



Research Article

Preconcentration and Determination of Trace Nickel in Water Samples Using Solvent Bar Microextraction Method with Dimethylglyoxime Ligand Coupled with FAAS

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ABSTRACT

A novel and highly efficient solvent bar microextraction (SBME) method was developed for the preconcentration and determination of trace nickel in water samples. The technique integrates a melt-blown facemask layer (MLF) as the extraction support, a hydrophobic deep eutectic solvent (DES), and dimethylglyoxime (DMG) as the chelating agent. Experimental conditions were optimized for maximum extraction efficiency, including an extraction time of 5 min, stirring rate: 300 rpm, pH: 10, sample volume: 200 mL, and MLF area: 14 cm². Elution was performed using 5 mL of ethanol, followed by quantification via flame atomic absorption spectrophotometry (FAAS). The method exhibited a linear range of 3–130 µg L⁻¹, a detection limit of 1 µg L⁻¹, a preconcentration factor of 40, and a relative standard deviation of 3.2% (n=10). The approach is rapid, cost-effective, environmentally friendly, and capable of providing precise trace nickel analysis in water samples with minimal solvent usage.

KEYWORDS

Solvent bar microextraction, trace nickel, melt-blown facemask, dimethylglyoxime, FAAS.



1. INTRODUCTION

Nickel (Ni) is an abundant transition metal widely present in the Earth's crust and extensively employed in industrial sectors due to its durability, corrosion resistance, and catalytic properties. It is an essential component of stainless steel, batteries, electroplating processes, and metal alloys, which contributes to their widespread presence in both environmental and occupational contexts [1]. While trace amounts of nickel are necessary for certain biological processes, excessive exposure can be harmful to humans and other organisms. The most common adverse effect is nickel-induced contact dermatitis, a delayed hypersensitivity reaction characterized by redness, itching, and skin inflammation following contact with nickel-releasing materials such as jewelry or coins [2]. Chronic exposure, particularly via inhalation in occupational settings, is associated with respiratory irritation, sinusitis, pulmonary fibrosis, and an elevated risk of lung and nasal cancers [3]. Certain nickel compounds are classified as Group 1 carcinogens by the International Agency for Research on Cancer (IARC), emphasizing the importance of accurate monitoring of nickel concentrations in environmental and biological systems [4].

Trace determination of nickel is challenging due to its low concentration in complex matrices, which can interfere with direct analysis and elevate detection limits [5]. Techniques such as Flame Atomic Absorption Spectrophotometry (FAAS) and Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS) are commonly used for nickel quantification due to their precision, but they require preconcentration for ultra-trace level analysis [6]. Preconcentration techniques are therefore critical for isolating nickel from complex matrices and increasing its detectable

concentration. Conventional methods, including liquid–liquid extraction [], ion exchange [], and precipitation [], often demand large volumes of hazardous solvents, multiple steps, and long processing times, limiting their practical and environmental feasibility [7,8].

Recent advancements in green analytical chemistry principles have promoted microextraction techniques that reduce solvent use and processing time. Methods such as cloud point extraction (CPE), dispersive liquid–liquid microextraction (DLLME), solid-phase extraction (SPE), solid-phase microextraction (SPME), and ionic liquid-based microextraction have shown effectiveness for nickel preconcentration [9–12]. For instance, CPE employs surfactants to form micellar phases that concentrate nickel complexes, whereas DLLME utilizes minimal solvent volumes dispersed in aqueous samples to rapidly enrich nickel ions [13]. SPE using nanostructured adsorbents offers high selectivity and enrichment efficiency, although challenges remain in sorbent regeneration and reproducibility [14]. Despite these improvements, there remains a demand for preconcentration strategies that are simple, efficient, environmentally friendly, and compatible with routine instruments. Solvent bar microextraction (SBME) addresses this need by integrating aspects of liquid phase microextraction with solid supports [15].

Recent research has increasingly focused on developing alternative solvents with reduced toxicity, simple and rapid preparation, lower reagent consumption, and improved safety for both analysts and the environment. These efforts are intended to replace conventional solvents, which are often associated with high vapor pressure, flammability, and considerable toxicity [16]. Ionic liquids (ILs) are salts composed entirely of ions that remain liquid at

relatively low temperatures. Their negligible vapor pressure, high thermal stability, and tunable physicochemical properties have made them attractive alternatives to conventional organic solvents in analytical chemistry [17-20]. However, their environmental impact and toxicity can vary considerably depending on their chemical structure [21, 22]. In this context, deep eutectic solvents (DESs) have emerged as promising alternatives to both conventional organic solvents and, in some applications, ILs. DESs are commonly formed by mixing a hydrogen-bond acceptor with a hydrogen-bond donor, resulting in a significant decrease in the melting point. Their simple preparation, low volatility, relatively low cost, and tunable physicochemical properties have made them particularly attractive for extraction and preconcentration procedures [23, 24].

