Fluorescence Quenching of the Fluorophore Diphenylamine for Determination of Neodymium (III)

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Abstract—**Advanced analytical techniques such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS) are powerful tools for chemical analysis; however, they present several practical challenges, including high operating costs, the need for skilled personnel, and time-consuming procedures for analysis and data interpretation. Their performance can also be affected by sample matrix interference, limited throughput, strict calibration requirements, and environmental concerns related to hazardous solvent disposal. Therefore, the development of a simple, sensitive, and cost-effective method such as fluorometry is highly desirable. In this study, fluorometry was applied for the determination of neodymium (III) based on the quenching mechanism of the fluorescent agent diphenylamine (DPA) in an ethanol medium. Neodymium, a lanthanide element, is important due to its environmental, industrial, and technological impacts. The fluorescence signal of DPA, excited at 310 nm, is quenched by Nd(III) in the presence of 2.2 mL of Britton–Robinson buffer at pH 3.0, forming a stable ion-associated complex. The method showed linearity over the concentration range of 0.5–24.0 µg/mL, with a limit of detection of 0.046 µg/mL and a limit of quantification of 0.140 µg/mL, and a strong correlation coefficient ($R^2 = 0.9956$). The tolerance of common coexisting substances was evaluated, and the results were consistent with those obtained using ICP-MS, confirming the method's accuracy and precision, indicating that it is a reliable, simple, and effective tool for environmental monitoring and analysis.**

***Index Terms*— Diphenylamine, Fluorimetry, Neodymium (III) determination, Quenching.**

I. INTRODUCTION

Neodymium, Nd (III), belongs to the lanthanide group, wherein the stable (III) oxidation is simply characterized by an insufficient filled 4f shell. Although they are referred to as rare earth elements, their abundance in the environment is almost in the same amount of zinc and copper (Behrsing, Deacon and Junk, 2022). Globally, there is a rapid growing of studying the science of lanthanide in different fields of technology (Haxel, Hedrick and Orris, 2002; McGill, 2005). Neodymium has many applications in fluorescent and laser technology due to their luminescent properties (Behrsing, Deacon and Junk, 2022).

Multiple techniques are used to detect neodymium, including Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), ICP-MS, ultraviolet (UV)-visible spectrophotometry, atomic absorption spectroscopy, and fluorometry (Yang et al., 2011; Lambert et al., 2016; Choi et al., 2007). Among those techniques that mostly need sophisticated requirement and preparation, plus the high cost, UV-visible spectrophotometer and fluorometry are promising techniques due to easy operation, low cost, and needless pre-treatment (Ghosh et al., 2024; Bose et al., 2018). Fluorometry, compared with a UV-visible spectrophotometer, is very sensitive and specific due to the selection of the excited and emitted wavelength of the light (Bose et al., 2018). The potential of fluorometry is still broadly uncharted.

Nd (III) has weak fluorescence due to 4f orbitals that are shielded from the surroundings by the filled $5s^2$ and $5p^2$ orbitals. Consequently, the 4f–4f transitions are valency-prohibited and weakly allowed. The transitions that are prohibited by odd parity turn into partially recognized by mixing 4f and 5d states through the ligand field (Hasegawa, Wada and Yanagida, 2004). On this basis, the fluorescence intensity of neodymium (III) is enhanced by forming a complex with a ligand that contains H, C, N, and O (Asif et al., 2021). Diphenylamine (DPA) was used as a fluorophore with lanthanide through a quenching process. Its interaction in the excited state with lanthanide and uranyl ions was scrutinized in acetonitrile solution and the quenching mechanism was studied, yet it didn't apply for quantification of neodymium (III) (Verma, Sawant and Pal, 2011). Despite the availability of various analytical methods, many existing techniques are often time-consuming, require expensive instrumentation, involve complicated sample preparation steps, and consume large amounts of reagents and chemicals. These limitations make such methods less practical for routine laboratory applications or resource-limited settings. Therefore, there is a need for a simple, low-cost, and efficient analytical approach that minimizes chemical consumption, eliminates the need for prior sample preparation, and is easy to perform while maintaining acceptable accuracy and reliability. The present method addresses these challenges by

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offering a straightforward procedure that reduces operational costs and simplifies the overall analysis process. In this study, a sensitive and specific technique of fluorometry is used for the determination of neodymium (III) in ethanol solution using DPA fluorophore through a quenching mechanism.

