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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University of Belgrade - Technical Faculty in Bor

Publisher: University of Belgrade - Technical Faculty in Bor

For the publisher: Dean Prof. dr Dejan Tanikić

Circulation: 200 copies

Publication Place, Year: Bor, 2025

Printed by "*GRAFIKA GALEB DOO" NIŠ, 2025*

CIP - Каталогизација у публикацији Народна библиотека Србије, Београд

622(082)(0.034.2)
669(082)(0.034.2)

INTERNATIONAL October Conference on Mining and Metallurgy (56 ; 2025 ; Bor Lake)

Proceedings [Elektronski izvor] / 56th International October Conference on Mining and Metallurgy - IOC 2025, 22-25 October, 2025, Bor Lake, Serbia ; [organized by] University of Belgrade, Technical Faculty in Bor and Mining and Metallurgy Institute Bor ; editors Ljubiša Balanović, Dejan Tanikić. - Bor : University of Belgrade, Technical Faculty, 2025 (Niš : Grafika Galeb). - 1 USB fleš memorija ; 1 x 1 x 5 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 200. - Preface / Ljubiša Balanović. - Bibliografija uz svaki rad.

ISBN 978-86-6305-164-5

a) Рударство -- Зборници b) Металургија -- Зборници

COBISS.SR-ID 177493257

Bor Lake, Serbia, October 22-25, 2025

The conference is financially supported by
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Development and Innovation
of the Republic of 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

TABLE OF CONTENTS

Plenary Lectures

Invited Lectures

Conference Papers

Geology and Mining

Mineral Processing and Recycling

Extractive Metallurgy and Process Innovations

Alloys, Composites, and Advanced Materials

Technology and Energy

Environmental Protection, Remediation and Risk Assessment

Industrial Management, Digitalization and Quality Control

Abstracts

The 56th International October Conference on Mining and Metallurgy
22-25 October 2025, Bor Lake, Bor, Serbia
www.ioc.tfbor.bg.ac.rs

DOI: 10.5937/IOC25579Z *Original scientific paper*

ATR-FTIR CHARACTERIZATION OF THE WHITE WILLOW BARK EXTRACT USED AS A COPPER CORROSION INHIBITOR

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Abstract
As proved inhibitor of copper corrosion in saline environment, the white willow bark (WWB) extract was characterized using the Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy (ATR-FTIR) method. By identifying the bands typical for phenolic profile of WWB extract, the anti-corrodic properties of WWB were explained. The hydrogen-bonded O-H stretching vibrations present in WWB extract is attributed to the phenolic hydroxyl groups and alcoholic hydroxyl groups within glycosides. The C-H stretching vibrations typical for salicin and for glucoside part of salicin aromatic were also identified, as well as the C=C ring stretching vibrations and C-O stretching vibrations that can be attributed to phenolic and alcoholic groups. The presence of these functional groups confirms the presence of a protective film of the WWB extract on the copper surface, protecting the metal from the corrosive effect of chloride ions.

***Keywords**: white willow bark, ATR-FTIR, copper, corrosion inhibitor*

1. INTRODUCTION

Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy is a frequently applied method for the analysis of environmentally friendly corrosion inhibitors for metals [1,2]. Corrosion inhibitors are useful for avoiding the dissolution of metal in different corrosive environments [1,3]. The effectiveness of organic inhibitors, including those derived from plants, is related to the chemical structure and physicochemical properties. These include functional groups, electron density at the donor atom, p-orbital character, and the electronic structure of the molecule [4,5]. The performance of organic inhibitors depends on several factors, such as the adsorption of the molecules or their ions on anodic and/or cathodic sites, an increase in cathodic and/or anodic over voltage, and the formation of a protective barrier film [4]. The ATR-FTIR method is significant for examining the film formation and functional groups of molecules that participate in the adsorption process, providing a detailed analysis of corrosion inhibitors [6]. For example, functional groups such as azole, thiol functional groups, and carboxylate tail group can influence the adsorption of corrosion inhibitors on the copper surfaces in a chloride environment. The thiol group improves the adsorptive interaction with the surface, while the carboxylate groups provide additional intermolecular attraction [7].

