

A comparative electrochemical study of electrosorbed 2- and 4-mercaptopyridines and their application as corrosion inhibitors at C60 steel[†]

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Abstract. The electrochemistry of self-assembled monolayers (SAMs) prepared from 2-mercaptopyridine (2 Mpy) and 4-mercaptopyridine (4 Mpy) dissolved in either water or an aqueous solution of 0.1 M H₂SO₄ on a polycrystalline gold electrode has been investigated in an aqueous electrolyte solution (0.5 M H₂SO₄) using cyclic voltammetry. Results suggest that 2 Mpy is adsorbed more strongly than 4 Mpy due to the formation of a S–Au–N chelate. The under- and over-potential deposition of copper from an aqueous solution of 0.1 M sulphuric acid is inhibited in the presence of these SAMs suggesting strong interactions between these adsorbates and the gold surface. A copper adlayer was partially displaced by adsorbing 2 Mpy and 4 Mpy. The inhibition effect of these SAMs on the corrosion of C60 steel has been investigated using electrochemical impedance measurements (EIM) in an aqueous 3.5 wt% NaCl solution. The polarization resistance and the inhibition efficiency were calculated. 2 Mpy has higher inhibition efficiency than 4 Mpy.

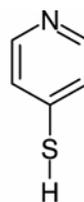
Keywords. Electrochemistry; self-assembled monolayers; 2- and 4-mercaptopyridine; corrosion inhibition.

1. Introduction

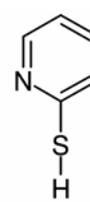
The phenomenon of self-assembly at interfaces has been recognized nearly 60 years ago.¹ Self-assembled monolayers of organic compounds can be obtained simply by adsorption of the respective molecules from their aqueous or non-aqueous solutions. In general, self-assembled monolayers (SAMs) can be defined as well-ordered and oriented molecular films, which are formed spontaneously on immersion of a substrate (solid surface) into a solution containing the respective surfactant molecule. These molecules organize themselves in a two-dimensional arrangement on the surface of the substrate.

Sulphur compounds have a strong affinity to transition metal surfaces;^{2–6} thus organosulphur compounds may coordinate very strongly to the surface of the metal. The number of reported surface-active organosulphur compounds that form monolayers on metal surfaces has increased in recent years.^{7–10} Thiols are organic compounds in which a S-atom is bonded to a carbon atom in the molecule. One of the important properties of such systems is that they

give the possibility of controlling the molecular construction at the electrode-solution interface. Thiols are appropriate for such studies because of the simplicity of preparation and the relatively large potential window within which such electrodes can operate.¹¹ Mercaptopyridines are thiol compounds that contain both N- and S-atoms in the molecule.



4-mercaptopyridine (4Mpy)



2-mercaptopyridine (2Mpy)

Mercaptopyridines can be easily adsorbed on the surface of a metal. Up-to-date, results of most investigations suggest that mercaptopyridines bond to the surface through S-atom after cleavage of the S–H bond and formation of a metal–S bond.^{12–20} However, it has been suggested also that mercaptopyridines might bind to the gold surface through its N-atom.²¹

Corrosion of pipes, pumps, turbine blades, coolers, superheaters, reheaters, fuel cells, and exhaust

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systems cause enormous industrial losses due to production downtime, accidental injuries, and replacement costs. One of the most important methods in corrosion protection of metals is the use of organic inhibitor molecules. These molecules inhibit on adsorption on the surface to be protected the anodic metal dissolution and/or the cathodic dioxygen reduction. Recently, SAMs have been considered as inhibiting systems. The inhibition efficiency of the organic compounds is apparently closely related to the structure and the properties of the film formed on the metal surface.^{22,23}

The present work aims to form SAMs of 2-mercaptopyridine and 4-mercaptopyridine on the surface of a polycrystalline gold electrode. The effect of the electrode potential, the electrolyte solution and the solvent on the adsorption process will be investigated. The influence of SAMs of 2- and 4-mercaptopyridines on electrodeposited layer of copper on the surface of the gold electrode will be electrochemically studied in order to elucidate structural integrity of the monolayer. Finally, 2- and 4-mercaptopyridine were tested as corrosion inhibitors on a steel surface in sodium chloride solution.

