

Synthesis, Characterisation, and Preliminary Evaluation of Bis-Indolylmethane Derivatives as Colorimetric Sensor for Metal Ions Detection

(Sintesis, Pencirian dan Penilaian Awal Terbitan Bis-Indolilmetana sebagai Penderia Kolorimetrik untuk Pengesanan Ion Logam)

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ABSTRACT

Heavy metal ions such as copper, chromium, and manganese are very harmful to both the environment and living organisms. Their presence in excess amount can harm the liver, kidneys, lungs, and other vital organs. A colorimetric sensor based on bis-indolylmethane (BIM) derivatives was preliminarily studied to investigate their ability as a heavy metal ionophore with existence of H-bonding interactions between the indolic N–H functional groups and the metal ions. Five different BIM derivatives were synthesised involving condensation reaction between 2-methylindole and different substituted benzaldehydes, and were characterised using ¹H and ¹³C NMR, FT-IR, and UV-Vis spectroscopy to confirm their molecular structure. Colorimetric sensing analysis involving metal screening with Cu²⁺, Mn²⁺ and Cr⁶⁺ ions via naked eye study showed compounds **1** and **5** had the most intense colour change, hence having the highest possibility to make interaction or to be bound to the metal ions. A further binding interaction study was conducted using UV-Vis titration analysis between compound **1** with the metal ions involving Cu²⁺ and Mn²⁺ and compound **5** with Cr⁶⁺, respectively, proved the synthesized BIM derivatives to act as a potential heavy metal ions colorimetric sensor.

Keywords: Bis-indolylmethane; colorimetric sensor; metal ion

ABSTRAK

Ion logam berat seperti kuprum, kromium dan mangan sangat berbahaya kepada alam sekitar dan organisma hidup. Kehadiran mereka dalam jumlah yang berlebihan boleh membahayakan hati, buah pinggang, paru-paru dan organ penting lain. Penderia metri warna berdasarkan terbitan bis-indolilmetana (BIM) telah dikaji awal untuk mengkaji keupayaannya sebagai ionofor logam berat dengan kewujudan interaksi ikatan-H antara kumpulan berfungsi N-H indolik dan ion logam. Lima terbitan BIM berbeza telah disintesis melibatkan tindak balas kondensasi antara 2-metilindola dan penggantian benzaldehid berbeza dan dicirikan menggunakan spektroskopi ¹H dan ¹³C NMR, FT-IR dan UV-Vis untuk mengesahkan struktur molekulnya. Analisis penderiaan metri warna yang melibatkan penyaringan logam dengan ion Cu²⁺, Mn²⁺ dan Cr⁶⁺ melalui kajian mata kasar menunjukkan sebatian **1** dan **5** mempunyai perubahan warna yang paling ketara, justeru, mempunyai kemungkinan paling tinggi untuk melakukan interaksi atau terikat kepada ion logam. Kajian interaksi pengikatan selanjutnya telah dijalankan menggunakan analisis titratan UV-Vis antara sebatian **1** dengan ion logam yang melibatkan Cu²⁺ dan Mn²⁺ dan sebatian **5** dengan Cr⁶⁺ masing-masing membuktikan terbitan BIM yang disintesis berpotensi untuk bertindak sebagai penderia metri warna ion logam berat.

Kata kunci: Bis-indolilmetana; ion logam; penderia metri warna

INTRODUCTION

Heavy metal ions such as copper, chromium, and manganese are very toxic to the environment and living organisms (Yaradua et al. 2023). Although they are essential for human health, in excess they are poisonous. Their toxicity can harm the liver, kidneys, lungs, and other vital organs. Besides, it can also cause cancer, damage, or reduction in mental and central nervous system function (Tibebe, Lemma & Teshome 2019). Some industrial processes, such as tanning leather, chrome plating, battery production, glass manufacture, agriculture, domestic waste, and pharmaceutical manufacturing, are regarded as significant sources of heavy metals, which release hazardous metal ions into the atmosphere (Singh et al. 2023).

Indole is a bicyclic chemical molecule that is usually found in a variety of biological products. It has an aromatic heterocyclic structure. For example, tryptophan is a significant indole derivative while serotonin and melatonin are biochemically active indole molecules. Many important indole derivatives are also used in pharmaceutical processes. The anti-inflammatory drug indomethacin, the betablocker pindolol, and the naturally occurring hallucinogen dimethyltryptamine are some of the important indole derivatives (Karaaslan & Suzen 2011).

Indole and its derivatives have attracted interest recently due to their structural characteristics and biological significance, hence these compounds have been frequently used in biosensing and sensing applications (Kaya 2021; Ozcan, Kazan & Çoşut 2019). For example, the unique fluorescence properties of the indole chromophore are making indole chemosensor more valuable in chemosensor field (Azees, Cooray & Kumarasinghe 2021). A study by Tang et al. (2017) stated that the inherent fluorescence of the indole chromophore and electron donor group is present in an indole-based system. It can transfer electrons from the fluorophore to transition metal ions while an empty orbit is present in the transition metal and heavy metal. Fluorescence quenching increases the possibility of spin-orbit coupling of heavy metal ions.

