

## Supporting Information

In-depth insight into the corrosion inhibition mechanism of *panax notoginseng* leaves extract on the corrosion of mild steel in acidic environment

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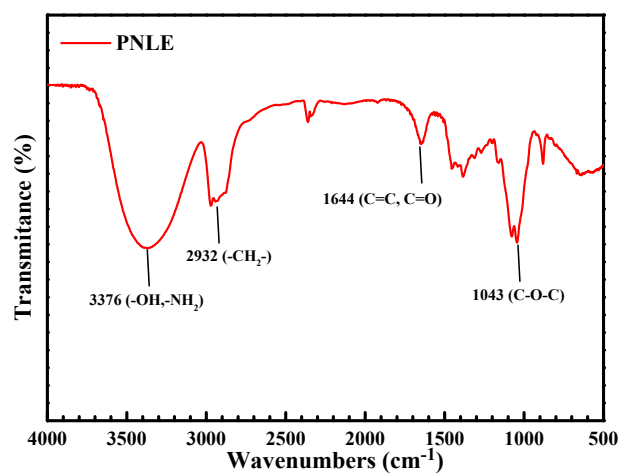


Fig. S1 FT-IR of *panax notoginseng* leaves extract.

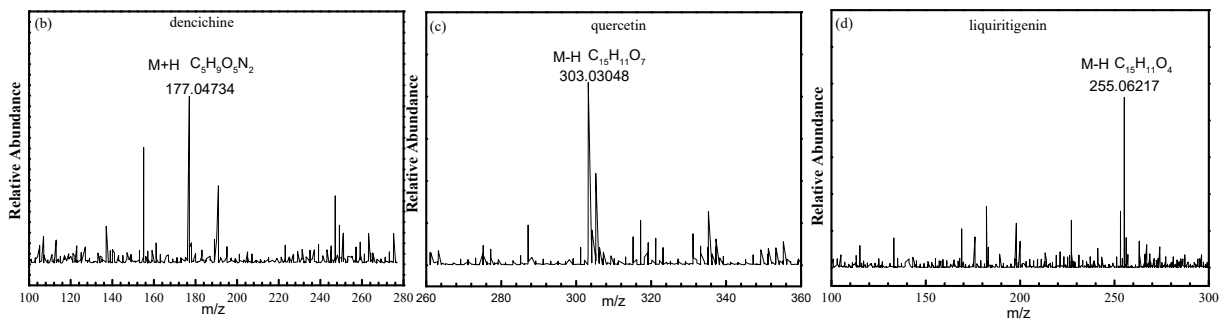
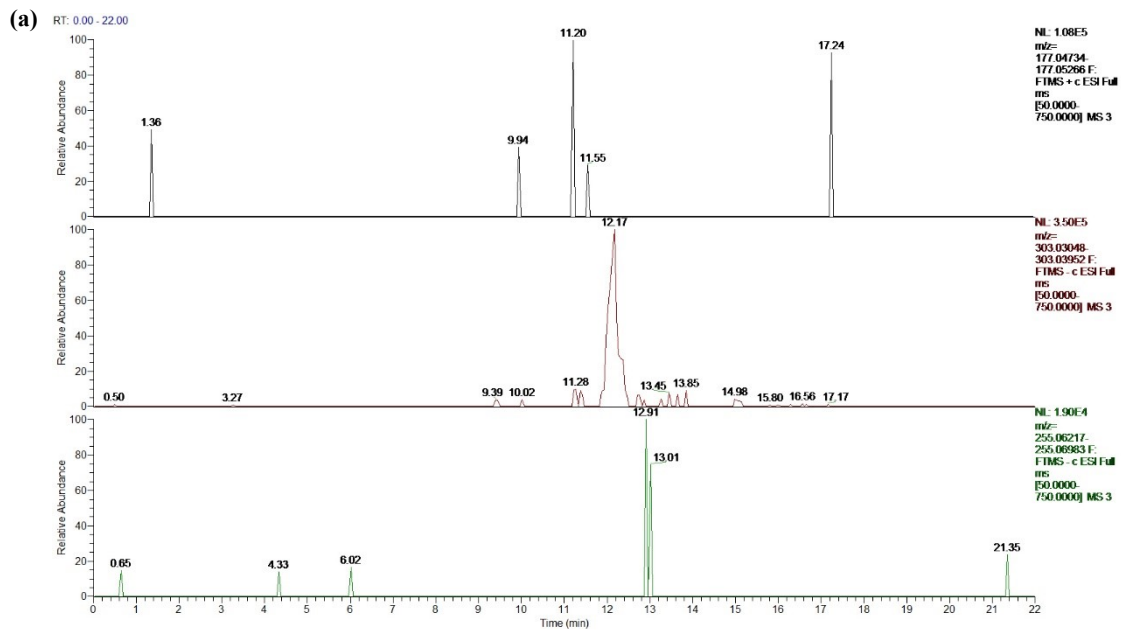


Fig. S2 LC-MS spectrum of the typical compounds in PNLE:(a) LC, (b) dencichine, (c) quercetin, (d) liquiritigenin.