II. Materials and Methods

A. Instruments

A Cary Eclipse fluorescence Agilent spectrophotometer, USA, that supplied a xenon lamp as the light source and a grating monochromator for excitation and emission measurements was used. The slits of the excitation and emission monochromators, with a width of 5.0 nm and a 1.0 cm quartz cell, were applied. The pH of the buffer solutions was measured using a digital pH meter (EUTECH, Thermo Fisher Scientific, USA). To record the molecular absorption, an Agilent Cary Eclipse UV-visible Spectrophotometer, USA, with a quartz cell of 1.0 cm length was administrated. The absorption spectra of neodymium (III) nitrate hexahydrate, Nd $(NO_3)_3\cdot 6H_2O$, in ethanol, DPA in water, and the Nd(III)–DPA complex solutions are recorded individually over the wavelength range of 250–340 nm using a blank solution. The blank solution is prepared by mixing ethanol and water in a 1:1 ratio.

B. Chemical and Reagents

All the chemicals that were used in the study were of analytical grade and did not require any more purification. Absolute ethanol of purity 99.5% and double-distilled water were used in the preparation of the reagents and the standard solutions.

Acetate buffers of pH range (1.7–7.0) were prepared by mixing 0.1 mol/mL CH_3COONa and 0.1 mol/mL CH_3COOH in a 1:1 ratio with adjusting the pH of the mixture to the desired one using 0.1 mol/mL HCl and 0.1 mol/mL NaOH solutions. Phosphate buffers of pH range (5.5–8.5) were prepared by mixing 0.1 mol/mL Na_2HPO_4 and 0.1 mol/mL NaH_2PO_4 in a 1:1 ratio and adjusting the pH of the mixture to the desired one using 0.1 mol/mL HCl and 0.1 mol/mL NaOH solutions. Britton Robinson buffers of pH range (2.0–7.0) were prepared by mixing an equal ratio of 0.1 mol/mL H_3BO_3, 0.1 mol/mL CH_3COOH, and 0.1 mol/mL H_3PO_4 by adjusting the pH of the mixture to the desired one using 0.1 mol/mL NaOH solution.

C. Preparation of Standard Solutions

A solution of 4.0 × 10^{-4} mol/mL DPA is prepared by dissolving an appropriate amount of the solid in deionized water. Standard solutions are prepared by mixing 1.5 mL of the DPA solution with 2.2 mL of Britton–Robinson buffer (pH 3.0) and varying concentrations of $Nd(NO_3)_3\cdot 6H_2O$, prepared in ethanol. The concentration of Nd (III) in the final solutions ranges from 0.5 to 24.0 µg/mL.

D. Proposed Procedure

The calibration curve is made by mixing 1.5 mL of 4.0 × 10^{-4} mol/mL DPA solution with 2.2 mL of Britton-Robinson buffer pH 3.0, and then added to different concentrations of neodymium (III) nitrate Nd $(NO_3)_3.6H_2O$ in ethanol, individually. Fluorescence measurements are carried out against a blank solution containing 2.2 mL of Britton–Robinson buffer (pH 3.0), 1.5 mL of 4.0 × 10^{-4} mol/mL DPA, and 5.0 mL of ethanol. The final volume is adjusted to 10.0 mL with deionized distilled water in a volumetric flask. The linear concentration range of Nd (III) is between 0.5 and 24.0 µg/mL. The fluorescent intensity is recorded within 30 s of mixing the solutions for each concentration of the solution.

Limit of detection (LOD) and limit of quantification LOQ were defined by International Union of Pure and Applied Chemistry:

$$\text{LOD} = 3.3\sigma/S \text{ eq} \quad (1)$$

$$\text{LOQ} = 10\sigma/S \text{ eq} \quad (2)$$

The σ, which is the standard deviation (SD), was calculated from five reagent blank measurements, since S expresses the slope of the calibration curve.

III. Results and Discussion

A. Molecular Emission

The weakened fluorescence intensity of molecular emission of 4.0 × 10^{-4} mol/mL Nd $(NO_3)_3.6H_2O$ solution prepared in ethanol at excitation wavelength (λ_ex) 310 nm is below 200 a.u. due to the prohibited 4f–4f transitions in the electronic configuration of the lanthanide ion (Hasegawa, Wada and Yanagida, 2004). In contrast, a 4.0 × 10^{-4} mol/mL solution of DPA fluoresces strongly above 500 a.u. at the same excitation wavelength due to the electrons donated by the amine group and the conjugated aromatic rings in the structure of the compound. These two groups in DPA evolve the efficient π→π* excitation and emission (Verma, Sawant and Pal, 2011). Quenching mechanism occurs after mixing Nd (III) and DPA ligand and forms Nd (III)-DPA complex (Fig. 1). The reasons for choosing ethanol as a solvent are due to good solubility of both Nd (III) and DPA, low toxicity, as well as minimal background quenching.