Coupling SBME with deep eutectic solvents (DESs), which are green, tunable solvents composed of hydrogen bond donors and acceptors, enhances extraction efficiency for metal–ligand complexes [25]. Additionally, renewable solid supports such as melt-blown facemask layers (MLF) provide cost-effective and sustainable platforms for preconcentration. In the present work, a DES-based solvent bar microextraction (SBME) method was developed for the selective preconcentration and determination of trace Ni(II) in water samples prior to FAAS analysis. The originality of the proposed approach lies in the integration of a DES as an alternative and less volatile extraction phase with MLF as the solvent-bar support and DMG as the chelating agent, providing an efficient and environmentally friendly extraction system. Unlike conventional microextraction procedures that rely on volatile organic solvents, the proposed method offers low solvent consumption, simple operation, and reduced environmental impact while enabling effective

analyte enrichment. The main experimental variables were systematically optimized to achieve maximum extraction efficiency. The developed method was then validated in combination with FAAS, demonstrating its applicability for sensitive determination of trace Ni(II) in water samples.

2. EXPERIMENTAL

2.1. Reagents

All the chemicals used in this research, including nitric acid, sodium hydroxide, ethanol, acetone, nickel nitrate, sodium chloride, ammonia, (2-hydroxyethyl)-trimethylammonium chloride (choline chloride) (ChCl), and 4-bromophenol (BPh), dimethylglyoxime and all ions used in the interference study, were obtained from Merck (Darmstadt, Germany), and were of analytical grade. Deionized water was used to prepare the solutions.

2.2. Instruments

A flame atomic absorption spectrometer (GBC Sens AA model) with a nickel hollow cathode lamp was used to determine the nickel concentration. A Japanese A&D analytical balance with an accuracy of one ten-thousandth of a gram was used to weigh the materials. In order to measure the pH of the solutions, a Metrohm model 827 pH meter was used. A Fourier transform infrared (FTIR) spectrometer (PerkinElmer Spectrum RXI) was used in the 400–4000 cm^{-1} wavenumber range using the KBr disk method. The samples were continuously stirred with an IKA RCT basic magnetic stirrer.

2.3. DES Synthesis

Choline chloride (ChCl) (1.39 g) and 4-bromophenol (BPh) (3.46 g) were added to a 10 mL screw-cap tube. The tube was then placed in a water bath at 75 °C for 10 min. Afterwards, it was vortexed for 5 min. The heating/vortexing

cycle was repeated and a homogeneous liquid was achieved. At 20 °C, the prepared DES possessed the viscosity and density of 1.32 Pa.S and 1.21 g cm⁻³, respectively. The structural characterization of the synthesized DES was evaluated using Fourier transform infrared spectroscopy (FT-IR). Fig 1 shows the infrared spectrum of DES. The most diagnostic feature was a broad and intense absorption band centered at ~3200 cm⁻¹, attributed to the stretching vibration of hydrogen-bonded O–H groups. Compared to free phenolic O–H (typically ~3300–3500 cm⁻¹), this significant broadening and red-shift indicate strong intermolecular hydrogen bonding between the phenolic –OH of 4-bromophenol and the chloride anion/hydroxyl group of choline chloride, which is the primary driving force for DES formation. A medium-intensity band at ~2800 cm⁻¹ was assigned to the asymmetric and symmetric C–H stretching vibrations of the methyl and methylene groups in the choline cation. The aromatic C=C stretching vibrations of the phenyl ring appeared as a very weak signal at ~1600 cm⁻¹, while a medium band at ~1400 cm⁻¹ corresponds to O–H in-plane bending and/or C–H deformation of the alkyl chain. Importantly, a medium-intensity band at ~1000 cm⁻¹ was assigned to the C–Br stretching vibration of the brominated phenol, confirming the structural integrity of 4-bromophenol within the DES. The absence of any new carbonyl (~1700 cm⁻¹) or nitrile (~2200 cm⁻¹) bands, along with the retention of the C–Br signature, confirms that the interaction is purely physical (hydrogen bonding and ionic association) without chemical degradation or covalent modification. Overall, the spectral data strongly support the successful synthesis of a DES stabilized by a robust hydrogen-bonding

network between the hydrogen-bond donor (4-bromophenol) and the hydrogen-bond acceptor (choline chloride).