2. Experimental

2.1 Cyclic voltammetry

Cyclic voltammograms (CVs) were recorded with a polycrystalline gold disk (surface area approx. 0.1 cm^2 (Schiefer, Hamburg, polycrystalline 99.99%, polished down to $0.3 \mu\text{m}$ and $0.05 \mu\text{m}$ $\alpha\text{-Al}_2\text{O}_3$, embedded in epoxy ARALDIT D/HY 956 (Ciba special chemicals)) as a working electrode in aqueous solutions of $0.5 \text{ M H}_2\text{SO}_4$ as a supporting electrolyte or 0.1 M aqueous H_2SO_4 containing 1.0 mM CuSO_4 (source?) using a custom-built potentiostat interfaced with a standard PC via an ADDA-converter card operating with custom-developed software. A gold sheet electrode was used as a counter electrode. A mercurous sulfate electrode ($\text{Hg}/\text{Hg}_2\text{SO}_4$ in $0.1 \text{ M K}_2\text{SO}_4$ (MSE) with $E_{\text{SHE}} = 641 \text{ mV}$) was used as a reference electrode in all cyclic voltammetry experiments. The CVs were recorded in a H-cell with glass frits separating cell compartments. Details of cyclic voltammetry in the presence of copper ions are given below.

Before each experiment the working electrode was polished and subsequently ultrasonicated for a few minutes in ultrapure water. Before adsorption,

the surface state of the electrode was ascertained by potential scanning in aqueous $0.5 \text{ M H}_2\text{SO}_4$ between $-0.4 > E_{\text{MSE}} > +1.3 \text{ V}$ until a stable CV was obtained. The electrode was rinsed with deionized water and immediately immersed into the solution of the mercaptopyridine for 3 min and then rinsed carefully with ultrapure water to remove non-chemisorbed species.

2.2 Corrosion studies

A C60-steel disk electrode manufactured as a cylinder of 12 mm height and 15 mm diameter (0.61% C, max. 0.40% Si, 0.75% Mn, max. 0.40% Cr, max. 0.10% Mo, max. 0.40% Ni and max. 0.63% others) was used as a working electrode. The peripheral surface was coated with PTFE (Teflon[®]) tape leaving 1.77 cm^2 surface area exposed to the electrolyte solution. It was polished on abrasive paper 1000 grade and with a slurry of $\alpha\text{-Al}_2\text{O}_3$ ($13 \mu\text{m}$). A gold sheet electrode and a saturated calomel electrode (SCE) were used as counter and reference electrodes, respectively. An aqueous supporting electrolyte solution 3.5 wt% NaCl was used. For electrochemical impedance measurements (EIM) a potentiostat Solartron SI 1287 connected to a frequency response analyzer SI 1255 interfaced to a PC with EIM software was used. The measurements were carried out at the spontaneously established open circuit potential (OCP) with modulation amplitude of 5 mV in a frequency range from 0.1 Hz to 100 kHz. Evaluation of the impedance data was performed with Boukamp software version 2.4.

2.3 Materials

Electrolyte solutions were prepared from 18 M Ω water (Seralpur Pro 90c); 2-mercaptopyridine (Aldrich), 4-mercaptopyridine (Aldrich), sulphuric acid (Merck, G.R.), copper sulfate (p.A., VEB Laborchemie Apolda) and sodium chloride (p.A., VEB Laborchemie Apolda) were used as received. 1 mM solutions of 2- and 4-mercaptopyridine in either water or $0.1 \text{ M H}_2\text{SO}_4$ were used for SAM formation. For the corrosion studies only aqueous solutions of mercaptopyridines were used in order to avoid acid corrosion of the sample electrode. All solutions were freshly prepared, purged with nitrogen (99.999%) except for corrosion studies. All measurements were performed at room temperature.

3. Results and discussion

3.1 Electrochemical behaviour in 0.5 M H₂SO₄

Figure 1 shows the cyclic voltammogram (CV) of a bare polycrystalline gold electrode in 0.5 M H₂SO₄ in the potential range of 0.0 > E_{MSE} > +1.3 V. In the anodic scan there is a peak at $E_{\text{MSE}} = 0.76$ V indicating gold hydroxide and oxide formation, which undergo reduction at $E_{\text{MSE}} = 0.43$ V in the cathodic scan.²⁴

CVs of a polycrystalline gold electrode pretreated with a 1 mM solution of 2 Mpy (dissolved in water) in 0.5 M H₂SO₄ are shown in figure 2. During

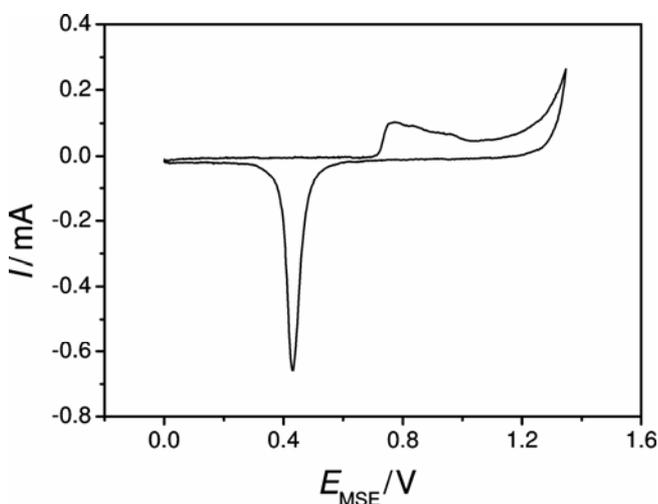


Figure 1. CV of a bare polycrystalline Au electrode in 0.5 M H₂SO₄, $dE/dt = 100 \text{ mVs}^{-1}$.