Recent research indicates the possibility of using white willow bark (WWB) extract can inhibit copper corrosion in a 0.5 M NaCl solution [8]. Also, WWB extracts have anti-inflammatory, antipyretic, and analgesic effects, making them popular in sports performance and weight loss products. Although these extracts are generally standardized to salicin, they also contain other

beneficial ingredients, including other salicylates, polyphenols, and flavonoids, which may play prominent roles in the therapeutic actions [9]. In addition to the use of white willow bark for pharmaceutical purposes, research shows that it can be used for phytoremediation [10,11].

In this paper, the ATR-FTIR results for WWB extract obtained by extraction with distilled water are shown. The goal is to determine the functional groups present in the extract and to explain in more detail their role in inhibiting copper corrosion in a 0.5 M NaCl solution.

2. EXPERIMENTAL

2.1 Preparation of white willow bark extract

WWB extract was obtained by extracting the white willow bark sample with distilled water and then evaporating it. Distilled water was chosen as a cheap, universal, and environmentally friendly solvent. The dry and ground WWB was manufactured by "Adonis" company, located in Sokobanja, Serbia. The dry bark mass was poured with hot distilled water (95 °C) in a solid:liquid ratio of 1:3. After 12 h at room temperature, the mixture was filtered using a Buchner funnel with filter paper No. 1. The filtered solution was evaporated on a rotary evaporator Buchi R-210 (72 mbar, 40 °C). WWB extract and hydrolate were obtained as products, as shown in Figure 1.

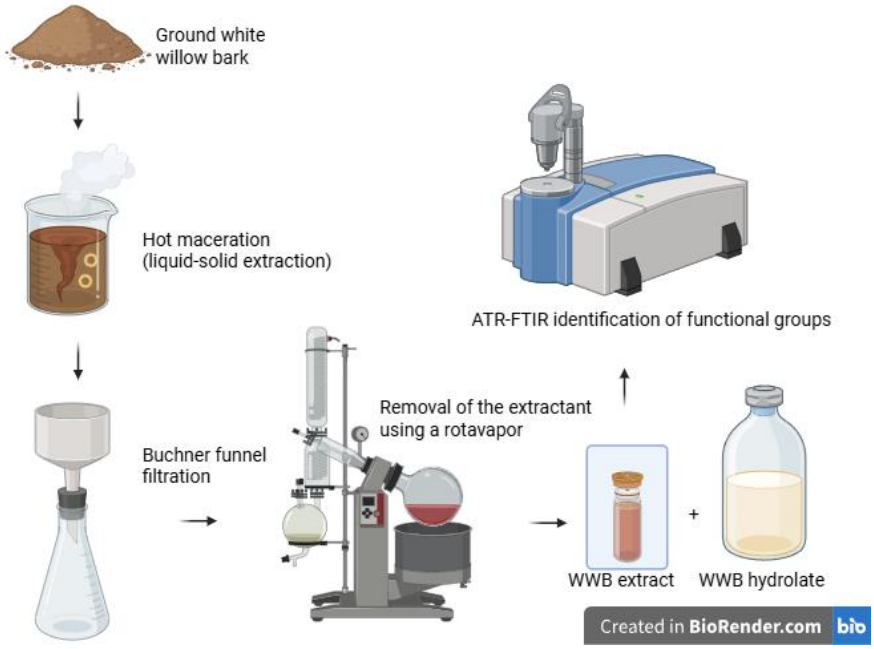

Figure 1. Scheme of obtaining WWB extract and its hydrolate

2.2 ATR-FTIR analysis

The ATR-FTIR characterization of the WWB extract was conducted using a Smart iTR Nicolet iS50 FTIR spectrophotometer (Thermo Fisher Scientific, USA), as reported elsewhere [12].