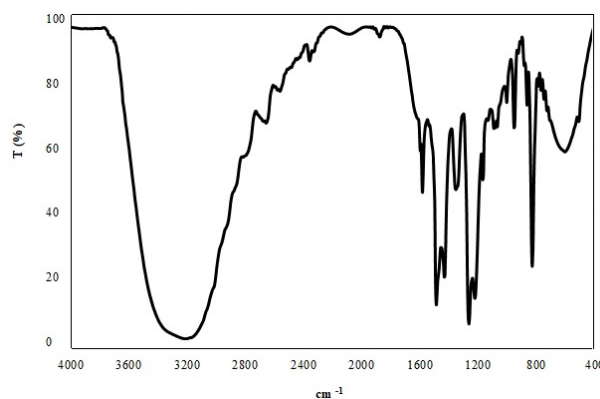


Fig. 1. Infrared spectrum of DES

2.4. Solvent Bar Microextraction Procedure

Before use, the MLF was washed with a detergent solution and deionized water and ultrasonically cleaned with ethanol and acetone to remove any potential impurities from the fibers. Then, it was cut into a segment of 2.0 × 7.0 cm² and folded alternately to reduce the occupied space. A thin iron wire (1 cm long) was passed through the folded MLF and immersed in the synthesized DES (ChCl:BPh) for several seconds until it was saturated with solvent. The MLF capacity of this section was approximately 80 µL. After that, the designed solvent bar was submerged into 200.0 mL of a solution which contained the analyte, 8.0 × 10⁻⁵ mol L⁻¹ DMG and 0.1 mol L⁻¹ ammonia buffer (pH=10). It was stirred for 5.0 min at 300 rpm. Nickel ions were extracted into the ChCl:BPh phase through complexation with DMG. After extraction, the solvent bar was removed, and the target analyte was eluted with 5.0 mL of ethanol by sonication for 30 s. The eluent was analyzed by FAAS using direct nebulization. The schematic diagram of the solvent bar microextraction procedure is shown in Fig 2.

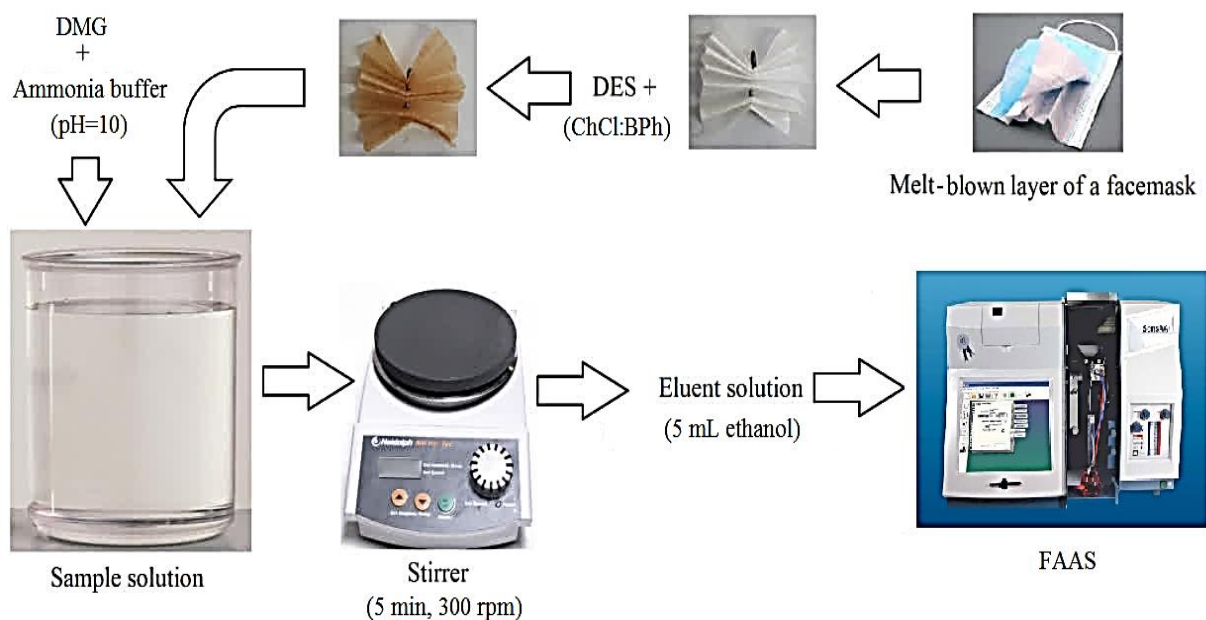


Fig. 2. Schematic Diagram of Solvent Bar Microextraction for Nickel Determination

3. RESULTS AND DISCUSSION

3.1. The effect of pH

pH plays an important role in the formation of the metal-ligand complex and, consequently, its extraction. Therefore, it should be checked and optimized. The results of this investigation are shown in Fig 3. Based on the obtained results, pH = 10 was chosen as the optimal value. The

low extraction efficiency at low pH values is due to the competition of H^+ ions with Ni^{2+} ions in the interaction with the ligand and the decrease in the extraction efficiency at pH values higher than 10 is due to the competition of OH^- ions with the nickel cations. Therefore, 4 mL of 0.1 mol L^{-1} ammonia buffer (pH=10) was used in all subsequent experiments.