In particular, the application of bisindoles, one of the indole derivatives in chemical sensors is widely recognised. Several bisindoles derivatives, such as bis(indolyl) methane, bispyridine azobenzene, triphenylamine-based indolylmethane, perylene bisimide derivatives, thiazolothiazole, and rhodamine hydrazine derivatives, have been reported to possess the ability to sense metal ion Cu^{2+} via colorimetric sensing application (Kandasamy et al. 2015).

In the present study, we synthesised a few derivatives of bis-indolylmethane (BIM) and evaluate their potential as colorimetric sensors in detecting heavy metal ions specifically on copper, chromium, and manganese ions. Besides synthesis and characterisation method, this study employed two primary analytical techniques involving

colorimetric sensing analysis via naked-eye study and binding study via UV-Vis titration method. Overall, the study integrates synthetic chemistry with analytical techniques to explore the properties and potential uses of bis-indolylmethane derivatives as metal ions sensor.

MATERIALS AND METHODS

CHEMICALS

Acetic acid and acetonitrile were purchased from Fisher Scientific, Massachusetts, USA. 2-methylindole, 4-acetomidabenzaldehyde, 3,5-dimethoxybenzaldehyde-4-hydroxybenzaldehyde, 4-hydroxybenzaldehyde, 2-chloro-6-fluorobenzaldehyde, 4-nitrobenzaldehyde, dimethyl sulfoxide-d₆ (DMSO-d₆), diethyl ether, chromium (VI) oxide (CrO_3) and copper (II) chloride dihydrate (CuCl_2) were purchased from Sigma-Aldrich, Darmstadt, Germany. Ethyl acetate was purchased from Merck KGaA, Darmstadt, Germany. Petroleum ether was purchased from R&M Chemicals, Semenyih, Selangor. All chemicals were used without further purification.

SYNTHESIS OF BIS-INDOLYLMETHANE (BIM) DERIVATIVES

Substituted benzaldehyde (1 mmol) and indole (2 mmol) were added into a round bottom flask containing 5 mL of acetic acid and was stirred vigorously at room temperature for 7 h. Deionised water were added dropwise to allow precipitation. Reaction mixture was then transferred into a beaker containing crushed ice. The precipitate formed was filtered and washed with diethyl ether to afford pure product. The pure product was allowed to dry at room temperature and characterised using ^1H and ^{13}C NMR, FT-IR, and UV-Vis spectroscopy.

COLORIMETRIC SENSING ANALYSIS

Stock solutions with concentration of 1×10^{-3} M was prepared for compounds (BIM derivatives) and metal ions (copper, chromium, and manganese) in acetonitrile and deionised water, respectively. The change of colour in 1 mL of the compounds (1×10^{-3} M) was observed immediately once mixed with 1 mL of stock solution of the metal ions.

UV-VIS TITRATION ANALYSIS

Bis-indolylmethane solutions with concentration of 3×10^{-4} M was prepared. Metal ions with concentration of 3×10^{-5} M for CuCl_2 , CrO_3 , and MnSO_4 were also prepared, respectively. Next, 3 mL of the analysed compound was transferred directly into a quartz cuvette and the spectrum of the solution is recorded by means of UV-Vis method, after each drop of the metal cation solution was added and

uniformly mixed using a micropipette. All experiments were conducted at room temperature. The Benesi-Hildebrand Equation (1) was used to obtain the association constant (K_a). The following equation was used to calculate K_a :

$$1/(A-A_0) = 1/\{K(A_{\max} - A_0) [M]\} + 1/(A_{\max} - A_0) \quad (1)$$

A_0 is the receptor's absorbance in the absence of a guest; A is the absorbance measured in the presence of an additional guest; A_{\max} is the absorbance measured in the presence of an additional $[M]_{\max}$; and K_a is the association constant, where $[M]$ is $[\text{Cu}^{2+}]/[\text{Mn}^{2+}]/[\text{Cr}^{6+}]$.

RESULTS AND DISCUSSION

SYNTHESIS OF BIS-INDOLYLMETHANE (BIM) DERIVATIVES

Synthesis of bis-indolylmethane (BIM) derivatives was conducted in a one pot reaction. The synthesis formed various bis-indolylmethane derivatives involving reaction between 2-methylindole with 5 different derivatives of benzaldehyde compounds (Scheme 1). During the synthesis process, two different methods were employed which involve conventional reflux and non-reflux (normal stirring) methods to evaluate the effect on the percentage yield, which indicates the efficiency and effectiveness of the synthetic method. Acetic acid was used as the catalyst and at room temperature, it serves to accelerate the electrophilic substitution reaction between indoles and aromatic aldehydes (El-Sayed, Mahmoud & Hilgeroth 2014). The synthesis process was also monitored using Thin Layer Chromatography (TLC). Ethyl acetate and petroleum ether were used as polar and non-polar solvent system, respectively, with 2 to 2.5 equivalent ratio accordingly to determine the reaction completion.

The results obtained from the experiment showed the reflux method which required higher temperature only to produce a percentage yield around 29%. While for the non-reflux method involving stirring at room temperature, was able to produce a larger yield of the product, ranging from 90 - 98 % (Table 1). This synthesis reactions are proposed to utilise an exothermic process since they yielded a high percentage of products at lower temperatures (Lu, Chung & Chang 2006). The use of acetic acid as a catalyst also contributed to the higher yield with shorter reaction time in room temperature (Kerru et al. 2020). However, this study only reported the results of the stirring method as the reflux method resulted in a minimal product yield and the obtained product was considered unsuitable for further characterisation and preliminary evaluation for metal ion sensor.