B. Molecular Absorption

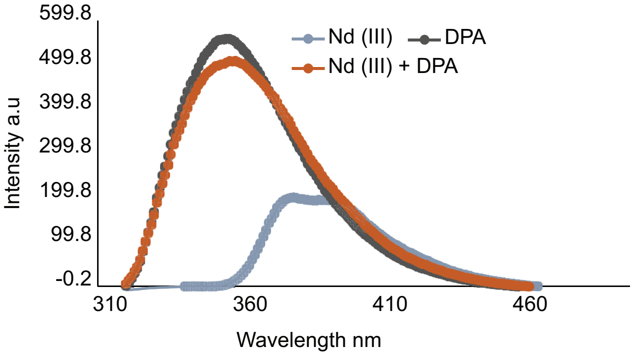


Fig. 1. Molecular emission spectra of 4.0 × 10^{-4} mol/mL solution of Nd $(NO_3)_3.6H_2O$, DPA and Nd (III)-diphenylamine complex, individually in ethanol at excitation wavelength (λ_ex) = 310 nm.

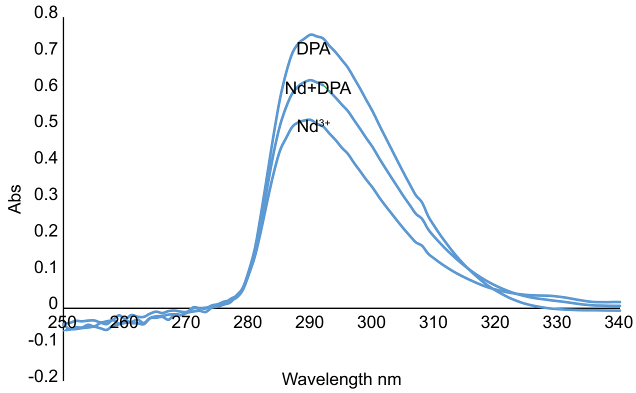


Fig. 2. Molecular absorption of 4.0 × 10^{-4} mol/mL solution of Nd $(NO_3)_3.6H_2O$, DPA and Nd (III)-DPA complex, individually in ethanol.

The molecular absorption of Nd $(NO_3)_3.6H_2O$, DPA and Nd (III)-DPA complex, were investigated individually, in ethanol solutions (Fig. 2). The spectrum of Nd (III) shows less absorbance compared with the ligand and the complex due to the domination of f-f transition in the UV region as the 4f electrons are shielded by outer 5s and 5p orbitals of their electronic configuration (Purohit and Bhojak, 2013). DPA displays higher absorbance because of two sources of transition, one from the aromatic π electrons ($\pi \rightarrow \pi^*$), and the second from the nitrogen lone pair ($n \rightarrow \pi^*$), as well as the charge-transfer interaction between amine nitrogen and aromatic rings (Saravanan et al., 2025). Unlike the Nd (III)-DPA complex, the coordination of DPA to Nd (III) diminishes the absorption as a result of retaining the N lone pair in bonding with Nd^{3+}, and the π system is disrupted.

C. Different Buffers with their Volumes

Nd (III)-DPA complex was assessed in different buffer solutions started with acetate buffer range pH (1.7–7.0), phosphate buffer range pH (5.5–8.5) and Britton Robinson buffer pH range (2.0–7.0) at λ_ex = 310 nm (Fig. 3). The mixture of 4.0 mL of 4.0 × 10^{-4} mol/mL DPA solution and 5.0 µL of 4.0 × 10^{-4} mol/mL Nd $(NO_3)_3.6H_2O$ was mixed with 2.0 mL of a buffer solution. Phosphate buffer of pH range (5.5–8.5) causes a turbid white solution; thus, it decline the fluorescence intensity below 10 a.u. because of the formation of $NdPO_4$, which is low soluble in aqueous solution (Van Hoozen, Gysi and Harlov, 2020). On the other hand, the Britton-Robinson buffer solution of pH 3.0 displays the highest intensity in comparison with the acetate buffer solutions; therefore, it is selected for further studies.

