University of Belgrade
Technical Faculty in Bor
Mining and Metallurgy
Institute Bor

56th International October Conference on Mining and Metallurgy

PROCEEDINGS

Editors:
Ljubiša Balanović
Dejan Tanikić

IOC 2025
International October Conference

22-25 October 2025,
Bor Lake, Serbia

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the **56th International October Conference on Mining and Metallurgy (IOC 2025)**, scheduled to take place at **Bor Lake, Serbia**, from **October 22nd to 25th, 2025**.

The collaborative efforts of the University of Belgrade – Technical Faculty in Bor and the Mining and Metallurgy Institute Bor have once again brought together academia, industry, and research institutions to organize this year's IOC. Our focus remains firmly set on presenting the latest research achievements and technological advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines.

This year's conference program is rich and diverse, featuring **4 plenary lectures, 4 invited lectures, 158 full papers, and 6 abstracts**. The proceedings reflect the contributions of authors from **19 countries**: Austria, Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Hungary, India, Mexico, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, and the United Kingdom. Among the submitted papers, eight young researchers under the age of 35 have qualified to participate in the "**MDPI Young Researcher Award**" competition, further emphasizing the conference's commitment to supporting and recognizing excellence among the new generation of scientists and engineers.

We are also delighted to host the **9th International Student Conference on Technical Sciences (ISC 2025)**, running in parallel with IOC 2025. The student conference brings together young researchers from Serbia and the wider region, with **one plenary** and **50 student papers** presented, offering an invaluable opportunity for the next generation of scientists and engineers to share their ideas and discuss the future of their disciplines with experts. The "**Professor Dragana Živković Best Student Paper Award**" will be presented to the most outstanding student contribution based on originality, research quality, and presentation.

The Organizing Committee expresses its deepest gratitude to all who have supported this event. Our General Sponsor is the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia. We are especially grateful to our Platinum Donors, HBIS Serbia and Serbia Zijin Mining, as well as our Gold Sponsor, DPM Metals Inc., and our Gold Donors, Copper Mill Sevojno and Serbia Zijin Copper Bor. This year, the conference is also supported by the Silver Donor, "MC LABOR" d.o.o. Beograd.

We proudly host a diverse exhibition, featuring Indemak, Labtim SE d.o.o., MERIS d.o.o., Krug International LTD, Altium International d.o.o., Metalurg Foundry Ltd., Fugro Germany Land GmbH, Analysis d.o.o., Lola institut, Tescan and Mikrolux d.o.o., Trokuttest Serbia, Novos d.o.o., Changsha Rui Rui Technology Co., Ltd., MDPI and the Winery of Bukovo Monastery. The official opening of the conference has been supported by Epiroc Srbija a.d.. Finally, we warmly acknowledge our Friends of the Conference: Messer Tehnogas AD Belgrade, the China-Serbia Joint Laboratory on Green Steel Manufacturing, and the Foundation B.Sc. Boško Injac.

We sincerely thank all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions to shaping IOC 2025. We are confident that the conference will once again serve as a alive platform for scientific exchange, professional networking, and the promotion of sustainable development in mining, metallurgy, and related fields.

On behalf of the 56th IOC Organizing Committee,
Prof. dr Ljubiša Balanović

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Abstracts

DOI: 10.5937/IOC25583Z *Original scientific paper*

EXTRACTION OF BIOACTIVE COMPOUNDS FROM NETTLE SEEDS AS A POTENTIAL INHIBITOR OF METAL CORROSION

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Abstract
The aim of the research is to determine the effectiveness of ultrasonic extraction of nettle seeds (Urtica dioica) whose products can be used as potential metal corrosion inhibitors. Different solvents were used (water, methanol, ethanol, acetone) in terms of total phenol content (TPC), flavonoids (TFC) and antioxidant activity (DPPH and FRAP). The results show that the aqueous extracts have the highest TPC and antioxidant capacity in both tests. The high correlation between TPC and antioxidant activity (R ≈ 0.98) confirms that phenolic compounds are key contributors to antioxidant capacity. These findings suggest that nettle seeds can be examined as a potential metal corrosion inhibitor.