In the characterisation study of the BIM compounds, ^1H NMR spectra for all compounds displayed a singlet

peak formed at around 5.8 to 6 ppm representing the methane group, C-H and the disappearance of the C=O peak from the ^{13}C NMR spectrum of the starting material (benzaldehyde) occurred confirmed the formation of the final BIM compound.

4-(bis(2-methyl-1H-indol-3-yl)methyl)-2,6-dimethoxyphenol (1)

Light pink solid; Yield 91%; IR (ATR, ν_{\max} / cm^{-1}): 3399 (N-H), 3324 (O-H), 2934 (C-H), 1513 (C=C aromatic), 1324 (C-N), 1200 (C-O); ^1H NMR (400 MHz, DMSO) δ 10.65 (s, 2H), 8.30 – 8.24 (m, 1H), 7.19 (d, $J = 8.0$ Hz, 2H), 6.87 (dd, $J = 13.4, 7.6$ Hz, 4H), 6.68 (t, $J = 7.5$ Hz, 2H), 6.47 (s, 2H), 5.80 (s, 1H), 3.51 (s, 6H), 2.05 (s, 6H); ^{13}C NMR (101 MHz, DMSO) δ 148.15 (COH), 135.41 (Ar-C), 134.74 (Ar-C), 134.15 (Ar-C), 132.28 (Ar-C), 128.70 (Ar-C), 120.04 (Ar-C), 118.87 (Ar-C), 118.36 (Ar-C), 113.16 (Ar-C), 110.78 (Ar-C), 107.21 (Ar-C), 56.47 ($2 \times \text{COCH}_3$), 12.34 ($2 \times \text{O-CH}_3, 2 \times \text{CH}_3$).

N-(4-(bis(2-methyl-1H-indol-3-yl)methyl)phenyl)acetamide (2)

Dark pink solid; Yield 95%; IR (ATR, ν_{\max} / cm^{-1}): 3383 (N-H), 3000 (C-H), 1670 (C=O), 1511 (C=C aromatic), 1303 (C-N); ^1H NMR (400 MHz, DMSO) δ 10.71 (s, 2H), 9.89 (s, 1H), 7.47 – 7.39 (m, 2H), 7.20 (dd, $J = 8.1, 1.0$ Hz, 2H), 7.11 – 7.04 (m, 2H), 6.88 (ddd, $J = 8.1, 7.0, 1.2$ Hz, 2H), 6.81 (d, $J = 7.9$ Hz, 2H), 6.67 (ddd, $J = 8.1, 6.9, 1.1$ Hz, 2H), 5.85 (s, 1H), 2.03 (d, $J = 16.1$ Hz, 9H); ^{13}C NMR (101 MHz, DMSO) δ 168.67 (CO), 139.35 (Ar-C), 137.46 (Ar-C), 135.49 (Ar-C), 132.45 (Ar-C), 129.24 (Ar-C), 128.69 (Ar-C), 119.99 (Ar-C), 119.15 (Ar-C), 118.92 (Ar-C), 118.38 (Ar-C), 112.74 (Ar-C), 110.78 (Ar-C), 38.51 (CH), 24.36 (CNH₃), 12.36 ($3 \times \text{CH}_3$).

4-(bis(2-methyl-1H-indol-3-yl)methyl)phenol (3)

Bright pink solid; Yield 98%; IR (ATR, ν_{\max} / cm^{-1}): 3392 (N-H), 3309 (O-H), 2999 (C-H), 1464 (C=C aromatic), 1302 (C-N); ^1H NMR (400 MHz, DMSO) δ 10.63 (s, 2H), 9.36 (s, 1H), 7.18 (d, $J = 8.0$ Hz, 2H), 6.94 (d, $J = 8.5$ Hz, 2H), 6.90 – 6.82 (m, 2H), 6.78 (d, $J = 8.0$ Hz, 2H), 6.69 – 6.58 (m, 4H), 5.76 (s, 1H), 2.03 (s, 6H); ^{13}C NMR (101 MHz, DMSO) δ 155.52 (COH), 135.44 (Ar-C), 134.91 (Ar-C), 132.28 (Ar-C), 129.95 (Ar-C), 128.70 (Ar-C), 120.01 (Ar-C), 118.95 (Ar-C), 118.36 (Ar-C), 115.15 (Ar-C), 113.20 (Ar-C), 110.78 (Ar-C), 38.20 (CH), 12.27 ($2 \times \text{CH}_3$).