The outstanding amounts of Britton-Robinson buffer pH 3.0 were carefully inspected where several amounts of the buffer (0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4 and 2.6 mL) were added to a mixture of 4.0 mL of 4.0 × 10^{-4} mol/mL DPA solution with 5.0 µL of 4.0 × 10^{-4} mol/mL $Nd(NO_3)_3.6H_2O$ solution (Fig. 4). The most significant fluorescence signal produced was for 2.2 mL of the buffer. Correspondingly, this volume was selected for the next experiments.

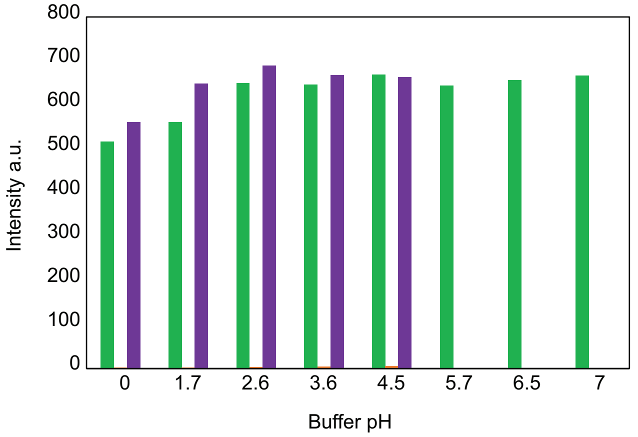


Fig. 3. Buffer solutions study of Nd (III)-DPA complex ■ acetate buffer solutions, pH range (1.7–7.0) ■ Britton-Robinson buffer solutions, pH range (2.0–7.0).

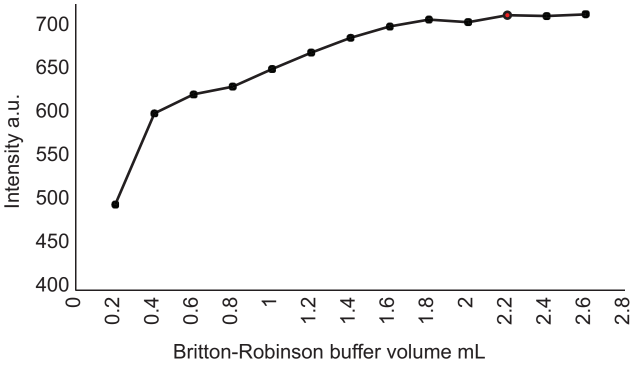


Fig. 4. Different volumes of Britton-Robinson buffer pH 3.0 for Nd (III)-DPA complex.

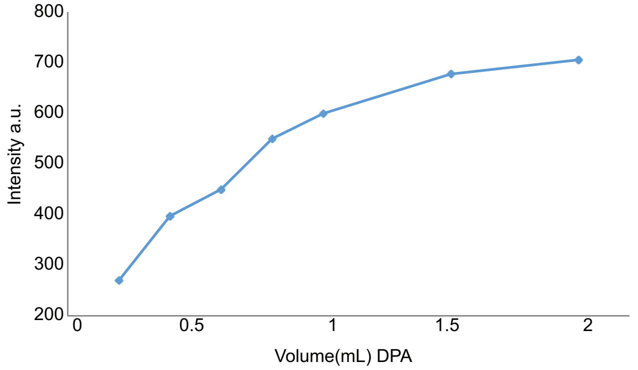


Fig. 5. Different volumes of 4.0 × 10^{-4} mol/mL diphenylamine reagent.

D. Different Concentrations of DPA

To assign the effect of differing DPA reagent concentrations, the quenching fluorescence signal of Nd (III)-DPA complex was recorded for the reagent volumes (0.2, 0.4, 0.6, 0.8, 1.0, 1.5, and 2.0 mL). Fig. 5 indicates the maximum fluorescence response at 1.5 mL of DPA reagent, which is applied for further examinations. The steady state of the fluorescence signal at a certain amount of DPA reagent (2.0 mL) indicates the saturation of binding sites of Nd^{3+} ions

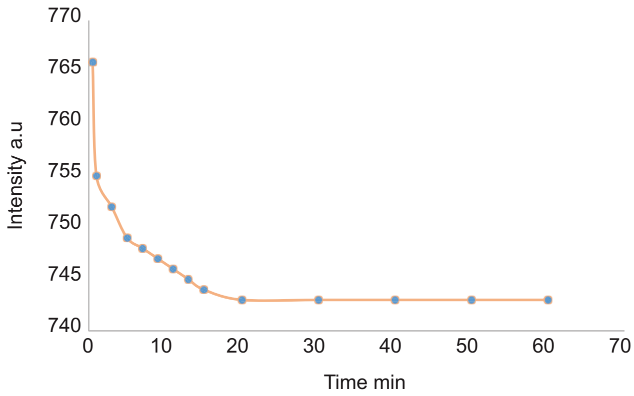


Fig. 6. Impact of response period of Nd (III)-diphenylamine complex at room temperature (25.0 ± 5.0°C).

and becomes totally complex; thus, maximum quenching capability has been reached. There is no significant change display when extra DPA is added.