3. RESULTS AND DISCUSSION

The ATR-FTIR spectra (Figure 2) of the WWB extract reveals characteristic bands consistent with its expected main constituents, such as salicin and its derivatives, other phenolic glycosides, along with tannins and flavonoids [13]. The prominent and broad band at ~3246 cm^{-1} (with percentage transmittance of 64%) indicates the presence of hydrogen-bonded O-H stretching vibrations, attributed to the phenolic hydroxyl groups and alcoholic hydroxyl groups in glycosides. The signal at 2933 cm^{-1} (79%), appearing as a shoulder to O-H band, indicates C-H stretching vibrations, typical for salicin [14]. The bands at ~1604 cm^{-1} (60%) and ~1521 cm^{-1} (73%) correspond to

aromatic C=C ring stretching vibrations. Furthermore, C-H bending, indicated by a band at 1374 cm^{-1} (62%), is characteristic of the glucoside part of salicin. Finally, C-O stretching vibrations are indicated by the band at ~1246 cm^{-1} (61%), whereas a strong peak at ~1032 cm^{-1} (36%) can be attributed to phenolic and alcoholic groups.

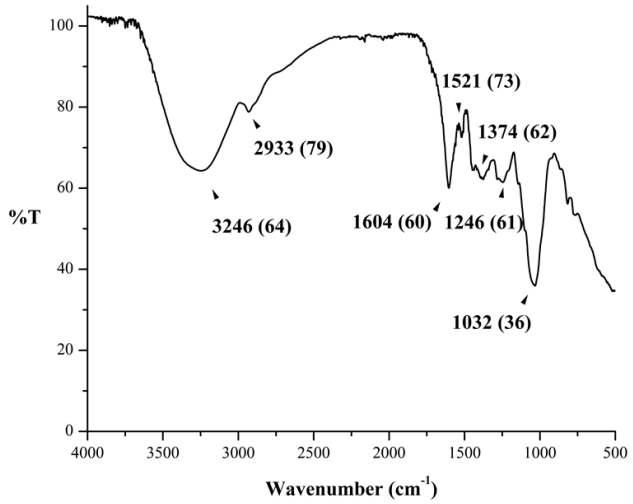

Figure 2. ATR-FTIR spectrum of WWB extract with the most prominent bands marked

The presence of certain functional groups affects the molecular interface adsorption. Some studies have shown that some coordination compounds exhibit good adsorption on the metal surfaces [15]. Heterocyclic compounds containing functional groups such as –OH, $–NH_2$, $–OCH_3$, –NHMe, $–NMe_2$, –CN, $–CONH_2$, $–COOC_2H_5$, –O–, $–NO_2$ have proven to be effective inhibitors of metal corrosion. Extensive conjugation in the form of non-bonding and π electrons of hetero and homo electrons, such as >C=O, >C=N–, >C=S, –C≡N, –N=O, –N=S, >C=C<, –N=N–, and –C≡C,– interact with metal surfaces as electron-rich adsorption centers [16]. On the other hand, organic compounds with electron-donor functional groups (–OH, $–NH_2$ and $–CH_3$) have a positive effect on the inhibition of metal corrosion, while those with electrons-acceptors groups (–CN, $–COOC_2H_5$, and $–NO_2$) have a negative effect, *i.e.* reduce the effectiveness of corrosion inhibition [17].

The presence of functional groups determined by the ATR-FTIR method confirms the capacity of WWB extract to act as an inhibitor of copper corrosion in saline environment. The hydrogen-bonded O-H stretching vibrations, attributed to the phenolic and alcoholic hydroxyl groups within glycosides, were determined. Previous research confirms the effect of herbal extracts containing glycosides and polysaccharides moieties are effective green and cost-efficient corrosion inhibitors [18]. The C-H stretching vibrations, aromatic C=C ring stretching vibrations, and C-O stretching vibrations are typical indicators of copper corrosion inhibitors [19,20,21,22].

4. CONCLUSION

The identification of functional groups in the WWB extract using the ATR-FTIR method indicates the presence of numerous functional groups that act as metal corrosion inhibitors. The presence of hydrogen-bonded O-H stretching vibrations, attributed to the phenolic hydroxyl groups and alcoholic hydroxyl groups within glycosides, C-H stretching vibrations, typical for salicin, aromatic C=C ring stretching vibrations, C-H bending characteristic for glucoside part of salicin, and C-O stretching vibrations attributed to phenolic and alcoholic groups was confirmed. This confirms the potential of WWB extract as an inhibitor of copper corrosion in chloride conditions.

ACKNOWLEDGEMENTS

The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration no. 451-03-137/2025-03/200131.

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