3,3'-((4-nitrophenyl)methylene)bis(2-methyl-1H-indole) (4)

Bright yellow solid; Yield 90%; IR (ATR, ν_{\max} / cm^{-1}): 3394 (N-H), 2911 (C-H), 1510 (C=C aromatic), 1318 (NO₂), 1224 (C-N); ^1H NMR (400 MHz, DMSO) δ 10.87 (s, 2H), 8.19 – 8.12 (m, 2H), 7.46 – 7.39 (m, 2H), 7.25 (d, $J = 8.0$

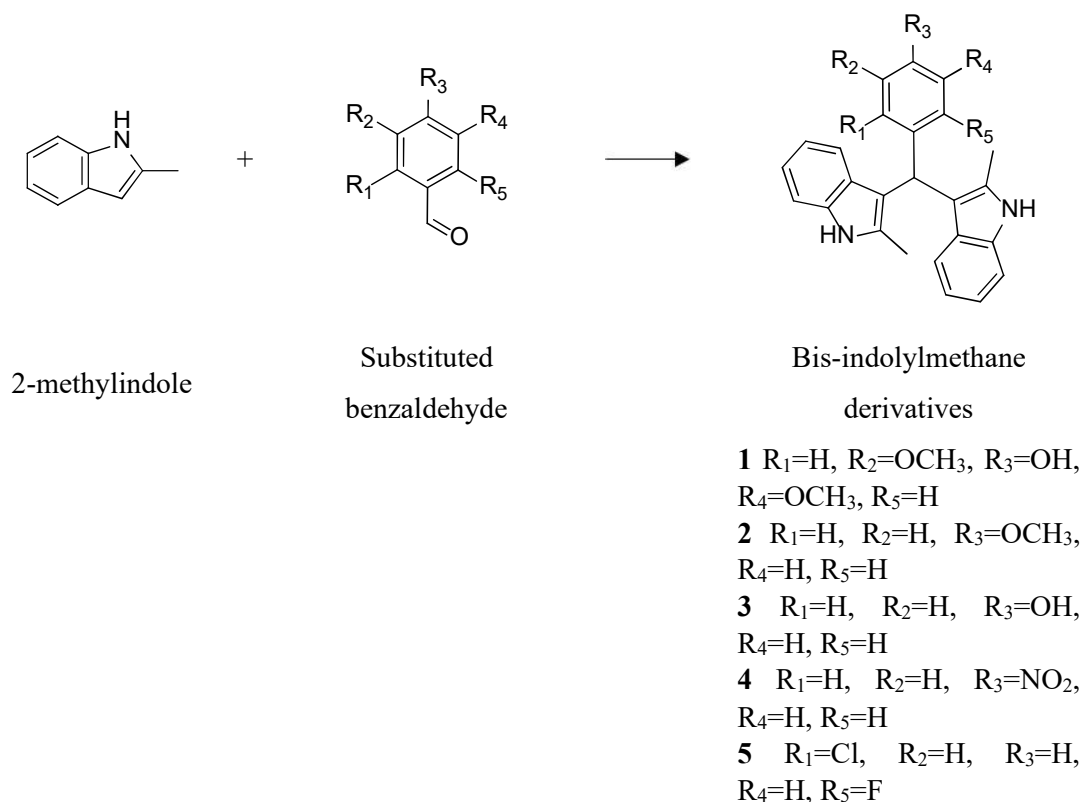
Hz, 2H), 6.92 (ddd, $J = 8.1, 6.9, 1.2$ Hz, 2H), 6.80 (d, $J = 8.0$ Hz, 2H), 6.70 (ddd, $J = 8.0, 6.9, 1.1$ Hz, 2H), 6.07 (s, 1H), 2.10 (s, 6H); ^{13}C NMR (101 MHz, DMSO) δ 153.38 (CNO₂), 146.16 (Ar-C), 135.58 (Ar-C), 133.05 (Ar-C), 130.30 (Ar-C), 128.34 (Ar-C), 123.72 (Ar-C), 120.27 (Ar-C), 118.71 (Ar-C), 111.32 (Ar-C), 111.02 (Ar-C), 39.16 (CH), 12.38 (2 \times CH₃).

3,3'-((2-chloro-6-fluorophenyl)methylene)bis(2-methyl-1H-indole) (**5**)

Light pink solid; Yield 94%; IR (ATR, ν_{max} /cm⁻¹): 3378 (N-H), 2910 (C-H), 1566 (C=C aromatic), 1242 (C-N); ^1H NMR (400 MHz, DMSO) δ 10.79 (s, 2H), 7.44 – 7.33 (m, 2H), 7.28 (dd, $J = 8.0, 1.1$ Hz, 2H), 7.14 (ddd, $J = 11.0, 8.0, 1.5$ Hz, 1H), 6.96 (ddd, $J = 8.1, 7.0, 1.2$ Hz, 2H), 6.89 (d, $J = 7.9$ Hz, 2H), 6.76 (ddd, $J = 8.1, 6.9, 1.1$ Hz, 2H), 6.37 (s, 1H), 1.99 (s, 6H); ^{13}C NMR (101 MHz, DMSO) δ 164.00 (CF), 161.51 (CCl), 129.79 (Ar-C), 129.34 (Ar-C), 128.75 (Ar-C), 126.09 (Ar-C), 120.13 (Ar-C), 118.62 (Ar-C), 118.03 (Ar-C), 115.88 (Ar-C), 115.65 (Ar-C), 110.86 (Ar-C), 109.81 (Ar-C), 34.62 (CH), 12.04 (2 \times CH₃); Melting point 271–272 °C.