E. Impact of Response Period

Optimum conditions of pH and concentration of the reagent DPA for Nd (III)-DPA complex were applied to investigate their response over time at room temperature (25.0 ± 5.0°C). The data in Fig. 6. displays the decline of the fluorescence quenching signal continuously over time, declining started after 1 min of mixing and continued until reaching 20 min, where the response remained constant for at least 60 min. Fluorescence intensity was decreased after 1 min, likely due to partial complex decomposition and photobleaching (Lakowicz, 2006). All measurements were recorded immediately after mixing to maintain reproducibility. Conclusively, the fluorescence signal of the Nd (III)-DPA complex must be examined within 30 s after mixing the chemicals.

F. Coexisting Materials Analysis

The efficiency of the proposed fluorescence approach for analysis of the Nd^{3+} ion as it is in a real sample was examined by adding the common coexisting metal ions to the Nd (III)-DPA complex. This study was performed by mixing 5.0 µL of 4.0×10^{-4} mol/mL $Nd(NO_3)_3.6H_2O$ solution, 2.2 mL of Britton-Robinson buffer pH 3.0, and 1.5 mL of 4.0×10^{-4} mol/mL DPA reagent with different volumes between (0.05 and 6.5 mL) of 4.0×10^{-4} mol/mL solution of interferences individually, in a 10.0 mL volumetric flask. The quenched fluorescence signal was recorded once all components were mixed at excitation wavelength = 310 nm. The quantitative examination of Nd (III) disclosed an error of no more than 3.0% for an average of five determinations. Fig. 7 illustrates that there is no significant interference from Co^{2+}, Cu^{2+}, Ni^{2+}, Fe^{3+}, Al^{3+}, Pb^{2+}, Zn^{2+}, Cd^{2+}, Mg^{2+}, Mn^{2+}, and Hg^{2+} is detected, controlled by their concentrations endure under the corresponding tolerance limits. Accordingly, the admissible concentrations are: Fe^{3+} and $Hg^{2+} \leq 0.808$ µg/mL; Cd^{2+}, Al^{3+} and $Pb^{2+} \leq 1.500$ µg/mL; Co^{2+}, Zn^{2+} and $Mn^{2+} \leq 3.569$ µg/mL; $Ni^{2+} \leq 4.652$ µg/mL; $Mg^{2+} \leq 5.128$ µg/mL and $Cu^{2+} \leq 9.664$ µg/mL.

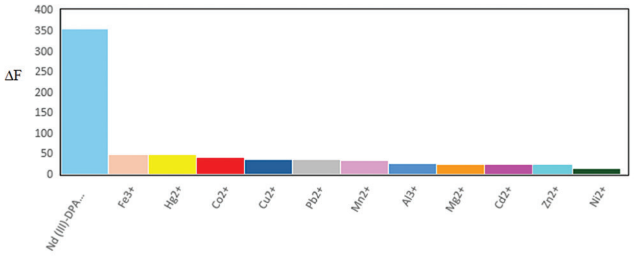


Fig. 7. The impact of coexisting metal ions on the quenching fluorescence signal of Nd (III)-diphenylamine complex.

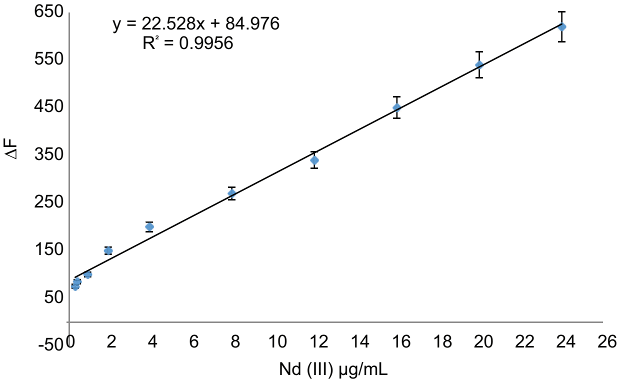


Fig. 8. Calibration graph for quantitative determination of Nd (III) via quenching fluorescence process of the reagent diphenylamine.