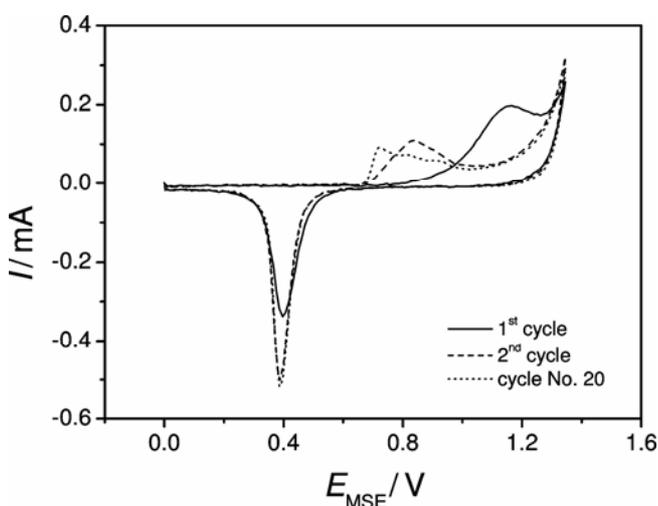


Figure 2. CVs of a polycrystalline gold electrode with adsorbed 2 Mpy (dissolved in water) in 0.5 M H₂SO₄, $dE/dt = 100 \text{ mVs}^{-1}$.

the anodic scan in the first cycle a broad peak at $E_{\text{MSE}} = 1.16$ V is formed. Two processes may cause this current: oxidation of the gold surface and oxidation of adsorbed 2 Mpy. During the cathodic scan of the first cycle the gold oxide reduction peak at $E_{\text{MSE}} = 0.40$ V shows a considerably diminished peak height smaller than observed with a bare Au electrode under identical conditions (table 1).

In the presence of adsorbed 2 Mpy the main process besides decreased gold oxide formation indeed adsorbate oxidation was noticed.^{17,24,25}

During the second cycle, the current at $E_{\text{MSE}} = 1.16$ V is decreased and a separate peak that distinctly splits with increasing number of cycles, corresponding to gold oxidation, could be noticed around $E_{\text{MSE}} = 0.84$ V. This peak is shifted to more negative potentials with subsequent cycling. In addition, with increasing number of cycles, the peak current due to the gold oxide reduction grows (table 1). This suggests that during the first scan the surface oxidation of gold is decreased owing to the presence

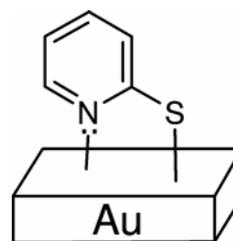


Figure 3. Suggested chelate structure of 2 Mpy on a gold Au surface.

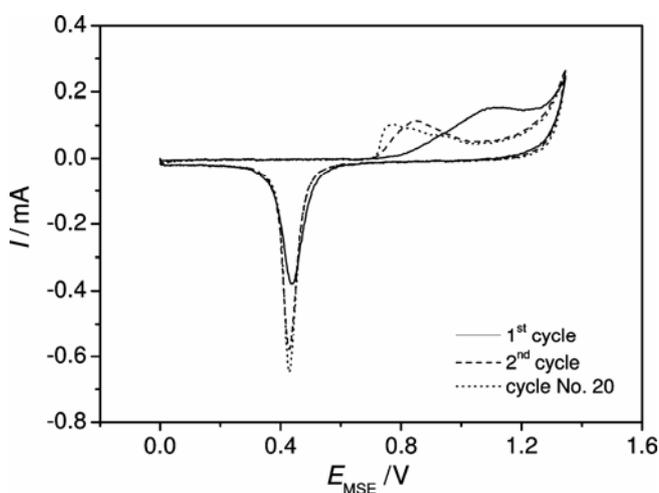


Figure 4. CVs of a polycrystalline gold electrode with adsorbed 2 Mpy (dissolved in 0.1 M H₂SO₄) in 0.5 M H₂SO₄, $dE/dt = 100 \text{ mVs}^{-1}$.

Table 1. Oxidation and reduction potentials and peak currents for a gold electrode in 0.5 M H₂SO₄ with 2 Mpy adsorbed from an aqueous solution.