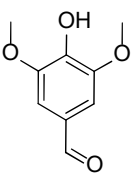
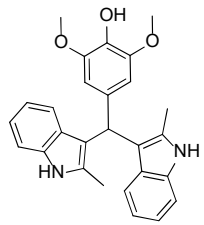
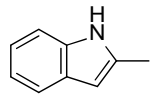
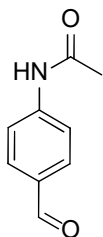
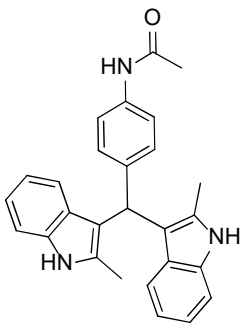
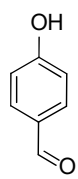
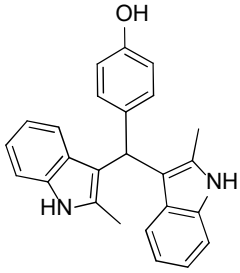
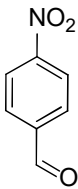
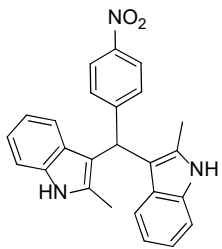
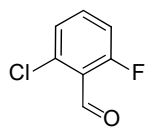
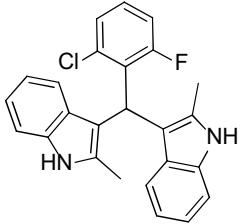
COLORIMETRIC SENSING ANALYSIS

In this study, the colorimetric sensitivity of all compounds to the heavy metal ions Cu²⁺, Cr⁶⁺, and Mn²⁺ was observed visually using human naked eyes (Figure 1). The colour changes demonstrated the highest potential of bis-indolylmethane derivatives to interact or bind with the metal ion. Colour changes observed after the introduction of metal ions solution to the compound solutions indicated a positive response between the analysed BIM compounds and metal ions. Additionally, an internal charge transfer (ICT) state, which oversees a variety of colour changes, resulted from the strong hydrogen-bond donor capability of the indolyl group NH in bis-indolylmethanes (Oliveira et al. 2014). Among all the compounds studied, compounds **1** and **5** were reported to demonstrate the most intense colour changes. For the compound **1**, after the addition of yellow colour of Cu²⁺ solution and colourless Mn²⁺ solution, the pale pink and the orangey colour of the ligand turned to red and pinkish, respectively, while for the compound **5**, after addition of yellow colour of Cr⁶⁺, the colourless ligand turn into light yellow. Hence, they are shown to have the highest possibility to interact or bound with the metal ions.



SCHEME 1. General reaction of 2-methylindole with substituted benzaldehydes to produce bis-indolylmethane derivatives **1** – **5**

TABLE 1. List of bis-indolylmethane derivatives with their percentage yield

Indole	Benzaldehyde	Compound	Percentage of yield
		 1	91% (M. Shanti et al. 2023)
		 2	95% (He et al. 2009)
		 3	98% (He et al. 2009)
		 4	90% (Barbero et al. 2011)
		 5	94% (New compound)

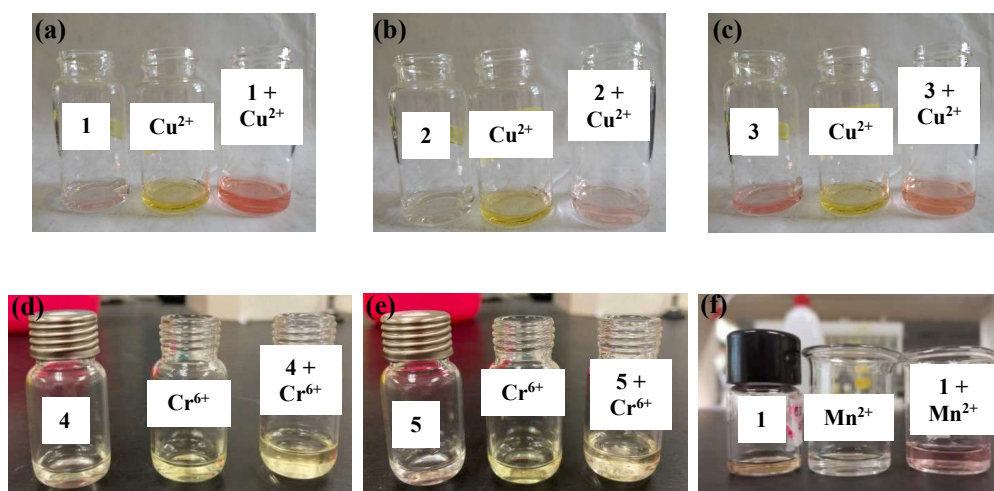


FIGURE 1. Colour changes of (a) ligand **1** with Cu^{2+} , (b) ligand **2** with Cu^{2+} , (c) ligand **3** with Cu^{2+} , (d) ligand **4** with Cr^{6+} , (e) ligand **5** with Cr^{6+} and (f) ligand **1** with Mn^{2+} tested at a concentration of 1×10^{-3} M

UV-VIS TITRATION ANALYSIS

Due to the properties of two compounds **1** and **5** which are seen to have the ability as ionophore for the metal ion sensor, a further analysis was conducted using UV-Vis titration analysis to identify binding interaction between compound **1** with the metal ions involving Cu^{2+} and Mn^{2+} and compound **5** with Cr^{6+} , respectively. The UV-Vis electronic spectrum of the free ligand for compound **1** exhibits two bands at 235 nm and 285 nm, respectively, while two bands at 228 nm and 282 nm were exhibited, respectively, in the electronic spectrum of the free ligand for compound **5** as shown in Table 2. The strong absorption band at 235 nm and 228 nm in each spectrum were due to the conjugated aromatic system $\pi \rightarrow \pi^*$ electron transitions (Figure 2). While the medium bands displayed in each of the spectrums at 285 nm and 282 nm are likely the result of $n \rightarrow \pi^*$ electron transitions (Figure 2) are involving lone pairs of nitrogen atoms near the edge of the compounds (Zhang et al. 2017).