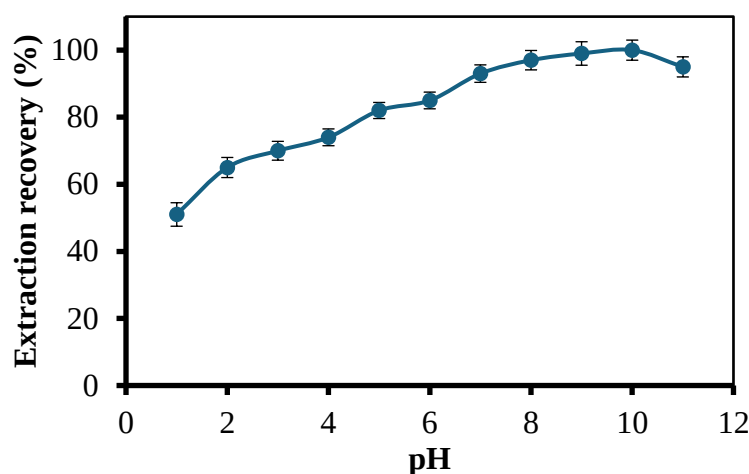


Fig. 3. The effect of pH on extraction recovery of nickel

3.2. The effect of chelating agent concentration

In the separation of metal ions, a ligand is

introduced into the solution containing the target metal ion to facilitate the formation of a hydrophobic complex between the ligand and

the metal species. It is essential that the ligand concentration is sufficient to ensure complete complexation of all metal ions present in the solution. Accordingly, the influence of ligand concentration on the extraction efficiency was systematically examined in this study. The results illustrating the effect of ligand concentration are shown in Fig 4. As observed,

increasing the ligand concentration enhances the formation of a stable complex with nickel ions, leading to a rapid improvement in extraction efficiency until a plateau is reached, indicating complete extraction. Based on these findings, a ligand concentration of $8 \times 10^{-5} \text{ mol L}^{-1}$ was selected as the optimal concentration.

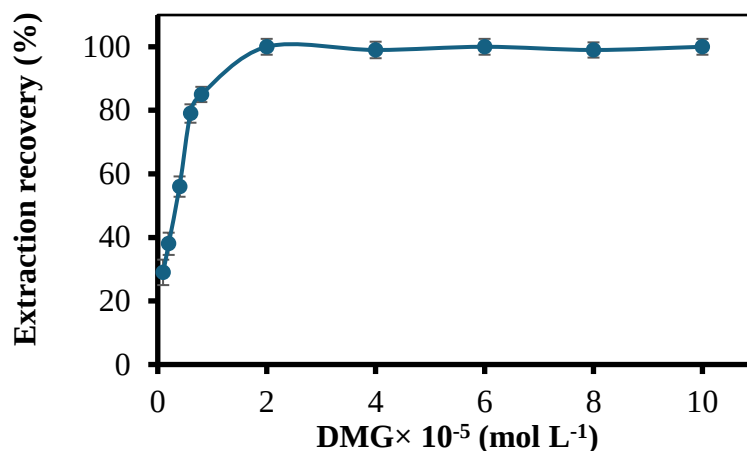


Fig. 4. The effect of ligand concentration on extraction recovery of nickel

3.3. The stirring speed of the sample

The melt-blown layer of the mask acts as the extraction phase; therefore, agitation plays a key role in facilitating the transfer of analytes from the aqueous solution to the extracting medium. Enhanced mass transfer under stirring conditions shortens the extraction time and improves the overall efficiency of the process. However, excessively high stirring speeds may have an adverse effect on extraction performance. At elevated agitation rates, air bubbles may accumulate on the surface of the melt-blown layer, or analytes may be partially lost, both of which

hinder mass transfer between the donor and acceptor phases and reduce extraction efficiency. The influence of stirring speed was evaluated by varying the agitation rate from 100 to 600 rpm while maintaining all other extraction parameters unchanged. As illustrated in Fig 5, the extraction efficiency of Ni(II) increased progressively as the stirring speed was raised, reaching its highest value at 300 rpm. Further increases in agitation did not produce any noticeable improvement in extraction efficiency. Consequently, 300 rpm was chosen as the optimum stirring speed for all subsequent experiments.