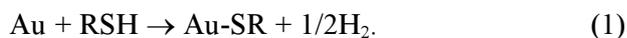
	E_{ox}/V	E_{red}/V	I_{ox}/mA	I_{red}/mA
Bare Au	0.76	0.43	0.10	-0.65
2 Mpy/1st cycle	1.16	0.40	0.20	-0.33
2 Mpy/2nd cycle	0.84	0.39	0.12	-0.48
2 Mpy/20th cycle	0.73	0.39	0.10	-0.52

Table 2. Oxidation and reduction potentials and peak currents for a gold electrode in 0.5 M H₂SO₄ with 2 Mpy adsorbed from 0.1 M H₂SO₄ solution.

	E_{ox}/V	E_{red}/V	I_{ox}/mA	I_{red}/mA
Bare Au	0.76	0.43	0.10	-0.65
2 Mpy/1st cycle	1.10	0.44	0.16	-0.37
2 Mpy/2nd cycle	0.85	0.43	0.12	-0.58
2 Mpy/20th cycle	0.77	0.43	0.10	-0.65

of adsorbed 2 Mpy. In subsequent cycles more gold surface is exposed to the solution due to the removal of the 2 Mpy layer facilitating the formation of gold oxide and its reduction.²⁴ The fraction of charge associated with gold oxide formation followed by its reduction increases gradually with increasing number of cycles. This supports the suggestion that 2 Mpy can be oxidised in an acidic medium on a gold electrode.

The adsorption process for mercaptopyrindines suggests a net electron transfer from the sulphur atom to the metal as a part of the monolayer formation process. However, the sulphur atom behaves as an electron acceptor when it is bonded to gold due to the large difference between the electronegativities of sulphur and gold.^{26,27} The overall reaction is frequently expressed as.²⁸⁻³²



Although 2 Mpy probably adsorbs primarily through the sulphur atom, the presence of the pyridine ring, with the nitrogen atom in the 'ortho' position, could give rise to the formation of a chelate with the gold surface, thus giving rise to more strongly adsorbed layer.¹⁷⁻²⁰ The formed surface chelate of type S-Au-N is shown in figure 3.²⁰

When 2 Mpy is adsorbed from a 1 mM solution in 0.1 M H₂SO₄ on the polycrystalline gold electrode the CVs in 0.5 M H₂SO₄ (figure 4) show similar features, but with a slightly to negative shift in the oxidation peak as compared to 2 Mpy in water due to weak adsorption of 2 Mpy (table 2). Since in the

acidic adsorption solution the nitrogen atom of pyridine ring is protonated the chelate structure cannot be formed; as a result the interaction is dominated by the sulphur atom.^{17,19}

The behaviour is similar in the presence of adsorbed 4 Mpy on the surface of the gold electrode. figure 5 shows CVs of a polycrystalline gold electrode in 0.5 M H₂SO₄ with 4 Mpy adsorbed from an aqueous 1 mM solution. During the first anodic scan a current plateau at $E_{\text{MSE}} = 0.93$ V is formed. This might be due to the oxidation of both adsorbed 4 Mpy and the Au surface. This plateau is shifted to a more negative potential compared with 2 Mpy (table 3). It means less inhibition of gold oxide formation in case of 4 Mpy.^{13,17,25}

As mentioned before for 2 Mpy, during the cathodic scan of the first cycle, a gold oxide reduction peak occurs at $E_{\text{MSE}} = 0.42$ V whose peak height is considerably less than that observed with a bare gold electrode under identical conditions suggesting that 4 Mpy monolayer decreases the gold oxide formation and that the main process is the adsorbate oxidation.^{17,30}

In the second and subsequent cycles, the current at $E_{\text{MSE}} = 0.93$ V decreases and a broad peak appears, which is shifted to more negative potentials with increasing number of cycles. In addition, the peak height of the gold oxide reduction increases. With subsequent cycles, due to the removal of the 4 Mpy layer, the formation of gold oxide and its reduction are facilitated. The tendency of gold oxide formation increases with increasing number of cycles indicating that also 4 Mpy can be oxidized in an acidic medium on the gold electrode.^{17,24}

With the nitrogen atom in the 'para' position 4 Mpy cannot form the chelate structure. Thus, the bonding to the surface is solely through the sulphur atom. This may result in a diminished interaction with the electrode.^{17,19,20} However, Alonso²⁰ suggested that the S-metal bond is stronger in case of 4 Mpy than in 2 Mpy.

