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The inhibitory properties of the boiling extracts from *Fagus sylvatica purpurea* fallen leaves on the corrosion of mild steel in acidic environments

ABSTRACT

The inhibitory ability of the boiling extracts from the fallen leaves ofFagus sylvatica purpurea on the corrosion of mild steel EN Fe37-3FN in 0.5 M hydrochloric acid and 0.5 M sulphuric acid media was investigated using gravimetric, electrochemical, and EIS methods. It was shown that the addition of 100 mg/l of the Fagus sylvatica purpureafallen leaves extract reduces the corrosion rate by 20–25%, and that of of 1 g/l and more – by 65–70%. The adsorption of the extract components on a steel surface follows the Langmuir adsorption model, and the nature of adsorption is physical. The Fagus sylvatica purpureafallen leaves extractshowsitself as prospective and environmentally friendly substance for reducing the steel corrosion rate in acidic environments.

***Keywords**: Fagus sylvatica purpurea, purple beech, boiling extracts, acid medium corrosion inhibition, mild steel, gravimetric study, electrochemical study, electrochemical impedance spectroscopy, Langmuir adsorption isotherm.*

1. INTRODUCTION

The usage of industrial side products and wastes [1], expired drugs [2], food and biomass waste [3,4] and compounds extracted from natural products [4]attracts a growing interest of the corrosion engineers around the globe. By employing environmentally degradable natural compounds one could drastically reduce the costs and the ecological impactof both production of inhibitors, and their subsequent utilisation. A plant's roots, leaves, aerial parts, fruits, and seeds are frequently used as the source of extracted compounds [4].

The purple beech (*Fagus sylvatica purpurea*) is a cultivar of the European beech, which is widely distributed in several parts of Europe, Middle Asia and North America [5]. Due to its unusual purple colour or leaves, it is commonlyused as the ornamental tree. The bark and the leaf of the European beech are well-known strong antioxidants [6,7], and contain several polyphenolic compounds including phenolic acids and flavonoids [7–9]. However, both flavonoids [10, 11] and phenols exhibit inhibitory properties on metal oxidation. Moreover, there is a clear dependency between the antioxidant and inhibition properties of natural compounds [12], and therefore, the compounds extracted from *Fagus sylvatica* leaves might be useful and environmentally friendly corrosion inhibitors.

Acidic environments are often employed for the study of the effectiveness of inhibitors, because acids give the most demonstrative results [11]. In addition, the study of the acidic corrosion of metals is important for oil and gas industry, the galvanic electroplating of metals, the development of the solutions for the metal pickling, and for the rust removal [11]. Only a single study concerning the usage of extract of the common beech leaves as the inhibitor of the corrosion of carbon steel in sulphuric acid was already published [13]. However, in that paper a commercial ethanolic extract was used, and its concentration was not specified, therefore, it is impossible to understand the dependency on the inhibitory properties on the concentration of the extracted compounds. Moreover, the employment of toxic organic extractant undermines the sustainability of the obtained extract. The usage of boiling water extract seems a more environmentally friendly solution.

At the end of September, the beech tree exhibits the leaf fall producing the considerable amount of fallen leaves. It was previously found [8]

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that the concentration of the bioactive compounds in the beech leaves remain stable till the leaf fall. Therefore, collecting the freshly fallen leaves and extracting phenolic compounds from them is a sustainable way to produce extract without jeopardising the growing tree.

Therefore, in the present study, the inhibitory properties of the boiling extracts of the *Fagus sylvatica purpurea*freshly fallen leaves on the corrosion of mild steel EN Fe37-3FN in 0.5 M hydrochloric acid and 0.5 M sulphuric acid media are aimed to be investigated.

2. METHODS

2.1. Reagents and Equipment

Ethanol (analytical grade) and hydrochloric and sulphuric acids (pure grade)were purchased from LLC "Sigma Tek". Steel electrodes were manufactured from cylindrical ingots made of mild steel EN Fe37-3FN (containing no more than 0.14% C, 0.3% Ni, Cu, and Cr, 0.05% Si, 0.4% Mn, 0.05% P and 0.04% S).The unused flat end surface of the ingots was sealed by the epoxy resin, and the cylindrical working surface immersed in the solution was equal to 0.04 cm^2.

Weighting of the samples was performed using the analytical balanceEX224/AD (Ohaus Corp.).Electrochemical and EIS measurements were conducted using the potentiostat-galvanostat PS-50 (LLC "SmartStat").The mercury-mercurous sulphate reference electrode by Schott Intstruments GmbH was used. A water for solution preparation was first distilled using the aquadistiller AE-15 (LLC "Livam") and then deionised using the water purification system AkvaLab S18 (LLC "Akvalab"). The magnetic stirrer MS-200 LT (LLC "Labtex") was used for stirring and heating the solutions. The single-channel laboratory pipettes manufactured by Thermo Fisher Scientific were used for pipetting the solutions. A laboratory glassware of 2nd grade was used.