G. Nd (III) Analysis and Calibration Curve

Under optimized conditions of reaction, a calibration curve is retrieved based on the different fluorescence intensity ΔF versus Nd (III) concentration (Fig. 8). The fluorescence quenching of DPA by Nd (III) was quantified as $\Delta F = F_0 - F$, where F_0 is the fluorescence intensity of the blank solution (without Nd (III)) and F is the fluorescence intensity of the sample after adding Nd (III). As Nd (III) concentration increases, F decreases due to quenching, resulting in a positive ΔF.

A linear range of Nd (III) concentration from 0.5 to 24.0 µg/mL is observed with a correlation value of 0.9956. The LOD of 0.046 µg/mL and limit of quantification LOQ of 0.140 µg/mL were achieved.

H. Validness of the Proposed Method

Assessment of accuracy and precision is part of the validness of the proposed fluorometric method for the determination of Nd (III), and this was done by calculation of relative error (Error%) and relative standard deviation (RSD%). SD is measured the degree of distribution inside a group of values.

Natural environmental samples from the local region (river water, tap water, and soil) were collected. However, Nd concentrations in these matrices were found to be below the detection limit, consistent with the low natural abundance of Nd in local soils and waters. To demonstrate the applicability of the proposed fluorometric method for environmental monitoring, spike-recovery experiments were performed by

TABLE I
Accuracy and Precision of Nd (III) ion Determination via Quenching Fluorescence of Diphenylamine

Spiked water river sample (μg/mL)	Found value (μg/mL)	SD	RSD%	Error[1]%
1.5	1.51	1.34	0.13	0.67
13.0	13.20	1.55	0.34	1.53
20.0	18.91	1.60	0.81	−5.45

SD: Standard deviation, RSD %: Relative standard deviation. [1]Mean value derived from five separate measurements

TABLE II
Measurement of Spiked River Water Sample Solution using the Proposed Procedure and ICP-MS Technique

Spiked river water sample (μg/mL)	Fluorescence procedure (proposed) (μg/mL)	ICP-MS procedure (μg/mL)	Recovery %	Error[1]%
10.0	11.2	11.3	99.1	−0.9
20.0	19.6	20.1	97.5	−2.5
30.0	30.4	29.8	102.0	2.0

[1]Mean value calculated from five measurements

adding known concentrations of Nd (III) standard solution of 1.5, 13.0, and 20.0 μg/mL to river water matrices, individually. The range of RSD% is 0.13%, 0.34%, and 0.81% while Error% range is 0.67%, 1.53%, and −5.45%. At higher Nd (III) concentration (20.0 μg/mL), fluorescence quenching saturation may happen as the quenching of DPA fluorescence may reach a point where the response is no longer perfectly linear (Table I). This causes the measured signal to underestimate the actual Nd (III) concentration, giving a negative error (Bae, Yoon, and Jeong, 2021; Zacharioudaki, Fitilis and Kotti, 2022). Overall, the proposed method is confirming good accuracy and precision in realistic sample matrices.

I. Stoichiometry of Fluorometric Complex

The stoichiometry reaction between the fluorescent reagent DPA and Nd (III) was obtained by applying the limiting logarithmic approach. In Fig. 9a, the graph reveals log Nd (III) versus log ΔF, with DPA concentration retained constant. Contrarily, Fig. 9b, the graph displays a relation between log DPA and log ΔF at a constant concentration of Nd (III). After evaluation of the slopes of the linear relations for both graphs, the 1:2 ratio of Nd (III) - DPA complex is endorsed. The fluorescence response exhibited a maximum change at an Nd: DPA molar ratio close to 1:2, suggesting an apparent binding ratio under the experimental conditions. However, because Nd (III) typically exhibits high coordination numbers (8–9) in solutions and DPA is a monodentate, weakly coordinating ligand, it is highly unlikely that a discrete, inner-sphere 1:2 complex is formed (Bünzli and Eliseeva, 2010; Tsukerblat, Klokishner and McInnes, 2021). Instead, the observed ratio probably reflects a partial association or an outer-sphere interaction, where DPA perturbs the Nd (III) solvation shell without occupying all its coordination sites (Marcus, 2015). The present analysis is limited to describing the spectroscopic interaction ratio responsible for the observed fluorescence quenching. The schematic diagram is illustrated the possible formation of the Nd (III) - DPA complex (Fig. 10).