***Keywords**: Urtica dioica L., ultrasonic extraction, bioactive compounds, antioxidant activity*

1. INTRODUCTION

Plants are a rich source of bioactive compounds that possess numerous biological activities, including antioxidant, antimicrobial, anti-inflammatory, cytotoxic and antiviral effects [1]. Nettle (*Urtica dioica L.*), also known as common nettle, is a perennial weed plant native to Eurasia, today widespread almost all over the world [2]. Nettle is a multi-purpose plant known for being used as both food and medicine since ancient times [3]. Recently, the plant has attracted a lot of attention due to numerous important biological activities and applications in the food industry [4]. Nettle is rich in proteins, minerals, vitamins (A, C, E), carotenoids and fibers [5]. Antioxidant effect of nettle is considered key for its pharmacological potential [6]. Also, nettle proved to be a good inhibitor of steel in an acidic environment [7,8].

Nettle seeds (*Urtica dioica L.*) are a rich source of bioactive compounds that possess significant biological activity, including antioxidant, anti-inflammatory, antimicrobial and anticancer activity. Nettle seeds are rich in various bioactive components, including phenolic acids, flavonoids, fatty acids and sterols. Phenolic acids, such as ferulic and caffeic acid, are present in significant concentrations and contribute to the antioxidant activity of the seeds. These components contribute to the antioxidant activity of the seeds, neutralizing free radicals and reducing oxidative stress. For example, the presence of 5-O-caffeoylquinic acid, an ester of caffeic and quinic acids, was identified as a major peak in nettle seed extracts, indicating a significant concentration of these compounds [9]. Although nettle seed has not yet been investigated as a metal corrosion inhibitor, it is a potential corrosion inhibitor due to the presence of caffeic acid. Caffeic acid has been shown to be an effective corrosion inhibitor of steel and copper [10,11].

Flavonoids, such as quercetin, kaempferol and isorhamnetin, are present in nettle seeds, often in the form of glucosides or rutinosides. These compounds have pronounced antioxidant, anti-inflammatory and antimicrobial activity [12]. Extracts rich in quercetin-3-O-glucoside, kaempferol-3-Oglucoside and isorhamnetin have proven to be effective inhibitors of metal corrosion [13,14]. Nettle seeds contain sterols, such as β-sitosterol, which have antioxidant properties and can contribute to the reduction of LDL cholesterol levels in the blood. Research shows that β-sitosterol isolated from rice husks and extracted from *Croton Persimilis* acts as an green inhibitor of mild steel corrosion in an acidic environment [15,16]. Nettle seeds are rich in fatty acids, including linoleic, oleic and α-linolenic acids. These essential fatty acids play an important role in maintaining the health of the heart and blood vessels, reducing the risk of cardiovascular diseases [17]. The fatty acid have an impact on adsorption and corrosion inhibition of iron by amine-fatty acid salts in acidic solution [18]. Also, fatty acids and its derivatives act as corrosion inhibitors for mild steel in various medium [19].

Considering these characteristics, the aim of this study is to investigate the chemical profile of nettle seeds, with a special focus on phenolic and flavonoid compounds, and to evaluate their contribution to antioxidant activity as an important factor of metal corrosion inhibitors. By applying ultrasonic extraction with the use of solvents of different polarities and chemical properties, the potential of nettle seeds is investigated in detail, with the aim of improving its applications in functional food and natural therapeutic products.

2. EXPERIMENTAL

2.1. Preparation of plant samples and chemicals

Nettle seeds (*Urtica dioica L.*) were harvested in a field near Tuzla, Bosnia and Herzegovina, were crushed into a homogeneous powder. The extraction was carried out in an ultrasonic bath at room temperature, using 0.5 g of powder in 50 mL of demineralized water for 2 hours. After filtering the samples, spectrophotometric analysis was performed on a UV-VIS device (Perkin Elmer Lambda25) at wavelengths of 510-765 nm in order to determine phenolic and antioxidant compounds.

2.2. Determination of total phenolic content (TPC)

Total phenolic content (TPC) was determined according to the method of Singleton et al. (1999), with minor adjustments [20]. In the analysis, 200 μL of extract was mixed with 10% Folin–Ciocalteu reagent and 10% Na_2CO_3, and incubated for 1 hour at room temperature. After dilution with distilled water, the absorbance was measured at 765 nm. The results are expressed as mg of gallic acid per gram of dry weight (mg GAE/g DM), with a standard curve ($y = 0.0042x + 0.0076$; $R^2 = 0.9998$) [21].