2.2. Preparation of the Extracts

The freshly fallen leaves of the purple beeches (*Fagus sylvatica purpurea*)were collected in early October from the trees located in the woods in the outskirts ofNovosibirsk, Russia. The leaves were air-dried in the absence of the direct sunlight during three months and subsequently ground.

A total of 100 g of dried and ground*Fagus sylvatica purpurea*leaves were weighted, immersed into a litre of the deionised water,heated and boiled under the reflux condenser during 3 h. The boiling extracts were cooled, the plant materialwas removed, and the solid residues were filtered off through the filter paper with the pore diameter of 12 µm.

A total of 10 ml of the extract was taken, placed in a beaker and heated to dryness in order to determine the mass of the dissolved substances and the initial concentrations of the extract solutions. Then the working solutions of the *Fagus sylvatica purpurea* leaf extract with the concentrations ranging from 0.2 to 20 g/l were prepared by the appropriate dilutions. The solutions were then equally diluted by 1 M hydrochloric acid or by 1 M sulphuric acid to finally produce a series of acidic solutions of *Fagus sylvatica purpurea* leaf extractin 0.5 M HCl or 0.5 M $H_2SO_4$with concentrations ranging from 0.1 to 10 g/l.

2.3. Gravimetric studies

For gravimetric tests, rectangular flat plates made of EN Fe37-3FN mild steel with thickness 3 mm, width 20 ± 2 mm, and height 30 ± 2 mm were polished using the P2500 emery paper and degreased by ethanol. The weighted plates (m_0) were immersed into corrosive media for 2 h, then washed with distilled water, dried, and reweighted (m). Each experiment was performed in triplicate. From the measured weight losses ($\Delta m = m_0 - m$), sample surfaces (S), and immersion times (t) the average corrosion rates (ω) were estimated [11]:

$$\omega = \Delta m / (S \cdot t). \qquad (1)$$

An inhibitory ability (IE) of the compound was estimated from the ratio of the corrosion rates in the absence (ω_0) and in the presence (ω) of the inhibitor [11]:

$$IE = (\omega_0 - \omega) / \omega_0 \cdot 100\%. \qquad (2)$$

2.4. Polarisation studies

For polarisation tests,electrodes made of EN Fe37-3FN mild steeland sealed with the epoxy resin with the working surface of 0.04cm^2were polished using theP2500 emery paperand degreased by ethanol.The measurements were conducted in a standard three-electrode electrochemical cell, consisting from the working electrode (steel sample), auxiliary electrode from the porous graphite, and the mercury-mercurous sulphate reference electrode. An open circuit potential (E_{corr}) was recorded during 30 min.

For the measurement of the linear polarisation resistance the polarisation curves were recorded in the current range from –10 µA and to +10 µAin galvanodynamic mode with the current sweep rate of 2µA/s. Each experiment was performed in triplicate. The obtained polarisation curves were presented in the coordinates $E(I)$, and the polarisation resistances were evaluated as the slopes of these curves using the least squares technique:

$$R_p = dE / dI. \qquad (3)$$

The inhibitory ability of the compound was estimated from the ratio of the polarisation resistances in the presence (*R*) and in the absence (R_0) of the inhibitor [11]:

$$IE = (R - R_0) / R \cdot 100\%. \quad (4)$$

For the measurement of the Tafel slopes [14] and the corrosion current density the polarisation curves were recorded in both directions in the potential ranges from the measured open circuit potential to –500 mVand to +500 mV relatively to it with the potential sweep rate of 10 mV/s. Each experiment was performed in triplicate. The obtained polarisation curves were presented in the coordinates$E(\lg i)$, and the Tafel slopes (*b*) and the corrosion current density (i_{corr}) were evaluated from them [15]. Subsequently, the polarisation resistances (R_p) were estimated from the Tafel slopes and the corrosion current densities using the Stern – Geary equation [16,17]:

$$R_p = \frac{1}{\ln 10} \cdot \frac{1}{i_{corr}} \cdot \frac{b_a \cdot |b_c|}{b_a + |b_c|}, \quad (5)$$

where b_a and b_c are the slopes of the anodic and cathodic branches of the polarisation curve. The inhibitory ability of the compound was estimated from the ratio of the corrosion current densities in the absence (i_0) and in the presence (*i*)of the inhibitor [11]:

$$IE = (i_0 - i) / i_0 \cdot 100\%, \quad (6)$$

and also from the ratio of the polarisation resistances in the presence (*R*) and in the absence (R_0) of the inhibitor using equation (4).