From the titration study between compounds **1** and **5** with their respective metal ions that were conducted, it is shown that all the spectra displayed formation of new absorption band peaks indicated interaction happened

between the compounds and the metal ions (Figure 3). As for the interaction between compound **1** with metal ion Cu^{2+} , different shifts were seen in the d-d bands of the metal complexes and a new peak rise at 500 nm because of d-d orbital transition of Cu^{2+} (Zhang et al. 2022) while for the interaction with Mn^{2+} , a lower energy Ligand-to-Metal Charge Transfer (LMCT) band was displayed around 350-390 nm. Additionally, interaction between compound **5** and Cr^{6+} also exhibited a new peak at 350 nm which indicated LMCT band (Stavrou et al. 2023). An intramolecular charge shift from two groups of NH in pyrrole moiety in all ligands which functions as chromophores in BIM that can possibly make interaction with the metal ions (Ding et al. 2015), resulted to a new absorption band formation. This occurrence also known as a 'red shift' which occurs when the absorbance peak of a metal complex shifts to a lower frequency and a longer wavelength, moving towards the red end of the spectrum. Apparently, the rise of UV-Vis titration new peak for the interaction between compound **1** with Cu^{2+} and compound **5** with Cr^{6+} reached a plateau after 25th and 50th times of titration, respectively. It indicated formation of a complex between compounds and the metal ions.

TABLE 2. UV-Vis electronic spectrum bands of free ligands **1** and **5**

Free ligand	Strong absorption band (nm)	Medium absorption band (nm)
1	235	285
5	228	282

Association constant (K_a) was calculated using Benesi-Hildebrand equation to determine the stoichiometric binding between the compounds and the metal ions. The study showed the plot of $1/(A-A_0)$ versus $1/[Cu^{2+}]$, $1/[Mn^{2+}]$, and $1/[Cr^{6+}]$, respectively, showed a linear relationship with R^2 values near to 1 as shown in Figure 4. The values obtained indicated the compound to metal ions stoichiometry is 1:1 ratio. Based on the binding constant (K_a) for compounds values calculated from the value of y -intercept, the interaction for Cu^{2+} and Cr^{6+} exhibit $2.921 \times 10^3 M^{-1}$ and $1.418 \times 10^3 M^{-1}$, respectively (Table 3). These values are comparable with the previous study that recorded K_a values within the range $10^3 - 10^5 M^{-1}$ (Alraqa et al. 2021; Iqbal

et al. 2020) indicates that they have a good binding ability with metal ions. Apart from that, interaction between the compound **5** with Mn^{2+} displays K_a value of $2.98 \times 10^1 M^{-1}$ (Table 3) which is considered low compared to average K_a values that have been recorded before.

The lower thermodynamic stability of manganese complexes compared to other divalent transition metal ions can be explained by the lack of compound-field stabilization due to the symmetric d^5 electron configuration system of the Mn^{2+} ion (Schanne et al. 2022) which then resulting in lower association constant of the complex. It also explained the reason for the new absorption peak that formed after the titration is lower compared to Cu^{2+} and Cr^{6+} interaction with the compounds.