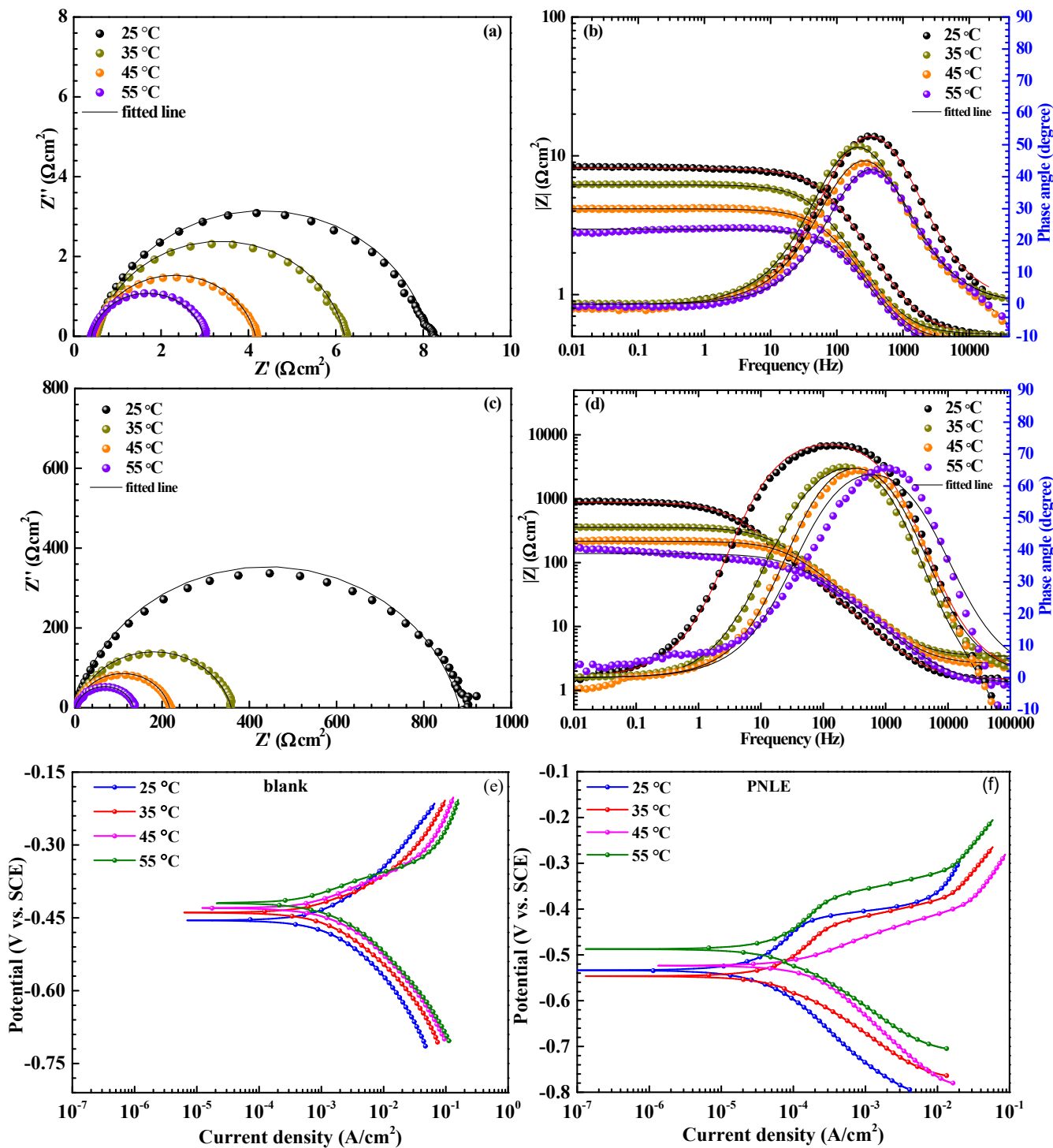


Fig. S3 Electrochemical test data of MS after soaked in test medium without or with 400 mg/L PNLE at different temperature: (a, b, e) in the blank solution, (c, d, f) in the solution containing 400 mg/L PNLE.