2.5. EIS studies

For EIS tests, electrodes were prepared similarly to that described in the previous section.An open circuit potential was recorded during 30 min.Impedance values were recorded at the open circuit potential value in the alternating current frequency interval from 100mHzto10kHzwith the potential amplitude of 10 mV. Each experiment was performed in triplicate.The obtained results were presented in the form of Bode and Nyquist plots [18].

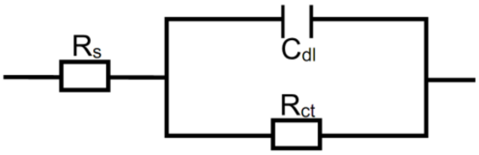


Figure 1. The Randles equivalent electrical circuit used to fit the EIS data

For the estimation of the impedance parameters, a simplified Randles equivalent electrical circuit (Figure 1) [19], containing the solution resistance R_s, the consecutive charge transfer resistance R_{ct} of the passivation layer, and the parallel constant-phase element representing the double electric layer, was employed.

The impedance (*Z*) of the Randles equivalent circuit is expressed by the equation [17]:

$$Z = R_s + \frac{1}{\frac{1}{R_{ct}} + P \cdot (i \cdot \omega)^n} = R_s + \frac{1}{\frac{1}{R_{ct}} + P \cdot \omega^n \cdot \left(\cos\left(\frac{\pi \cdot n}{2}\right) + i \cdot \sin\left(\frac{\pi \cdot n}{2}\right)\right)}, \quad (7)$$

where $\omega$is the frequency of the alternating current, *P* and *n* are the parameters of the constant phase element.

The fitting of the equivalent circuit parameters to the experimental impedance values was performed using the free software EIS Spectrum Analyser [20]. In addition, the capacitance (C_{dl}) and the thickness (*d*) of the double electric layer were estimated [21]:

$$C_{dl} = P^{\frac{1}{n}} \cdot \left(\frac{R_s \cdot R_{ct}}{R_s + R_{ct}}\right)^{\frac{1-n}{n}}, \quad (8)$$

$$d = (S \cdot \varepsilon_0 \cdot \varepsilon) / C_{dl}. \quad (9)$$

where *S*is the electrode surface, ε is the dielectric constant of water, and $\varepsilon_0 = 8.85\ 10^{-12}$ F/m is the dielectric constant of vacuum.

The inhibitory ability of the compound was estimated from the ratio of the charge transfer resistances in the presence (*R*) and in the absence (R_0)of the inhibitor using equation (4) [11].

3. RESULTS AND DISCUSSION

3.1. Gravimetric studies

The dependence of the measured inhibition efficiencies at the different inhibitor concentrations (c_{inh}) is presented in Table 1.

Table 1.Variation of corrosion rates and inhibition efficiencies for mild steel in 0.5 M HCl and 0.5 M H_2SO_4 acid solutions with different concentrations of Fagussylvaticapurpureafallen leaves extracts obtained in the gravimetric measurements

Medium	0.5 M HCl		0.5 M H_2SO_4	
c_{inh}, g/l	ω, mg/(cm^2 · h)	IE, %	ω, mg/(cm^2 · h)	IE, %
0	0.89 ± 0.08	–	1.1 ± 0.1	–
0.1	0.67 ± 0.07	24.9	0.81 ± 0.09	25.9
0.3	0.51 ± 0.06	43.1	0.72 ± 0.08	34.7
1	0.30 ± 0.04	66.3	0.54 ± 0.06	51.3
3	0.28 ± 0.04	67.9	0.40 ± 0.05	63.8
10	0.26 ± 0.04	70.8	0.26 ± 0.05	76.2

3.2. Polarisation studies

The graphs of the open circuit potential measurements are presented in Figure 2.

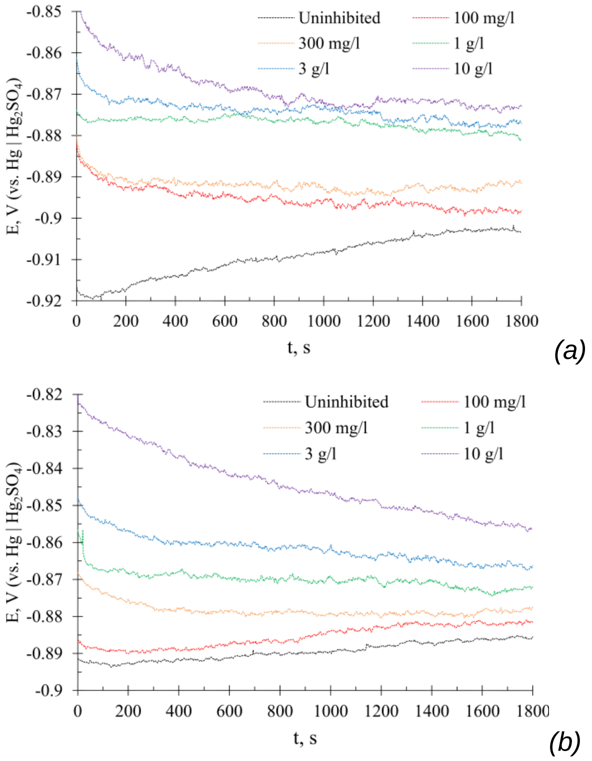


Figure 2. The open circuit potential of steel in (a) 0.5 M HCl, and (b) 0.5 M H_2SO_4 with the different additions of the Fagussylvaticapurpurea leaf extract after 30 min of exposure