2.3. Determination of total flavonoid content (TFC)

Total flavonoids content (TFC) was determined spectrophotometrically according to the modified protocol of Olajira and Azeez [22]. The extract sample was treated with $NaNO_2$, $AlCl_3$ and NaOH, and then diluted to 10 mL. Absorbance was measured at 510 nm, and the results were expressed as mg quercetin per gram dry mass (mgQE/g DM), using a standard curve ($y = 3.024x – 0.0034$; $R^2 = 0.9984$) [23].

2.4. Ferri-reducing antioxidant capacity (FRAP)

The antioxidant potential of the samples was assessed using the FRAP method according to Benzie and Strain[24]. The extract (100 μL) was incubated with 3 mL of FRAP reagent at 37°C for 30 minutes, and the absorbance was measured at 593 nm. Results are expressed as μmol Fe^{2+}/g dry weight, using a standard curve ($y = 0.001x + 0.0698$; $R^2 = 0.9997$).

2.5. DPPH test

The antiradical activity was determined by the DPPH method according to the adapted protocol of Horozić et al. [25]. The extract (2 mL, 0.5 mg/mL) was mixed with 0.5bmL of DPPH solution (0.5bmM in methanol) and incubated for 30 minutes in the dark at room temperature. The absorbance was measured at 517 nm, and the activity was expressed as a percentage of radical inhibition:

$$I\ (\%) = [(Ac - As) / Ac] \times 100$$

where Ac and As are the absorbances of the control and tested samples [26,27].

3. RESULTS AND DISCUSSION

Ultrasonic extraction significantly improves the extraction of bioactive compounds from nettle seeds, thanks to the cavitation effect that breaks the cell structures and increases the availability of phenols and flavonoids. The following table shows a comparison of antioxidant activity and quantitative analysis of phenols and flavonoids in extracts prepared with different solvents.

Table 1. Antioxidant activity and content of bioactive compounds in ultrasound extracts of nettle seeds

Sample	Solvent	FRAP [µmol/g]	DPPH inhibition [%]	TPC [mg GAE/g]	TFC [mg QE/g]
A-1	ethanol	699.6	8.15	1.73	0.0227
A-2	methanol	943.1	24.8	6.83	0.165
A-3	acetone	476	6.85	0.54	0.2286
A-4	water	967.3	44.69	23.47	0.091

Aqueous extracts showed the highest FRAP result (967.3 µmol Fe^{2+}/g), which indicates a strong reducing power, while methanol was second with 943.1 µmol/g. Ethanol and acetone provided significantly lower values, indicating a weaker reduction potential. This trend confirms general observations in plant extraction, where polar solvents such as water and methanol more efficiently extract polar bioactive compounds, including phenols and flavonoids. In the DPPH test, the aqueous extract was again the leader with 44.69% inhibition, followed by methanol with 24.8%, while ethanol and acetone showed minimal activity (8.15% and 6.85%, respectively). This confirms that water extracts more effectively neutralize free radicals, which is in accordance with the findings from the literature where water as a solvent gives superior antioxidant results in ultrasonic nettle extraction [28]. Based on these results, it can be assumed that the extract obtained by extraction with water has the highest potential to act as a corrosion inhibitor [29].