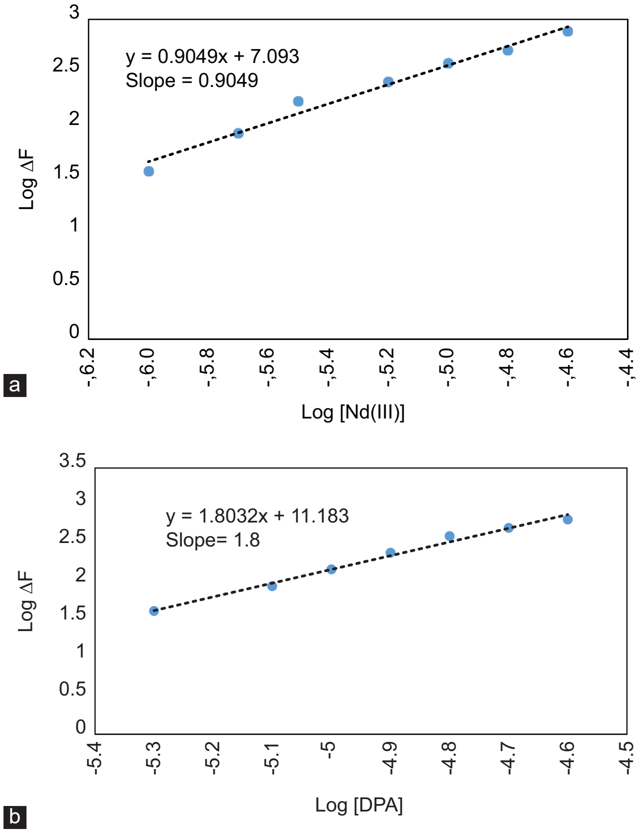
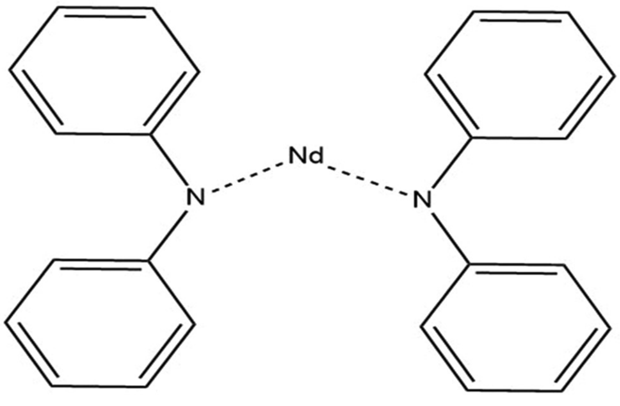


Fig. 9. The stoichiometric ratio of the fluorometric reaction of diphenylamine (DPA) reagent and Nd (III) (a), log Nd (III) against log ΔF (b), log DPA against log ΔF.



Nd (III) -DPA complex

Fig.10. Schematic diagram of possible formation of Nd (III)-diphenylamine complex.

J. Quenching Fluorescence Mechanism

Quenching fluorescence mechanism takes place when there is an interaction between the fluorescent ligand and the quenching agent. There are two main quenching mechanisms: One is called static quenching, and the other is called dynamic quenching. Static quenching resulted in the interaction between the fluorescent compound in the ground state and the quencher agent, forming a complex. While dynamic quenching developed when the interactions between

TABLE III
Resemblance of the Assessment Parameters of the Proposed Fluorometric Method with Other Techniques

Reagent	**Method**	**LOD (μg/mL)**	**Linear range (μg/mL)**	**References**
2,2′- ((1E,1′E) - (1,4 phenylenebis (Azanylylidene)) Bis (Methanylylidene)) diphenol	Spectrophotometer	0.22000	0.0010–0.02	Uwanta et al., 2025
Arsenazo III	Spectrophotometer	0.00075	0.0025–0.50	Słota et al., 2023
2,2′-((1E,1′E)-(1,2-phenylenebis (azanlylidene) bis (methanylylidene)) diphenol	Spectrophotometer	0.65000	0.001–0.02	Uwanta et al., 2023
Diphenylamine	Fluorometry	0.04600	0.5–24.0	Proposed method

LOD: Limit of detection

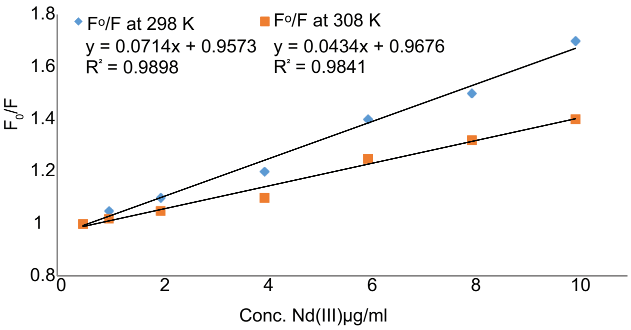


Fig. 11. Stern-Volmer plot of fluorescence quenching mechanism of Nd (III) - diphenylamine complex at temperatures of 298.0 K and 308.0 K.