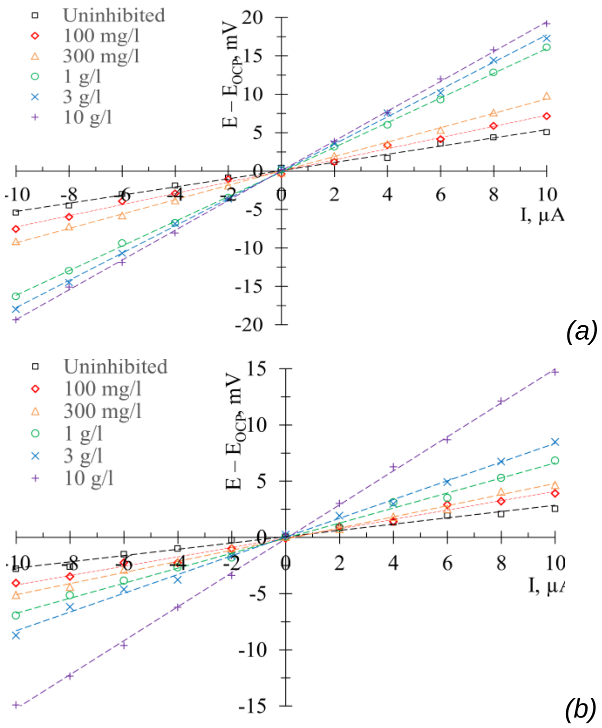


Figure 3. The linear polarisation resistance curves of steel in (a) 0.5 M HCl, and (b) 0.5 M H_2SO_4 with the different additions of the Fagussylvaticapurpurea leaf extract

The results of the linear polarisation resistance measurements are presented in Figure 3 and in Table 2.

Table 2. Variation of the measured polarisation resistance and estimated inhibition efficiencies of mild steel in 0.5 M HCl and 0.5 M H_2SO_4 acid solutions with different concentrations of Fagussylvaticapurpurea fallen leaves extracts

Medium	0.5 M HCl		0.5 M H_2SO_4	
c_{inh}, g/l	R_p, Ohm ·cm^2	IE, %	R_p, Ohm ·cm^2	IE, %
0	520±10	–	300±10	–
0.1	700±20	25.2	450±10	32.2
0.3	950 ± 20	45.0	510 ± 20	40.0
1	1460 ± 30	64.1	660 ± 20	53.3
3	1640 ± 30	68.0	860 ± 20	64.4
10	1790 ± 30	70.7	1540 ± 30	80.1

The results of the potentiodynamic polarisation measurements are presented in Figure 4 and in Table 3.