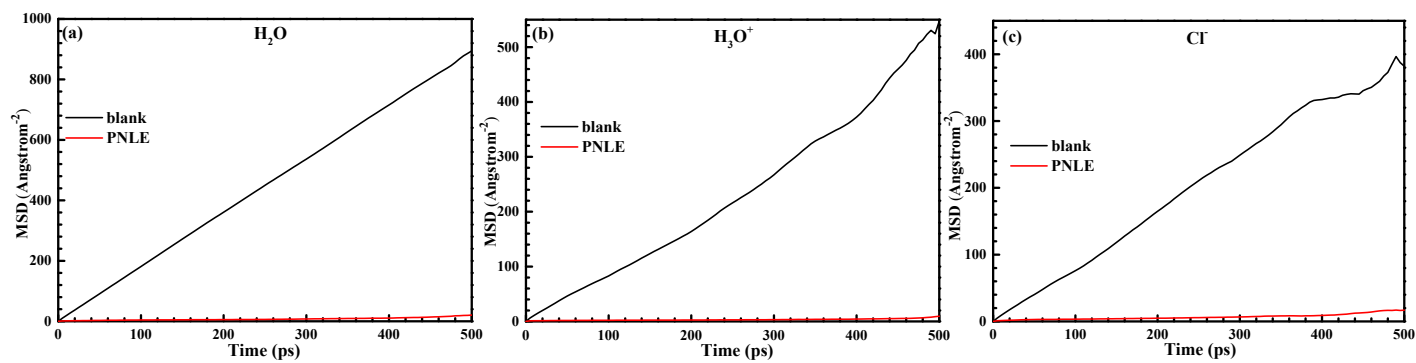


Fig. S4 MSD plots of the diffusion of corrosive species in the blank solution (H<sub>2</sub>O phase) and the adsorbed inhibitor film: (a) H<sub>2</sub>O, (b) H<sub>3</sub>O<sup>+</sup>, (c) Cl<sup>-</sup>.

Table S1 The chemical composition of Q235 mild steel

Elements	C	Si	Mn	P	S	Cr	Fe
Content (%)	0.20	0.30	0.35	0.030	0.35	0.25	balance

Table S2 Inhibition of steel by different plant extract in 1 M HCl medium

Extract	Medium	Material	Concentration	$\eta\%$	Ref.
<i>lemon verbena</i>	1 M HCl	Mild steel	2500 mg/L	94.9	[1]
<i>Ruta graveolens</i>	1 M HCl	304 SS	450 mg/L	94.3	[2]
<i>Pouzolzia zeylanica L.</i>	0.5 M HCl	SS-410	400 mg/L	94.9	[3]
<i>Zea mays bracts</i>	1 M HCl	Mild steel	5 g/L	82.0	[4]
<i>Ammophila arenaria</i>	1 M HCl	Mild steel	700 mg/L	84.3	[5]
<i>Chamaerops humilis fruit waste</i>	1 M HCl	low carbon steel	500 mg/L	91.4	[6]
PNLE	1 M HCl	Mild steel	400 mg/L	99.1	This work

Table S3 The fitted EIS parameters of MS in test medium without or with 400 mg/L

PNLE inhibitor at different temperatures

Inhibitors	Temperature (°C)	$R_s$ ( $\Omega \text{ cm}^2$ )	$CPE_{dl}$		$R_{ct}$ ( $\Omega \text{ cm}^2$ )	$\eta_R(\%)$
			$Y_0$ ( $\mu\Omega^{-1} \text{ s}^n$ $\text{cm}^{-2}$ )	n		
blank	25	2.10±0.13	520.6±23.5	0.80±0.02	8±2	
	35	1.16±0.14	1051.0±27.8	0.89±0.03	5.7±1.1	
	45	1.02±0.07	1228.0±16.1	0.88±0.01	3.7±1.2	
	55	1.19±0.15	1166.0±13.3	0.89±0.04	2.6±0.6	
inhibitors	25	1.48±0.07	92.8±8.6	0.86±0.02	881±28	99.1
	35	1.54±0.11	139.5±10.3	0.85±0.01	355±17	98.4
	45	1.29±0.09	118.9±9.4	0.86±0.04	214±11	98.3
	55	1.33±0.12	65.2±7.8	0.85±0.02	134±10	98.1

Table S4 Fitted electrochemical parameters of the polarization curves for MS in 1 M HCl solution without or with 400 mg/L PNLE inhibitor at different temperatures