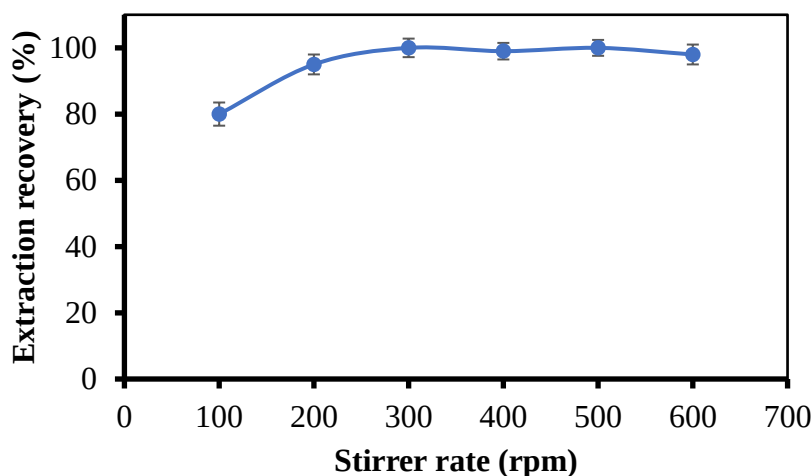


Fig. 5. The effect of stirring speed on extraction recovery of nickel

3.4. Optimization of extraction time

Extraction time is one of the most influential parameters in liquid-phase extraction, as it determines the extent of analyte transfer from the aqueous sample to the extraction solvent. The efficiency of the extraction process depends on providing sufficient time for mass transfer to reach equilibrium. To determine the optimum extraction duration, experiments were carried out over a time interval of 1–10 min while

keeping all other experimental variables constant. The corresponding results are presented in Fig 6. As observed, the analyte recovery increased gradually with increasing extraction time up to 5 min, after which no significant improvement was obtained. Accordingly, an extraction time of 5 min was considered optimal and was applied in all subsequent experiments.

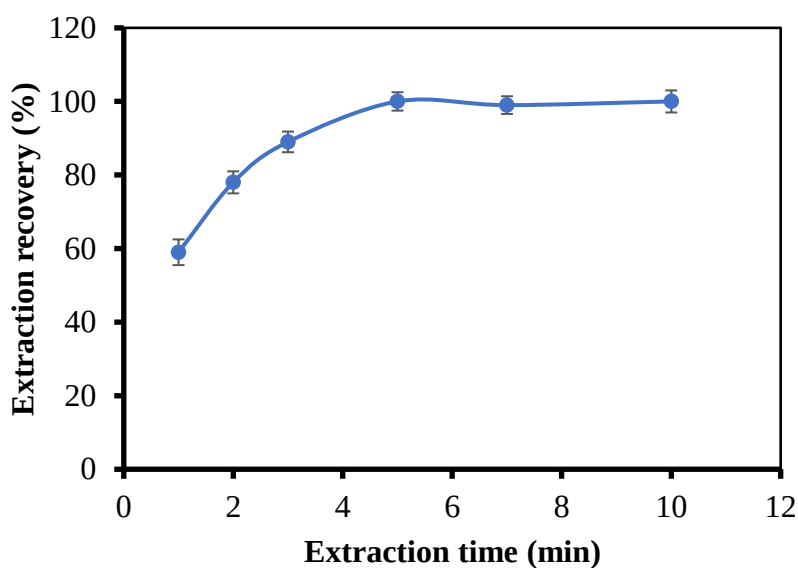


Fig. 6. The effect of extraction time on extraction recovery of nickel

3.5. MLF size

To optimize the amount of extraction medium, different dimensions of the melt-blown layer of

the mask (MLF), ranging from $2.0 \times 2.0 \text{ cm}^2$ to $2.0 \times 10.0 \text{ cm}^2$, were evaluated. As illustrated in Fig 7, the extraction efficiency increased with

increasing MLF size, reaching a maximum at approximately $2.0 \times 6.0 \text{ cm}^2$. The extraction performance then remained nearly unchanged up to $2.0 \times 9.0 \text{ cm}^2$, followed by a gradual decline at larger dimensions.