the excited fluorescent species and the quencher agent via collisions (Park et al., 2009). The Stern-Volmer equation is examined to specify the type of fluorescence quenching quantitatively at different temperatures.

$$F_0/F = 1+K_{SV}\ C_{que}$$

Where F and F_0 represent the intensity of the fluorescence signals emitted by the DPA fluorescence reagent when the quencher (Cque) is present and when it is not.

The equation was implemented for examination of the fluorescence quenching of Nd (III) - DPA complex at two different temperatures (298.0 and 308.0 K) as shown in Fig. 11. When the Stern-Volmer quenching constant K_{SV} declines with elevating temperature, a static quenching mechanism exists, but an enhancement reveals a dynamic quenching mechanism. The linear relation between F_0/F and C_{que} recommends the quenching process, and with increasing the temperature to 308.0 K, the quenching constant K_{SV} decreases, advocating static quenching as the dominant source of fluorescent quenching of the complex.

K. Assessment using the Fluorometric Method

The proposed fluorometric method administers the quantification method for the assessment of neodymium (III) through the quenching fluorescence mechanism of DPA fluorescent reagent. Reliability of the method is approved when the assessment of the proposed fluorometric method is compared with another sensitive and selective technique, such as the ICP-MS technique. In Table II, the results display a robust level of compliance between the proposed fluorometric method and the sensi-selective ICP-MS technique. Three different concentrations, 10.0 μg/mL, 20.0 μg/mL, and 30.0 μg/mL of the spiked neodymium (III) samples were implemented, and the recovery percentages ranged from 97.5% to 102.0%. Acceptable relative errors ranged from −2.5% to 2.0%; hence, this indicates the reliability of the proposed fluorometric method for the assessment of neodymium (III) via quenching of fluorescent DPA reagent. The method is convenient for environmental analysis and monitoring.

Student's t-test was measured to statistically compare the accuracy of the proposed spectrofluorometric method with the ICP-MS method for the analysis of neodymium (III) in spiked river water samples. Mean value was calculated from five measurements (n = 5), and the test was conducted at a 95% confidence level. The calculated t values for the three spiked river samples were found to be 1.23, 1.78, and 1.92, respectively. These values were lower than the tabulated t value (2.67), indicating that there was no statistically significant difference between the mean results obtained by the proposed method and the ICP-MS method. This confirms the acceptable accuracy of the proposed spectrofluorometric method.

L. Resemblance with Other Reported Methods

In Table III, the linear range and lower LOD of the proposed fluorometric method are compared with those claimed in previously published research. Despite the sophisticated, expensive techniques having better LOD and linear range of detection, the proposed fluorometric method demonstrated better LOD and linear range of detection compared to the recently published spectrophotometric methods (Słota et al., 2023; Uwanta et al., 2023; Uwanta et al., 2025). This achievement reveals the elevated sensitivity accomplished through the optimization of the method. Limitation in sophisticated techniques involves the need for sample pre-extraction, longer analysis time, complexity of the working procedure, and high cost encourages, such a fluorometric method. These aspects make the current method exceptionally reasonable for regular analysis of neodymium (III) in environmental samples.

IV. Conclusion

The aim of this study is to develop a simple and low-cost fluorometric method for the determination of neodymium (III) using the quenching effect of DPA in an ethanol medium. The results confirm that this objective is successfully achieved, as the proposed method provides a reliable and straightforward approach for the analysis of Nd (III).

The method shows good analytical performance and selectivity, even in the presence of eleven commonly occurring ions. The tolerated concentrations of these ions cause errors of less than about 3%, indicating that their interference is minimal. Another advantage of the method is the rapid formation of the Nd (III)–DPA complex, which allows the analysis to be carried out without extraction procedures or lengthy sample preparation, making the method both convenient and time-saving.

In addition, the simplicity of the procedure, along with the use of a relatively mild solvent system and minimal handling steps, highlights its practical and environmentally considerate nature compared with more complicated analytical techniques. These characteristics emphasize the novelty of applying the DPA quenching system as a rapid fluorometric approach for the detection of Nd (III).

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