. Various concentrations (10 - 100 µg/mL) of compound in test tubes were added with 1.0 mL of iron-EDTA solution (0.13% ferrous ammonium sulphate and 0.26% EDTA), 0.5 mL of EDTA solution (0.018%), and 1.0 mL of DMSO (0.85% DMSO (v/v) in 0.1 M phosphate buffer, pH 7.4) sequentially. The reaction was initiated by adding 0.5 mL of ascorbic acid (0.22%) and incubated at 80-90 °C for 15 min in a water bath. After incubation, the reaction was terminated by the addition of 1.0 mL of ice-cold TCA (17.5% w/v). Subsequently, 3.0 mL of Nash reagent was added to each tube and left at room temperature for 15 min. The reaction mixture without sample was used as control. The intensity of the colour

formed was measured spectrophotometrically at 412 nm against reagent blank. The % hydroxyl radical scavenging activity was calculated by the following formula:

% HRSA= [(Control OD - Sample OD)/Control OD] × 100

Assay of superoxide radical ($O_2^{\circ-}$) scavenging activity

The assay was based on the capacity of the extracts to inhibit formazan formation by scavenging the superoxide radicals generated in riboflavin-light-NBT system [39]. Each 3 mL reaction mixture contained 50 mM sodium phosphate buffer (pH 7.6), 20 µg riboflavin, 12 mM EDTA, 0.1 mg NBT and 1 mL sample solution (50-250 µg/mL). Reaction was started by illuminating the reaction mixture with different concentrations of compounds for 90 s. Immediately after illumination, the absorbance was measured at 590 nm. The entire reaction assembly was enclosed in a box lined with aluminum foil. Identical tubes with reaction mixture kept in dark served as blanks. The percentage inhibition of superoxide anion generation was calculated using the following formula: % of inhibition = $[(A_0-A_1)/ A_0]$ x 100 where A_0 is the absorbance of the control, and A_1 is the absorbance of the compound.

***in vitro* cytotoxicity**

Cell lines and cell culture

Cytotoxicity studies of the compounds along with ADR were carried out on human cervical cancer cells (HeLa), colorectal adenocarcinoma cell line (HCT116), and Stomach adenocarcenoma cells (AGS) which were obtained from National Centre for Cell Science, Pune, India. Cell viability was carried out using the MTT assay method[40]. The HeLa, HCT8 and HCT116 cells were grown in Eagles minimum essential medium containing 10% fetal bovine serum (FBS). For the screening experiment, the cells were seeded into 96-well plates in 100 μL of the respective medium containing 10% FBS, at a plating density of 10 000 cells/well, and incubated at 37 °C, under conditions of 5% CO_2, 95% air, and 100% relative humidity for 24 h prior to the addition of compounds. The compounds were dissolved in DMSO and diluted in the respective medium containing 1% FBS. After 24 h, the medium was replaced with the respective medium with 1% FBS containing the compounds at various concentrations and incubated at 37 °C under conditions of 5% CO_2, 95% air, and 100% relative humidity for 48 h. Triplication was maintained, and the medium not containing the compounds served as the control. After 48 h, 10

μL of MTT (5 mg/mL) in phosphate buffered saline (PBS) was added to each well and incubated at 37 °C for 4 h. The medium with MTT was then flicked off, and the formed formazan crystals were dissolved in 100 μL of DMSO. The absorbance was then measured at 570 nm using a microplate reader. The percentage of cell inhibition was determined using the following formula, and a graph was plotted with the percentage of cell inhibition versus concentration. From this, the IC_{50} value was calculated: % inhibition = [mean OD of untreated cells (control)/mean OD of treated cells (control)] × 100. The results were expressed as the concentration at which there was 50% inhibition (IC_{50}).

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