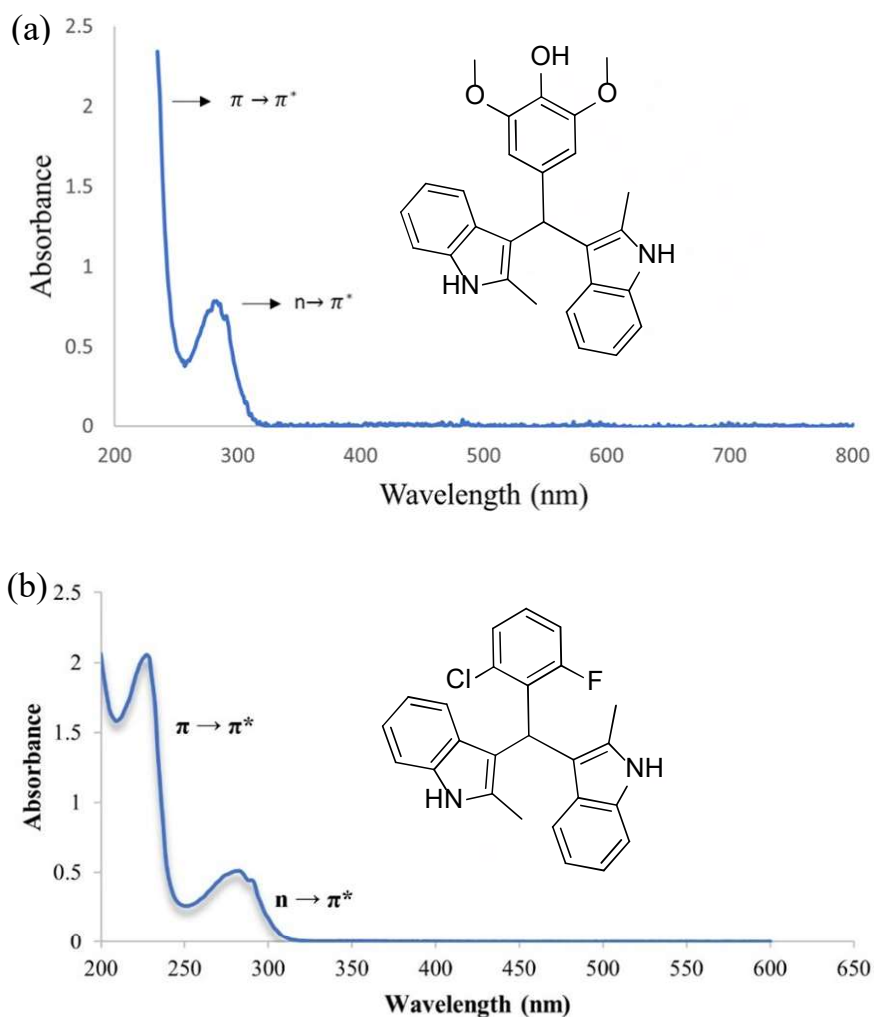


FIGURE 2. UV-Vis spectrum of (a) free ligand 1 and (b) free ligand 5

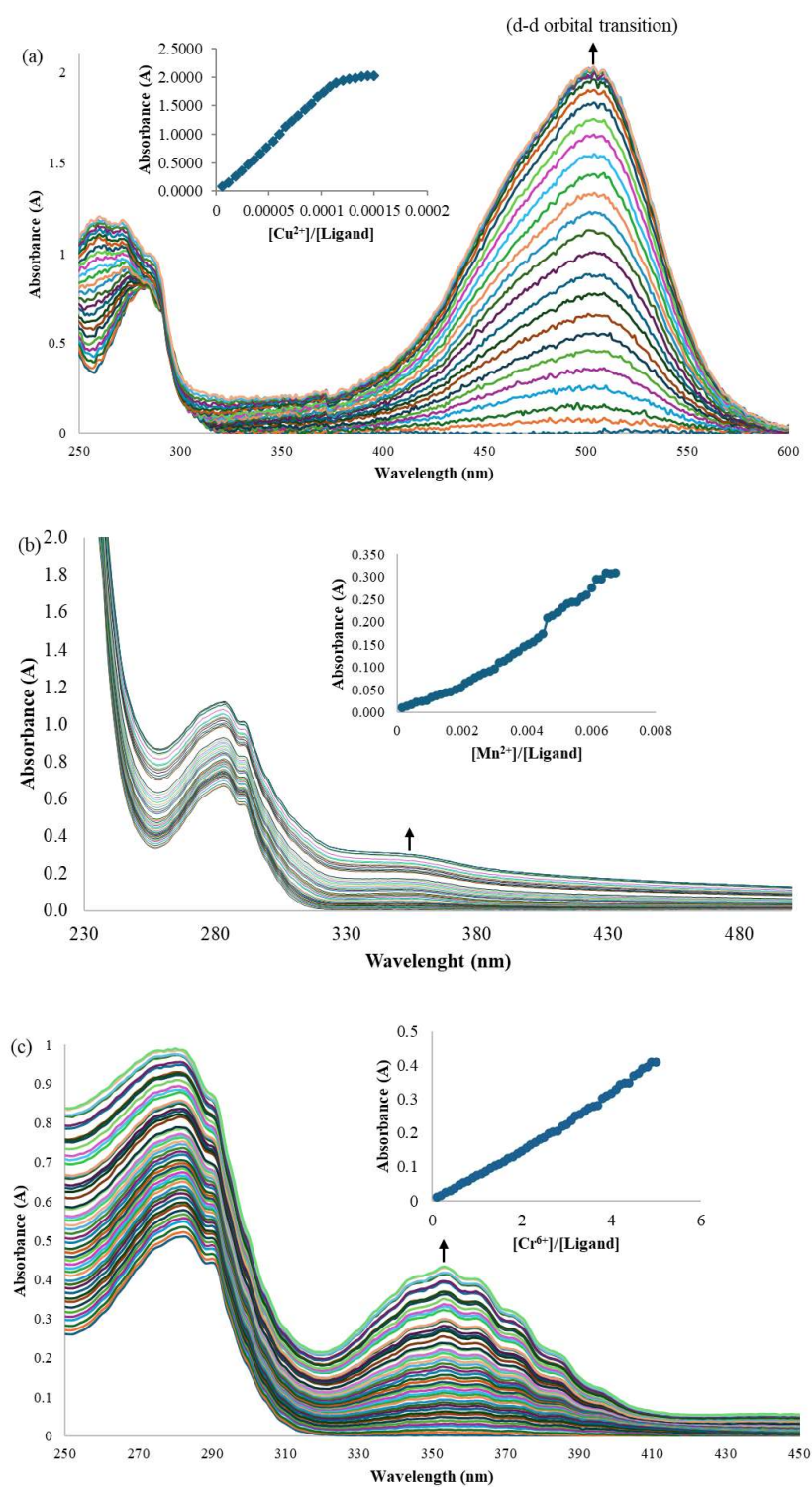


FIGURE 3. UV-Vis spectra generated from titration of (a) ligand 1 with Cu^{2+} , (b) ligand 1 with Mn^{2+} and (c) ligand 5 with Cr^{6+}