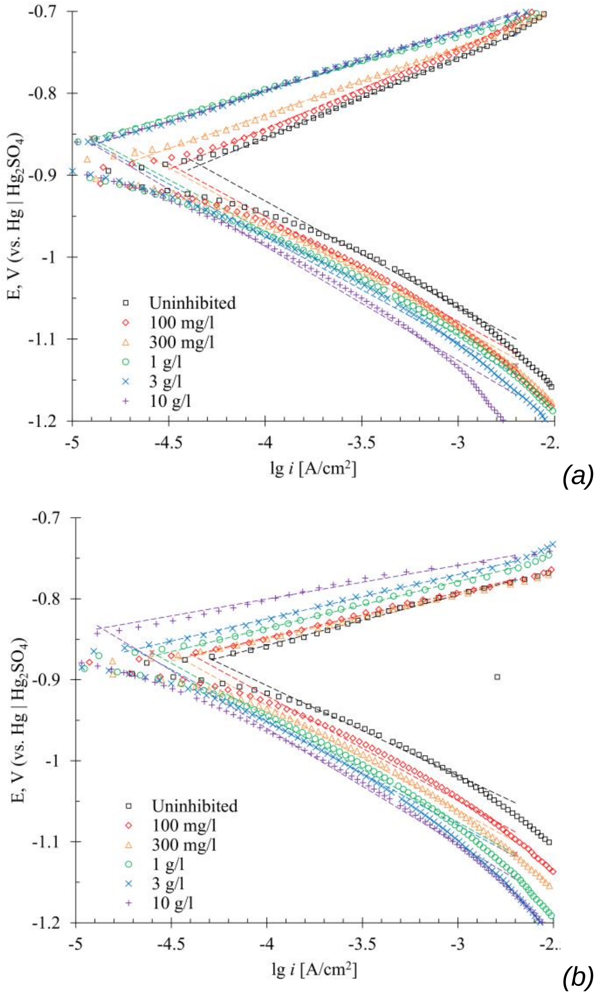


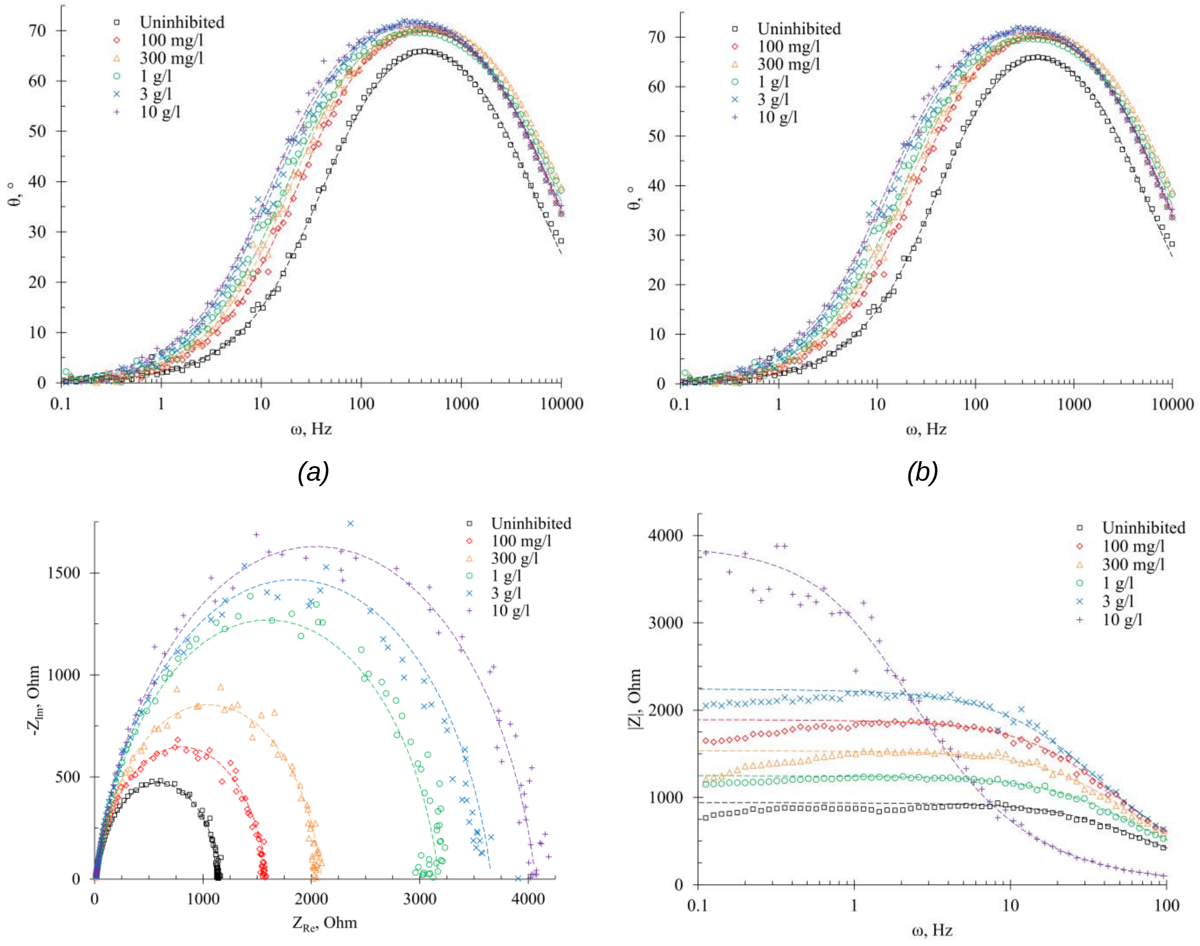
Figure 4. The polarisation curves of steel in (a) 0.5 M HCl, and (b) 0.5 M H_2SO_4 with the different additions of the Fagussylvaticapurpurea leaf extract after 30 min of exposure