The reduction in extraction efficiency at higher MLF sizes can be attributed to the greater amount of extraction solvent retained within the extraction medium, which increased the viscosity of the final solution after dilution to 5.0 mL with ethanol. The higher viscosity

negatively affected the pneumatic nebulization efficiency during FAAS analysis. In addition, larger pieces of MLF limited effective agitation and prevented complete desorption of the extracted analytes when only 5.0 mL of the selected eluent was used, resulting in lower extraction recoveries. Considering these results, an MLF size of $2.0 \times 7.0 \text{ cm}^2$ was selected as the optimum size for the subsequent experiments.

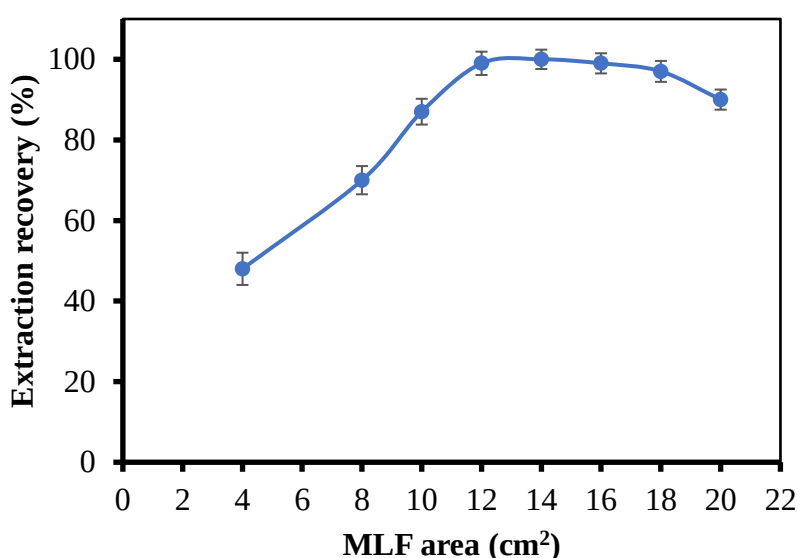


Fig. 7. The effect of MLF area on extraction recovery of nickel

3.6. Type and volume of eluent agents

Eluent selection plays a fundamental role in the overall performance of the extraction process. The nature of the elution solvent can significantly affect the extent to which the retained metal ions are released from the extraction medium, thereby influencing the reproducibility of the analytical procedure. Therefore, the selected eluent must provide efficient recovery of the retained analytes by effectively weakening or disrupting their interactions with the extraction medium, while also being suitable for subsequent determination by FAAS. Based on previous studies, both mineral acids and organic solvents can be

employed as effective eluents for the desorption of metal ions.

The effect of the elution solvent on the desorption of the retained metal ions was investigated by comparing several eluents: namely, $1.0 \text{ mol L}^{-1} \text{ HNO}_3$, $2.0 \text{ mol L}^{-1} \text{ HNO}_3$, $1.0 \text{ mol L}^{-1} \text{ HNO}_3$ in ethanol, $2.0 \text{ mol L}^{-1} \text{ HNO}_3$ in ethanol, acetone, and ethanol. A constant eluent volume of 5.0 mL was used in all experiments. As shown in Table 1, ethanol exhibited the highest desorption efficiency, with a recovery of 99.9%. Accordingly, ethanol was chosen as the eluent for the subsequent optimization of the eluent volume.

The effect of the eluent volume on analyte recovery was examined by varying the volume of ethanol from 1.0 to 8.0 mL. An increase in recovery was observed as the eluent volume was increased up to 5.0 mL, suggesting that this volume was sufficient to completely dissolve the extraction phase and facilitate the effective release of the retained metal ions. Increasing the ethanol volume beyond this level did not produce any significant improvement in the extraction recovery. However, when volumes lower than 5.0 mL were used, incomplete dissolution of the extraction phase and the corresponding metal–chelate complexes occurred, leading to reduced recoveries. Based on these findings, 5.0 mL of ethanol was selected as the optimum eluent volume and was subsequently used in all subsequent experiments.

Table 1. Selection of eluent solution

Type of elution	Extraction recovery (%)
HNO ₃ , 1M	70.0
HNO ₃ , 2M	75.8
Acetone	68.6
EtOH	99.9
EtOH + HNO ₃ , 1M	83.0
EtOH + HNO ₃ , 2M	85.8

3.7. The volume of the sample solution

To achieve high enrichment factors, the effect of sample volume on target analyte extraction efficiency is often investigated during the assay development process. Accordingly, sample volumes ranging from 10 to 500 mL of a solution containing 50.0 µg L⁻¹ of nickel ions were examined, and the proposed method was

performed under the optimized experimental conditions. Results showed that the recovery was constant up to a sample volume of 200 mL. Increasing the sample volume beyond 200 mL resulted in reduced analyte recovery. Therefore, 200 mL was selected as the optimal sample volume to achieve a good preconcentration factor and sensitivity.