Presumably 4 Mpy binds to the electrode surface through the sulphur atom (normal geometry) in almost vertical orientation. In this case the packing density is larger than that for 2 Mpy. There is also a small probability that 4 Mpy binds to the surface through a nitrogen atom (out of normal geometry).^{14,17,20}

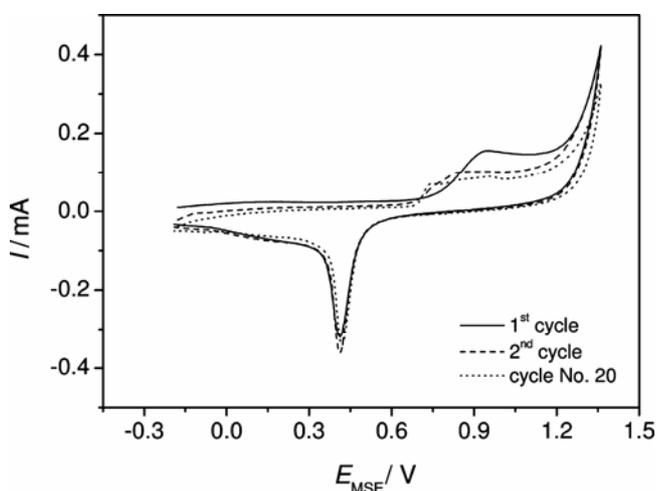


Figure 5. CVs of a polycrystalline gold electrode with adsorbed 4 Mpy (dissolved in water) in 0.5 M H₂SO₄, $dE/dt = 100 \text{ mV s}^{-1}$.

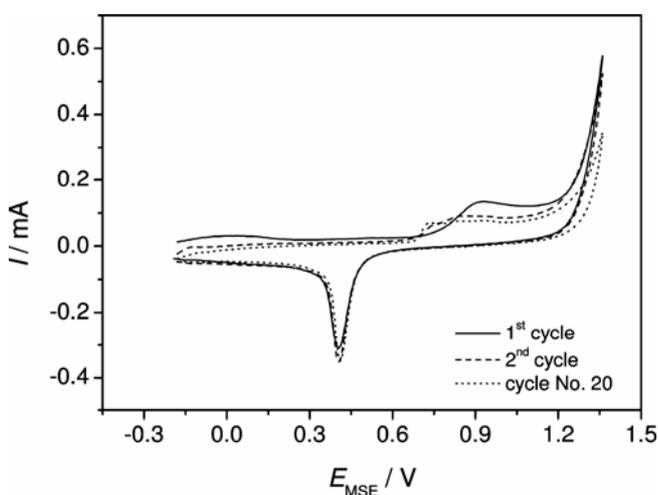


Figure 6. CVs of a polycrystalline gold electrode with adsorbed 4 Mpy (dissolved in 0.1 M H₂SO₄) in 0.5 M H₂SO₄, $dE/dt = 100 \text{ mV s}^{-1}$.

When 4 Mpy is adsorbed from its solution in 0.1 M H₂SO₄ on the gold electrode, the CVs (figure 6) show analogous behaviour to that found with 4 Mpy adsorbed from water, with the exception that the oxidation peak is slightly shifted to negative potentials (table 4). In addition, the height of the reduction peak is slightly lower than that obtained in the case of 4 Mpy dissolved in water. It is also lower than that for 2 Mpy either in water or in 0.1 M H₂SO₄. This indicates a smaller inhibition of Au oxidation and a smaller overpotential for adsorbate oxidation. This behaviour might be due to weaker interaction between gold surface and the bonded 4 Mpy adsorbed from its solution in 0.1 M H₂SO₄ since in this solution the N-atom is protonated. Such protonation would cause (by inductive effect) a weakening of the sulphur-gold bond, besides diminishing the possibility of adsorption of the molecule onto the electrode surface.^{17,19,20}

In summary, when 2 Mpy is deposited on the Au electrode surface from both media the formation of gold oxide is more inhibited than in the case of 4 Mpy and the inhibition in case of adsorption from neutral solvent than from acidic solution. This behaviour is similar to that described by Alonso *et al*¹³ for polycrystalline platinum electrode.

3.2 Electrodeposition of copper on a gold electrode

Electrochemical techniques such as cyclic voltammetry allow the characterization of the processes taking place during the electrodeposition of metals in absence and presence of co-adsorbed species, reflecting the interaction between co-adsorbates, the electrode surface and the metal overlayer.³³⁻³⁹ The effect of the adsorption of numerous organic species on the electrodeposition of the metals has been previously studied.^{12,18,39} These studies show that they are able to hinder or even completely inhibit the electrodeposition process onto metal substrates depending on their strength of adsorption.