Table 3.Variation of the measured open circuit potentials, Tafel slopes of polarisation curves,and estimated corrosion current densities, polarisation resistance and inhibition efficiencies of mild steel in 0.5 MHCl and 0.5 M H_2SO_4 acid solutions with different concentrations of Fagussylvaticapurpureafallen leaves extracts

c_{inh}, g/l	E_{cor}, mV	b_a, mV/dec	b_c, mV/dec	i_{cor}, µA/cm^2	IE, %	R_p, Ohm·cm^2	IE, %
0.5 M HCl with additions of *Fagussylvaticapurpurea*leaf extract							
0	–903	98.8	–129.8	45.9	–	527	–
0.1	–898	92.7	–128.3	33.9	26.1	715	26.3
0.3	–892	82.2	–129.6	24.5	46.7	891	40.9
1	–881	66.1	–126.1	12.7	71.2	1482	64.5
3	–877	74.0	–129.1	12.9	71.8	1529	65.5
10	–873	72.7	–129.4	13.2	72.4	1622	67.6
0.5 M H_2SO_4 with additions of *Fagussylvaticapurpurea*leaf extract							
0	–886	65.2	–131.4	51.7	–	335	–
0.1	–881	55.5	–129.2	40.8	21.2	414	19.1
0.3	–877	52.3	–129.3	35.6	31.1	466	28.2
1	–872	47.8	–130.0	26.6	48.5	655	48.9
3	–865	44.2	–128.2	20.3	60.7	821	59.2
10	–857	41.6	–133.0	13.6	73.6	1026	67.4

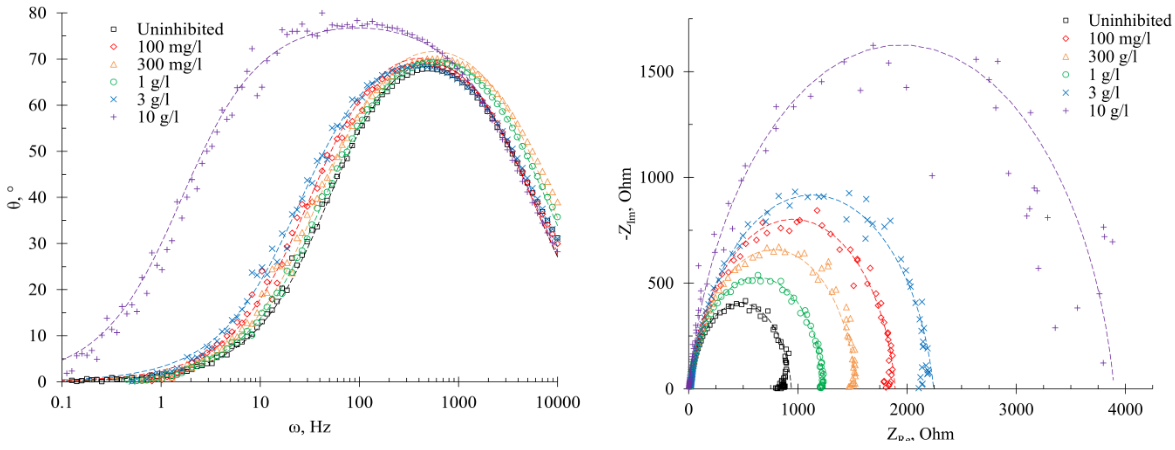
3.3. EIS studies

The results of electrochemical impedance measurements are presented in Figure 5 and in Table 4.



(a) *(b)*

(c) *(d)*



(e) (f)

Figure 5. The Bode plots of steel in (a), (b) 0.5 M HCl, and (d), (e) 0.5 M H_2SO_4, and the Nyquist plots of steel in (c) 0.5 M HCl, and (f) 0.5 M $H_2SO_4$with the different additions of the Fagussylvaticapurpurea leaf extract after 30 min of exposure

Table 4.Variation of theestimatedelectrochemical parameters obtained in the electrochemical impedance measurements and of inhibition efficiencies of mild steel in 0.5 MHCl and 0.5 M H_2SO_4 acid solutions with different concentrations of Fagussylvaticapurpureafallen leaves extracts

c_{inh}, g/l	R_s, Ohm	P, $\mu Ohm^{-1} \cdot s^n$	n	C_{dl}, μF	d, nm	R_{ct}, Ohm	IE, %
0.5 M HCl with additions of *Fagussylvaticapurpurea*leaf extract							
0	17.0	67.6	0.88	26.8	1.04	1144.7	–
0.1	9.9	82.4	0.87	28.4	0.98	1583.5	27.7
0.3	9.8	71.3	0.87	24.1	1.15	2087.0	45.1
1	14.8	55.7	0.86	17.5	1.58	3163.2	63.8
3	14.4	60.7	0.86	19.3	1.44	3645.5	68.6
10	14.7	59.1	0.86	18.8	1.48	4052.8	71.7
0.5 M H_2SO_4 with additions of *Fagussylvaticapurpurea*leaf extract							
0	13.3	55.6	0.91	342	0.08	927.4	–
0.1	12.5	50.9	0.90	290	0.10	1237.1	25.0
0.3	12.5	43.0	0.91	256	0.11	1521.8	39.1
1	18.5	44.5	0.90	261	0.11	1873.1	50.4
3	18.1	52.7	0.88	279	0.10	2225.4	59.3
10	2.8	32.9	0.89	138	0.20	3894.1	76.2