3.8. The effect of ionic strength

The addition of salt increases the ionic strength and viscosity of the aqueous solution. The solubility of the analyte in water decreases with increasing ionic strength of the solution thereby increasing the extraction efficiency. However, increasing the viscosity of the solution can reduce the mass transfer rate of the analyte, diminishing the extraction efficiency. Thus, the effect of solution's ionic strength on extraction recovery must be investigated. For this purpose, different concentrations of NaCl ranging from 0.0 to 15.0% (w/v) were tested. The results indicated no significant effect of ionic strength (up to 15.0% NaCl) on extraction efficiency and sensitivity.

3.9. Matrix effects

The influence of various cations and anions on the recovery of Ni²⁺ using this method were investigated. A change in the recovery greater than ± 5% was considered interference for the preconcentration and determination of nickel. The results in Table 2 show that this method is acceptable for the determination of nickel in real samples.

Table 2. Effect of interfering ions on the extraction of lead

Interfering ions	Ion/Ni(II) ratio (w/w)	Recovery (%)
K ⁺ , I ⁻ , Na ⁺ , Li ⁺ , Ca ²⁺ , Ba ²⁺ , Mg ²⁺ , Br ⁻ , F ⁻ , Cl ⁻ , NO ₃ ⁻ , PO ₄ ³⁻ , Cr ³⁺ , Hg ²⁺ , As ³⁺ , Cr (VI), SO ₄ ²⁻ , Fe ²⁺	1000	99.5
Pb ²⁺ , CO ₃ ²⁻	800	99.8
Ag ⁺ , Al ³⁺ , Cd ²⁺ , Fe ³⁺ , Mn ²⁺	400	99.5
Zn ²⁺ , Cu ²⁺ , Co ²⁺	300	99.0

3.10. Analytical Performance

Table 3 presents the figures of merit obtained for the SBME of nickel. The results are as follows: The dynamic linear range for Ni determination varies from 3.0 to 130.0 $\mu\text{g L}^{-1}$ ($R^2=0.9995$). The relative standard deviation (RSD) was obtained

as 3.2% ($n = 10$, $C=50 \mu\text{g L}^{-1}$); while the limit of detection (LOD) was measured as 1.0 $\mu\text{g L}^{-1}$ (3Sb/m). The preconcentration and enrichment factor were 40 and 58, respectively, for a 200 mL sample solution.

Table 3. Analytical performance of the method

Parameter	Analytical feature
LOD($\mu\text{g L}^{-1}$)	1.0
LOQ($\mu\text{g L}^{-1}$)	3.0
Linear range ($\mu\text{g L}^{-1}$)	3–130
PF	40
EF	58
RSD (%) ^a	3.2

^aFor 200 solutions containing 50.0 $\mu\text{g L}^{-1}$ of Ni ions

3.11. Comparison of analytical figures of merit for Ni(II) determination

The analytical performance of the proposed method was compared with previously reported FAAS methods for Ni(II) determination, as

summarized in Table 4. As shown in Table 4, the proposed method provides a favorable analytical performance for Ni(II) determination compared with several previously reported FAAS methods.

Table 4. Comparison of analytical figures of merit for Ni(II) preconcentration and determination by FAAS

Method	LOD ($\mu\text{g L}^{-1}$)	Linear range ($\mu\text{g L}^{-1}$)	PF	EF	Sample volume (mL)	RSD (%)	Ref.
This method	1.00	3–130	40	58	200	3.2	This study
SPE	1.10	5–250	30	24	-	< 5.0	26
CPE	1.09	Up to 240	25	29	10	2.89	27
HLLME	3.60	10-450	-	340	20	2.1	28
SPE	9.60	13–80	125	120	125	< 5.0	29
LPME-SFO	1.07	10-300	-	65	25	3.6	30
LLME	7.00	7-667	-	21	10	9.1	31
μSPE	1.50	5–400	200	-	100	2.0	32
DLLME	1.59	10-250	-	51.8	25	2.17	33
CPE	4.90	4.9-3000	-	15.5	50	4.3	34

3.12. Real Sample Analysis

The proposed SBME methodology was applied to the determination and preconcentration of nickel in several water samples (i.e., tap, river, mineral, and seawater) (Table 5).

For the analysis of water samples, a 0.45 μm

Millipore membrane was used to filter the collected water samples (river and sea water) before extraction. The results in Table 4 show that nickel concentrations in river and seawater samples were 3.5 and 3.4 $\mu\text{g L}^{-1}$, respectively, and tap and mineral water samples showed no

nickel contamination. To assess the accuracy of the method, the samples were spiked with nickel at concentrations of 50 and 100 $\mu\text{g L}^{-1}$ before extraction. The relative recoveries and RSDs were in the range of 98.4-100.4% and 2.9-3.5%,

respectively. Therefore, according to these results, this technique is suitable for the determination of nickel in water samples at the ultra-trace level.