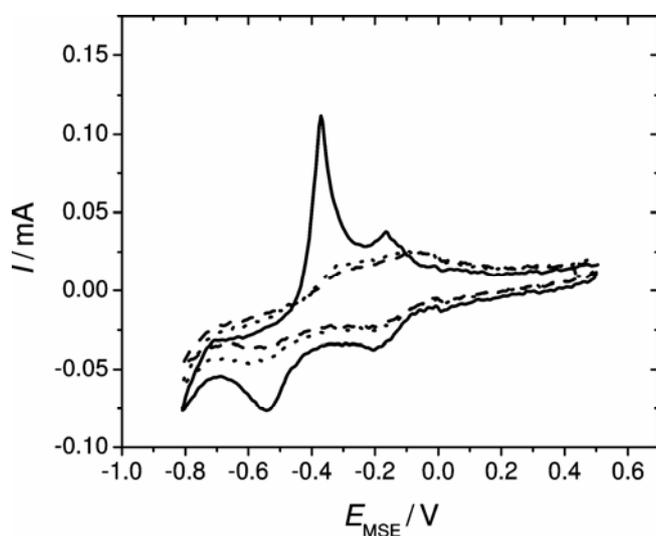
The copper deposition on a polycrystalline gold electrode from 1 mM aqueous CuSO₄ solution in absence of an adsorbate (solid line) is displayed in figure 7. The potential was scanned in the negative direction at 50 mV s⁻¹ from $E_{\text{MSE}} = +0.5 \text{ V}$. The CV shows both underpotential (UPD) at $E_{\text{MSE}} = -0.20 \text{ V}$ and overpotential deposition (OPD) at $E_{\text{MSE}} = -0.54 \text{ V}$. In the subsequent positive going scan, two features are observed due the stripping of the electro-

Table 3. Oxidation and reduction potentials and peak currents for a gold electrode in 0.5 M H₂SO₄ with 4 Mpy adsorbed from an aqueous solution.

	E_{ox}/V	E_{red}/V	I_{ox}/mA	I_{red}/mA
Bare Au	0.76	0.43	0.10	-0.65
4 Mpy/1st cycle	0.93	0.42	0.15	-0.32
4 Mpy/2nd cycle	0.83	0.41	0.10	-0.36
4 Mpy/20th cycle	0.74	0.42	0.07	-0.34

Table 4. Oxidation and reduction potentials and peak currents for a gold electrode in 0.5 M H₂SO₄ with 4 Mpy adsorbed from 0.1 M H₂SO₄ solution.

	E_{ox}/V	E_{red}/V	I_{ox}/mA	I_{red}/mA
Bare Au	0.76	0.43	0.10	-0.65
4 Mpy/1st cycle	0.93	0.41	0.14	-0.31
4 Mpy/2nd cycle	0.84	0.40	0.10	-0.35
4 Mpy/20th cycle	0.73	0.40	0.08	-0.35

**Figure 7.** Deposition of copper from 1 mM copper solution in 0.1 M aqueous H₂SO₄ solution onto a bare polycrystalline Au electrode (solid line) and a Au electrode pretreated with a 1 mM solution of 2 Mpy in water (dashed line) and in 0.1 M aqueous H₂SO₄ (dotted line), $dE/dt = 50 \text{ mVs}^{-1}$.

deposited copper: a sharp peak at $E_{\text{MSE}} = -0.37 \text{ V}$ corresponding to the removal of bulk copper (OPD) and a peak at $E_{\text{MSE}} = -0.17 \text{ V}$ corresponding to the stripping of UPD copper.¹⁹ The CVs for copper deposition on a gold electrode with 2 Mpy adsorbed from its aqueous solution (dashed line) and from 0.1 M aqueous H₂SO₄ (dotted line) are shown in figure 7. Copper deposition is inhibited on the gold surface due to the presence of adsorbed 2 Mpy. It has been suggested in a previous study¹⁷ that the strength of interaction between the sulphur atom of the adsorbate and the Au surface is greater than that between the deposited copper and the surface.

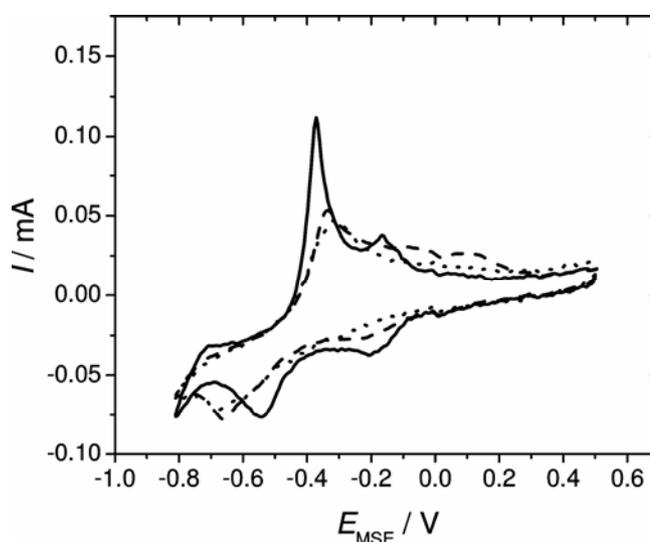
**Figure 8.** Deposition of copper from 1 mM copper solution in 0.1 M aqueous H₂SO₄ solution onto a bare polycrystalline Au electrode (solid line) and a Au electrode pretreated with a 1 mM solution of 4 Mpy in water (dashed line) and in 0.1 M aqueous H₂SO₄ (dotted line), $dE/dt = 50 \text{ mVs}^{-1}$.