3.4. Langmuir adsorption model

The description of the adsorption of the leaf extract components on the steel surface was performed in terms of the Langmuir adsorption model, because this model is simple and used in most corrosion inhibition studies [22]. The Langmuir adsorption isotherm equation was linearised in the form:

$$c_{inh}/\theta = 1/K_{ads} + c_{inh}, \qquad (10)$$

where $c_{inh}$is the concentration of the *Fagus sylvatica purpurea* leaf extract solution, $K_{ads}$is the adsorption-desorption equilibrium constant, and $\theta$is the degree of surface coverage which represents the fraction of the surface of the metal covered by the inhibitor molecules adsorbed on to the metal surface. It is connected to the inhibition efficiency, IE of the inhibitor through the relation:

$$IE = \theta \cdot 100\% \qquad (11)$$

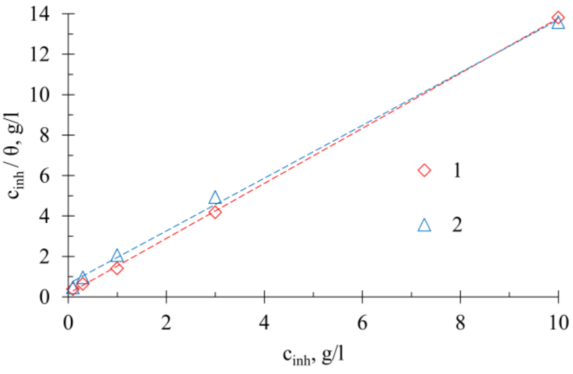


Figure 6. The plots of c_{inh} / θ vs. c_{inh} for the adsorption of the Fagussylvaticapurpurea leaf extract on the steel surface

The dependencies of c_{inh}/θ on c_{inh} are presented in Figure 6 and in Table 5.

The data were processed using the least squares technique [23], and the equilibrium constants K_{ads} were estimated as the intercepts of the regression equations. The Gibbs energy changes of the sorption ($\Delta_{ads}G$) were estimated from the equation:

$$\Delta_{ads}G = -RT \ln (K_{ads} \cdot c_{water}), \qquad (12)$$

where $c_{water} = 10^3$ g/l is the water concentration in the extracts. The results are presented in Table 5.

Table 5. The estimated parameters of the Langmuir adsorption model, sorption-desorption equilibrium constants and the Gibbs energies of adsorption for the sorption of Fagussylvaticapurpureafallen leaves extracts on the steel surface

C_{inh}, g/l	θ	C_{inh} / θ, g/l	Regression equation	K_{ads}, l/g	$\Delta_{ads}G$, kJ/mol
0.5 M HCl with additions of *Fagussylvaticapurpurea*leaf extract					
0.1	0.261	0.383	$c_{inh} / \theta = (1.36 \pm 0.01) \cdot c_{inh} + (0.16 \pm 0.06)$; $R^2 = 0.999$	7 ± 3	–21 ± 2
0.3	0.467	0.642			
1	0.712	1.404			
3	0.718	4.178			
10	0.724	13.812			
0.5 M H_2SO_4 with additions of *Fagussylvaticapurpurea*leaf extract					
0.1	0.212	0.472	$c_{inh} / \theta = (1.31 \pm 0.04) \cdot c_{inh} + (0.6 \pm 0.2)$; $R^2 = 0.997$	1.8 ± 0.6	–18 ± 2
0.3	0.311	0.965			
1	0.485	2.062			
3	0.607	4.942			
10	0.736	13.587			

3.5. Discussion

The results of the open circuit potential measurements show that with the addition of a *Fagus sylvatica purpurea* leaf extract the potential of the mild steel both in the solution of 0.5 M HCl and 0.5 M H_2SO_4 shifts to the more positive values. In addition, the Tafel slopes of the anodic branches of the polarisation curves decrease with alteration of the extract concentration, whereas the slopes of the cathodic branches remain nearly the same. This implies that in the solutions of both acids the purple beech leaf extract acts as the anodic-type inhibitor [24,25].

The values of the inhibition efficiencies estimated from the data of gravimetric, electrochemical and EIS experiments coincide well and show the similar trend (see Table 6). The values of the polarisation resistance of the absorbed inhibitor estimated from the data of linear polarisation and from the Tafel slopes also coincide well.