Table 5. Analytical results for water samples

Sample	Ni(II)		RSD ^a (%)	Recovery (%)
	Added ($\mu\text{g L}^{-1}$)	Found ($\mu\text{g L}^{-1}$)		
Tap water	0	ND ^b	-	-
	50.0	49.7 $\pm$ 1.6 ^c	3.3	99.4
	100.0	99.0 $\pm$ 3.2	3.2	99.0
Mineral water	0	ND	-	-
	50.0	49.4 $\pm$ 1.7	3.5	98.8
	100.0	99.6 $\pm$ 3.3	3.3	99.6
River water	0	3.5	2.9	-
	50.0	53.7 $\pm$ 1.7	3.1	100.4
	100.0	103.2 $\pm$ 3.1	3.0	99.7
Seawater	0	3.4	3.3	-
	50.0	52.6 $\pm$ 1.8	3.5	98.4
	100.0	102.0 $\pm$ 3.2	3.1	98.6

^aRelative standard deviation of three replicates analysis

^bNot Detected

^cMean $\pm$ standard deviation

4. CONCLUSION

In conclusion, a simple and effective solvent bar microextraction method was successfully developed for the extraction and determination of trace nickel in water samples. The proposed approach combines the advantages of liquid-phase microextraction with the use of a solvent bar, providing an efficient extraction procedure while reducing the consumption of organic solvents. The obtained analytical results demonstrated satisfactory extraction performance and confirmed the applicability of the proposed method for the analysis of the target analyte in real samples.

The main significance of the proposed method lies in its simple experimental procedure, low solvent consumption, and effective enrichment of the target analytes. In addition, the use of the

previously reported deep eutectic solvent (DES) as the extraction phase provides an alternative to conventional extraction systems and contributes to the development of more sustainable microextraction strategies. The proposed method therefore has potential as a practical alternative for sample preparation prior to instrumental analysis.

Despite these advantages, some limitations should be considered. The extraction procedure requires careful control of the experimental conditions to obtain optimal extraction performance, and preparation and handling of the solvent bar may add some complexity to the analytical procedure. Moreover, further optimization may be required for samples with more complex or substantially different matrices. Future studies could focus on

extending the applicability of the proposed method to a wider range of analytes and sample matrices, as well as further improving the extraction procedure and its practical implementation. Overall, the proposed method provides a promising, simple, and efficient approach for the extraction and determination of the target analyte.

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پیش تغلیظ و اندازه گیری مقادیر کم نیکل در نمونه های آبی با استفاده از روش میکرواستخراج نوار حلال با استفاده از لیگاند دی متیل گلی اکسیم و دستگاه جذب اتمی شعله ای

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چکیده

یک روش جدید و بسیار کارآمد تحت عنوان میکرواستخراج با نوار حلال برای پیش تغلیظ و تعیین مقادیر ناچیز نیکل در نمونه های آبی به کار برده شد. این تکنیک از یک لایه ماسک صورت (MLF) به عنوان پایه استخراج، یک حلال اتکتیک عمیق آبگریز و دی متیل گلی اکسیم (DMG) به عنوان عامل کیلیت ساز استفاده می کند. شرایط آزمایش برای حداکثر راندمان استخراج بررسی و بهینه شدند از جمله زمان استخراج: ۵ دقیقه، سرعت همزن: ۳۰۰ دور در دقیقه، pH=10، حجم نمونه: ۲۰۰ میلی لیتر و مساحت MLF14 سانتی متر مربع. شویش با استفاده از ۵ میلی لیتر اتانول انجام شد و سپس با استفاده از اسپکترومتری جذب اتمی شعله ای مقدار نیکل اندازه گیری شد. این روش محدوده خطی ۳ تا ۱۳۰ میکروگرم در لیتر، حد تشخیص ۱ میکروگرم در لیتر، ضریب پیش تغلیظ ۴۰ و انحراف معیار نسبی ۳.۲٪ (n=10) را نشان داد. این روش سریع، مقرون به صرفه، سازگار با محیط زیست و قادر به اندازه گیری دقیق نیکل در نمونه های آب با حداقل استفاده از حلال است.

واژه های کلیدی

استخراج با نوار حلال، مقادیر کم نیکل، ماسک صورت، دی متیل گلی اکسیم، اسپکترومتری جذب اتمی شعله ای.

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