Figure 8 shows the CVs of 4 Mpy when adsorbed from its aqueous (dashed line) or its acidic (dotted line) solution on gold electrode. It can be noticed that the electrodeposition of Cu is diminished which indicates that the presence of 4 Mpy monolayer deposited from both media inhibits the Cu deposition. The charge consumed during copper deposition in the presence of 4 Mpy is larger than in the presence of 2 Mpy indicating a smaller degree of coverage with 4 Mpy and/or a weaker interactions, both aspects are closely related. This closely corresponds to

conclusion described above as derived from cyclic voltammograms.

When an electrodeposited up-copper monolayer on a polycrystalline gold electrode is exposed to a 1 mM solution of 2 Mpy (figure 9) or 4 Mpy (figure 10) in either water or 0.1 M aqueous H_2SO_4 , the copper monolayer is partially stripped as can be observed in a positive going potential scan. This implies the same conclusion that the strength of interaction between the S atom and the Au surface is

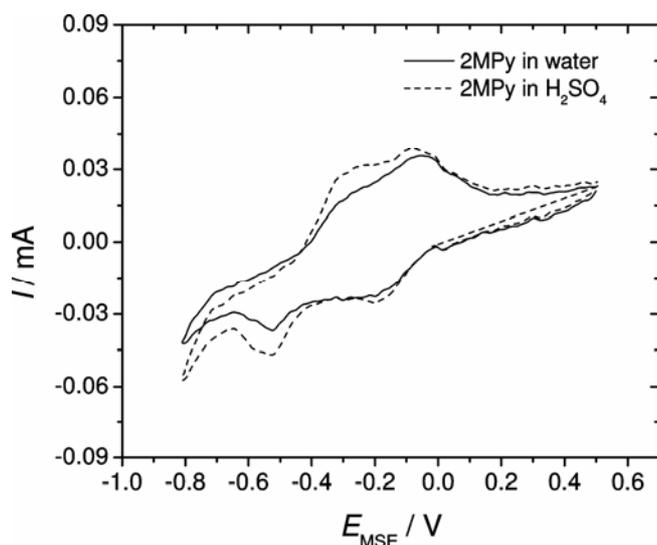


Figure 9. CVs of a polycrystalline gold electrode with an initially deposited Cu adlayer in 0.1 M aqueous H_2SO_4 after immersion in 2 Mpy solutions, $dE/dt = 50 \text{ mV s}^{-1}$.

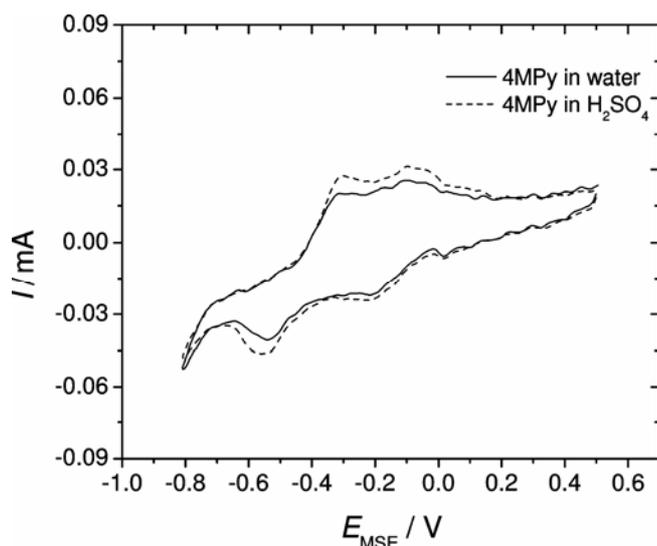


Figure 10. CVs of a polycrystalline gold electrode with an initially deposited Cu adlayer in 0.1 M aqueous H_2SO_4 solution after immersion in 4 Mpy solutions, $dE/dt = 50 \text{ mV s}^{-1}$.

greater than that between the copper adlayer and the surface.