Table 6. The comparison of the inhibition efficiencies of Fagussylvaticapurpureafallen leaves extractsobtained by the various methods

C_{inh}, g/l			Inhibition efficiency, %		
	Gravimetric experiment	Linear polarisation resistance	Corrosion current density	Calculated polarisation resistance	Charge transfer resistance
	0.5 M HCl with additions of *Fagussylvaticapurpurea*leaf extract				
0.1	24.9	25.2	26.1	26.3	27.7
0.3	43.1	45.0	46.7	40.9	45.1
1	66.3	64.1	71.2	64.5	63.8
3	67.9	68.0	71.8	65.5	68.6
10	70.8	70.7	72.4	67.6	71.7
	0.5 M H_2SO_4 with additions of *Fagussylvaticapurpurea*leaf extract				
0.1	25.9	32.2	21.2	19.1	25.0
0.3	34.7	40.0	31.1	28.2	39.1
1	51.3	53.3	48.5	48.9	50.4
3	63.8	64.4	60.7	59.2	59.3
10	76.2	80.1	73.6	67.4	76.2

With the increase of the extract concentration from 0.1 to 1 g/l its inhibition efficiency on the corrosion of mild steel EN Fe37-3FN in a 0.5 M hydrochloric acid medium rises from ~25–30% to ~65–70%, but the further concentration increase gives no significant improvement of the inhibition efficiency. In contrast, the inhibition efficiency of the extract on the corrosion of the same steel in a 0.5 M sulphuric aicd medium continues to increase with the rise of extract concentration, and approaches ~70–75% when the concentration of 10 g/l is achieved.

The adsorption of the extracted components on the steel surface fairly obeys the Langmuir adsorption model. The values of the sorption–desorption equilibrium constants and the Gibbs energies of sorption estimated using the degrees of surface coverage obtained from the different methods coincide within their ranges of uncertainty. The calculated Gibbs energies of sorption are in the range ~ –20 kJ/mol for both hydrochloric and sulphuric acids, which means that the nature of the adsorption is physical due to the electrostatic interactions [26].

Despite the experimental values of the inhibition efficiencies may vary significantly with alteration of both the solution composition and temperature [27], the leaf extracts of *Fagus sylvatica purpurea*revealed the prospective inhibition potential against the corrosionofmild steel in acidic environments. The addition of common beech leaf extracts to a corrosive environment can be used to protect equipment from corrosion in pickling areas of metal processing industries, and in electroplating baths.The extracts may also be used as the part of products for removing corrosion products from steel surfaces [28,29]. Moreover, using the freshly fallen leaves for extract preparation does not put the trees into danger, and could contribute to the biomass waste usage.

4. CONCLUSION

The inhibitory ability of the *Fagus sylvatica purpurea*leaf boiling extracts on the corrosion of mild steel EN Fe37-3FN in 0.5 M hydrochloric acid and 0.5 M sulphuric acid media was investigated using the gravimetric, electrochemical, and EIS methods. It was shown that the addition of 100 mg/l of the extract reduces the corrosion rate in HCl by 25% and in H_2SO_4 by 20–25%, and that of of 1 g/l – by 65–70% and 45–50%, respectively, whereas the addition of 10 g/l of the extract further reduces the corrosion rate in $H_2SO_4$by 70–75%.The inhibition efficiency values obtained by the various methods show the similar trends. The adsorption of the extract components on a steel surface follows the Langmuir adsorption model, and the nature of adsorption is physical. The *Fagus sylvatica purpurea* leaf extract showsitself as prospective and environmentally friendly substance for reducing the steel corrosion rate in acidic environments.

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IZVOD

INHIBITORNA SVOJSTVA EKSTRAKATA IZ OPALOG LIŠĆA *FAGUS SILVATICA PURPUREA* NA KOROZIJU BLAGOG ČELIKA U KISELIM SREDINAMA

Inhibiciona sposobnost ekstrakata iz opalog lišća Fagus silvatica purpurea na koroziju mekog čelika EN Fe37-3FN u 0,5 M medijumu hlorovodonične kiseline i 0,5 M sumporne kiseline ispitivana je gravimetrijskim, elektrohemijskim i EIS metodama. Pokazalo se da dodatak 100 mg/l ekstrakta opalog lišća Fagus silvatica purpurea smanjuje stopu korozije za 20–25%, a od 1 g/l i više – za 65–70%. Adsorpcija komponenti ekstrakta na čeličnoj površini prati Langmuir model adsorpcije, a priroda adsorpcije je fizička. Ekstrakt opalog lišća Fagus silvatica purpurea pokazuje se kao perspektivna i ekološki prihvatljiva supstanca za smanjenje stope korozije čelika u kiselim sredinama.

Ključne reči: *Fagus silvatica purpurea, ljubičasta bukva, ključajući ekstrakti, inhibicija korozije u kiseloj sredini, blagi čelik, gravimetrijska studija, elektrohemijska studija, spektroskopija elektrohemijske impedanse, Langmuir adsorpciona izoterma*

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