TABLE 3. Binding constant (K_a) values for interaction between compounds **1** and **5** with metal ions

Compound	Metal ion	R^2	K_a (M^{-1})
1	Cu^{2+}	0.997	2.921×10^3
1	Mn^{2+}	0.996	2.98×10^4
5	Cr^{6+}	0.999	1.418×10^3

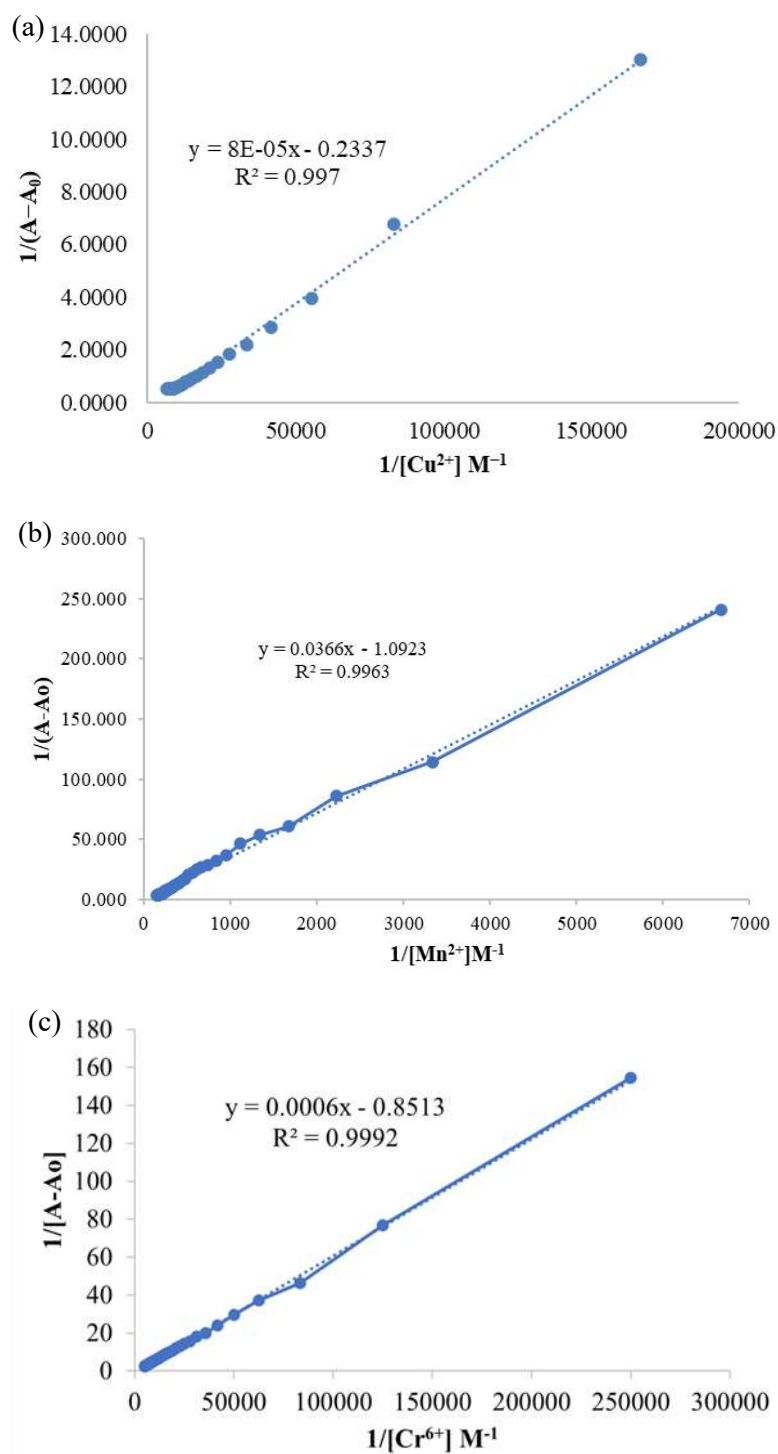


FIGURE 4. Benesi Hildebrand plot of $1/(A-A_0)$ versus (a) $1/[Cu^{2+}]$, (b) $1/[Mn^{2+}]$, and (c) $1/[Cr^{6+}]$

CONCLUSIONS

In this work, bis-indolylmethane derivatives have been successfully synthesised using a new convenient stir method compared to the conventional reflux method. This straightforward and simple approach requires short reaction time, produces larger yields, and it is also environmentally friendly. In the colorimetric sensing analysis, obvious colour changes were observed after the metal ions were introduced into the compounds, hence signify the interaction of BIM with the metal ions is occurred. UV-Vis titration results proved the binding ability of BIM towards the metal ions, through the formation of a new peak at LMCT and d-d bands which is highly attributed from the reaction of metal ions with NH functional group in the pyrrole moiety. The good binding constant (K_a) values obtained also showed the ability of BIM to interact and act as a potential heavy metal ion sensor especially on copper and chromium ions. BIM derivatives analysed in this study can be further scrutinised for future development of heavy metal ion colorimetric sensors.

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