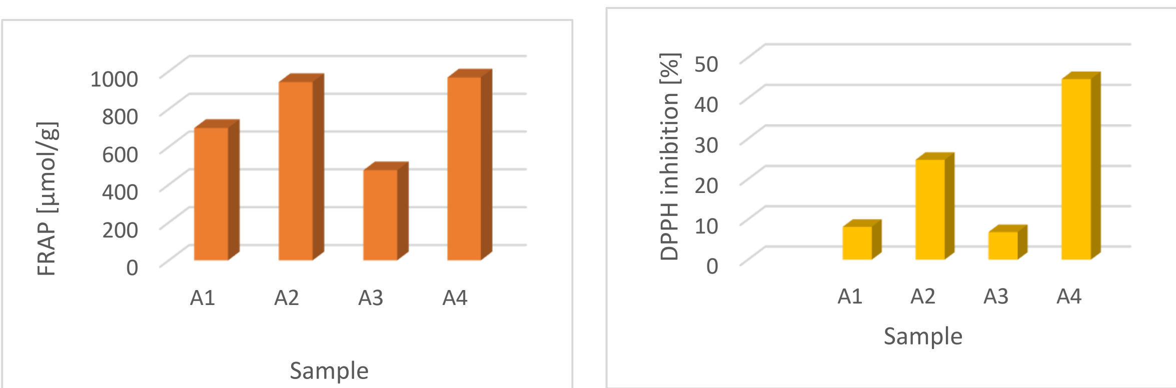

Figure 1. Comparative analysis of reduction potential (FRAP) and inhibition of DPPH radicals in ultrasound extracts of nettle seeds

The total phenolic content (TPC) was significantly highest in the water extract (23.47 mg GAE/g), followed by the methanol extract (6.83 mg GAE/g), while ethanol and acetone had low values (1.73 and 0.54 mg GAE/g). This points to the superior ability of water to extract phenolic compounds from nettle seeds. The high correlation between TPC and antioxidant activity (FRAP and DPPH) is in accordance with the results of other works [30] where R ≈ 0.98 confirms that phenols are the primary carriers of antioxidant activity in plant extracts.
The highest content of flavonoids (TFC) was recorded in acetone extract (0.2286 mg QE/g), followed by methanol (0.165 mg QE/g), while ethanol (0.0227 mg QE/g) and water (0.0910 mg QE/g) showed significantly lower content. This result suggests that the polyphenolic profiles of nettle seeds may contain specific flavonoids more soluble in medium-polar solvents such as acetone and methanol. The results of earlier research show that extraction solvents have significant effects on TPC, TFC, CTC and inhibition properties of extracts, on the basis of which the effect of aqueous and acetone extracts of nettle seeds can be expected as potential corrosion inhibitors [31].

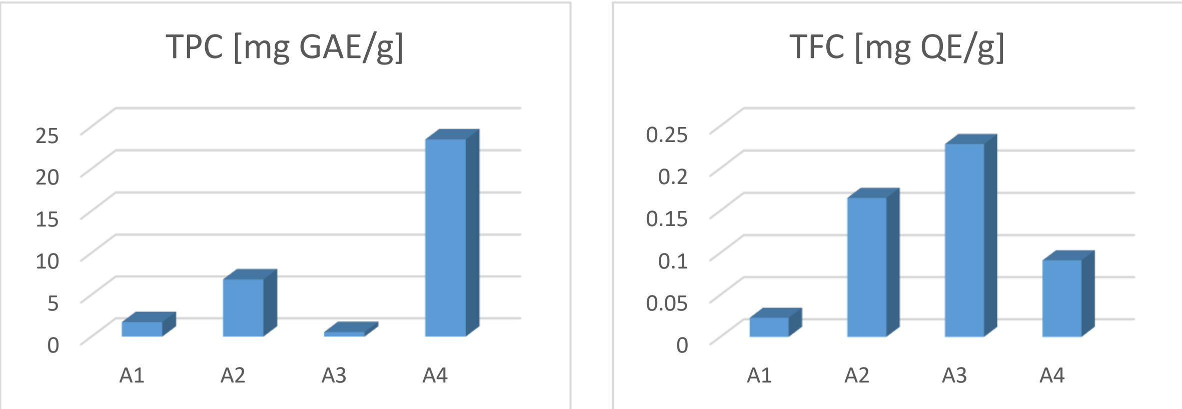

Figure 2. Comparison of the content of polyphenols and flavonoids in ultrasound extracts of plants

4. CONCLUSION

The results of this research confirm the high efficiency of ultrasonic extraction in the isolation of bioactive compounds from nettle seeds (*Urtica dioica L.*), for potential application as metal corrosion inhibitors. The results show that water as a solvent shows superior results compared to methanol, ethanol and acetone. The highest total phenolic content and antioxidant activity in DPPH and FRAP tests were recorded in aqueous extracts, which is consistent with the findings of other studies that highlight the advantages of using water as a solvent in the ultrasonic extraction of nettle. Further research will be focused on the optimization of extraction conditions, the identification of specific bioactive compounds and the evaluation of their biological activities in order to maximize the potential of nettle seeds in various industrial applications.

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