Inhibitors	Temperature (°C)	$E_{\text{corr}}$ (V vs. SCE)	$i_{\text{corr}}$ (A/cm <sup>2</sup> )	$b_a$ (mV/dec)	$b_c$ (mV/dec)	$\eta_P$ (%)
blank	25	-0.456±0.002	(1.87±0.09)×10 <sup>-3</sup>	170±6	-158±3	-
	35	-0.444±0.002	(2.66±0.05)×10 <sup>-3</sup>	160±2	-168±3	-
	45	-0.437±0.002	(4.16±0.08)×10 <sup>-3</sup>	186±1	-189±5	-
	55	-0.435±0.001	(5.71±0.10)×10 <sup>-3</sup>	175±3	-215±7	-
inhibitor	25	-0.533±0.005	(1.22±0.02)×10 <sup>-5</sup>	92±13	-106±6	99.35
	35	-0.535±0.003	(3.58±0.05)×10 <sup>-5</sup>	65±8	-107±5	98.65
	45	-0.521±0.002	(1.48±0.03)×10 <sup>-4</sup>	116±15	-128±7	96.44
	55	-0.487±0.004	(2.39±0.04)×10 <sup>-4</sup>	87±10	-227±8	95.81

Table S5 The fitted EIS parameters of MS corroded in different concentrations of HCl media without or with 400 mg/L *Swertia cincta* extract inhibitor at 25 °C

Inhibitors	HCl (M)	$R_s$ (Ω cm <sup>2</sup> )	$CPE_{dl}$		$R_{ct}$ (Ω cm <sup>2</sup> )	$\eta_R$ (%)
			$Y_0$ (μΩ <sup>-1</sup> s <sup>n</sup> cm <sup>-2</sup> )	n		
blank	1	2.10±0.13	520.6±23.5	0.80±0.02	8±2	
	3	1.61±0.09	646.9±26.7	0.84±0.05	6.5±1.6	
	5	1.57±0.10	447.1±21.2	0.86±0.04	3.6±1.2	
inhibitors	1	1.48±0.07	92.8±8.6	0.86±0.02	881±28	99.1
	3	0.83±0.05	59.1±5.3	0.82±0.05	287±19	97.7
	5	0.74±0.04	149.4±12.7	0.83±0.03	148±13	97.6

Table S6 The fitted PC parameters of MS corroded in different concentrations of HCl media without or with 400 mg/L *Swertia cincta* extract inhibitor at 25 °C

Inhibitors	HCl (M)	$E_{\text{corr}}$ (V vs. SCE)	$i_{\text{corr}}$ (A/cm <sup>2</sup> )	$b_a$ (mV/dec)	$b_c$ (mV/dec)	$\eta_P$ (%)
blank	1	-0.456±0.002	(1.87±0.09)×10 <sup>-3</sup>	170±6	-158±3	-
	3	-0.419±0.004	(3.52±0.13)×10 <sup>-3</sup>	136±2	-164±2	-
	5	-0.408±0.003	(6.67±0.18)×10 <sup>-3</sup>	142±5	-133±4	-
inhibitor	1	-0.533±0.005	(1.22±0.02)×10 <sup>-5</sup>	92±13	-106±6	99.35
	3	-0.481±0.003	(1.02±0.03)×10 <sup>-4</sup>	52±11	-156±9	97.10
	5	-0.439±0.004	(2.25±0.05)×10 <sup>-4</sup>	80±14	-117±7	96.63

## References

- [1] G.S. Sajadi, F. Salmanian, R. Naghizade, S.M.A. Hosseini, *Int. J. Electrochem. Sci.*, 2024, **19**, 100699.
- [2] S.E. Hernández-Sánchez, J.P. Flores-De los Rios, H.A. Monreal-Romero, N.R. Flores-Holguin, L.M. Rodríguez-Valdez, M. Sánchez-Carrillo, A.D. Delgado, J.G. Chacón-Nava, *Metals*, 2024, **14**, 1267.
- [3] V. Tripathi, D. Prasad, R. Maithani, B.E. Ibrahimii, *J. Taiwan Inst. Chem. Eng.*, 2024, **165**, 105693.
- [4] J.-h. Zhu, B.-l. Lin, T.-h. Duan, H.-q. Lin, G.-y. Zhang, X.-x. Zhou, Y.-y. Xu, *Arab. J. Chem.*, 2024, **17**, 105895.
- [5] Z. Jebali, H. Ferkous, M. Zerroug, A. Boubli, A. Delimi, A. Bouzid, H. Majdoub, B. Ernst, N. Elboughdiri, Y. Benguerba, *J. Environ. Chem. Eng.*, 2024, **12**, 112374.
- [6] F.-Z. Eddahhaoui, A. Najem, M. Elhawary, M. Boudalia, O.S. Campos, M. Tabyaoui, A. José Garcia, A. Bellaouchou, H.M.A. Amin, *J. Alloys Compd.*, 2024, **977**, 173307.