3.3 Study of the corrosion of C60 steel

In order to study the efficiency of corrosion inhibition of the SAMs in the selected medium, a number of methods can be used. Electrochemical impedance measurement (EIM) is a particularly valuable and convenient method yielding information on changes of rate and mechanism of corrosion.^{40,41}

The Nyquist plot of a C60 steel electrode in 3.5% aqueous NaCl solution at OCP shows a semicircle in figure 11. The equivalent circuit used in this study is a modified Randles circuit as shown in figure 12 where R_s is the solution resistance; R_{ct} is the charge transfer resistance, W is the Warburg impedance and C_{dl} is the double layer capacitance.^{42,43}

The polarization resistance R_p value of the bare steel electrode as obtained by the numerical simula-

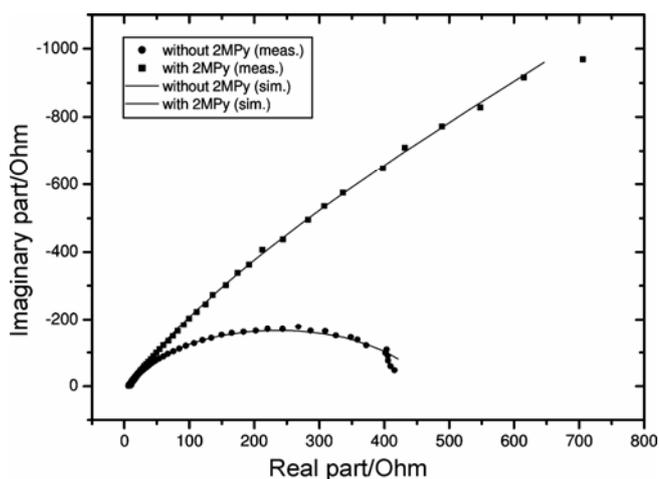


Figure 11. Nyquist plot of measured and simulated impedance of a C60 steel electrode in absence and presence of 2 Mpy monolayer in aqueous solution of 3.5 wt% NaCl.

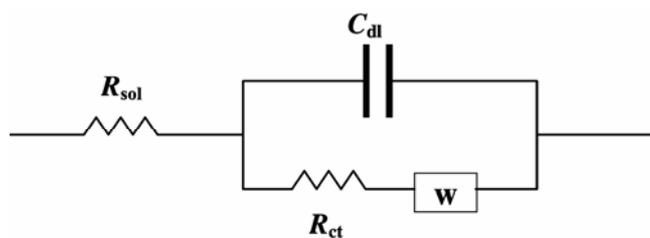


Figure 12. Proposed equivalent circuit for the impedance of a bare steel electrode.

tion and also available by extrapolation of the semi-circle to the impedance real axis was found to be equal to 459 Ω .

3.4 Influence of 2-mercaptopyridine on the corrosion of C60 steel electrode

Figure 11 shows the complex plane plot of a C60 steel electrode in the absence and presence of adsorbed 2 Mpy. The polarization resistance of the modified electrode obtained with the same Randles equivalent circuit as above is significantly increased indicating effective corrosion inhibition.

The electrode coverage θ with adsorbed molecules is related to the polarization resistance. Assuming that the corrosion reaction occurs only at bare areas on the electrode surface the following equation for the apparent fractional coverage of the electrode can be used:^{40,44–46}

$$\theta = 1 - (R_p^0/R_p), \quad (2)$$

where R_p^0 and R_p are the electrode polarization resistance in the absence and presence of the inhibitor, respectively.

Table 5. EIS (R_p , η , and θ) results for steel electrode in the absence and presence of the monolayer.

	R_p/Ω	η (%)	θ	
Bare Fe	459	–	–	
2 Mpy	1.25×10^3	63	0.633	Figure 11
4 Mpy	1.08×10^3	58	0.575	Figure 13

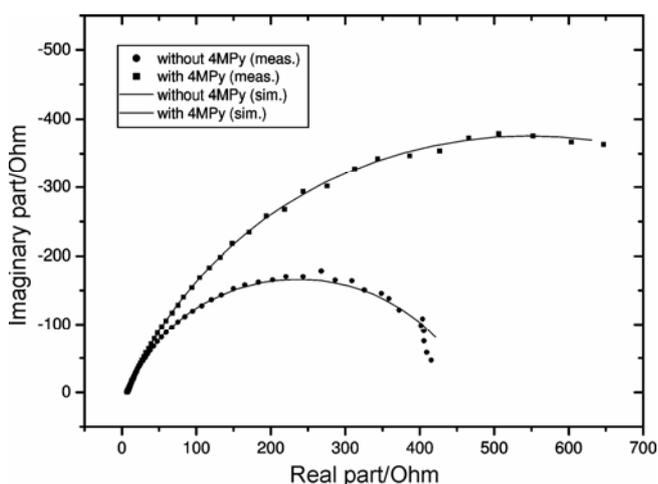


Figure 13. Nyquist plot of measured and simulated impedance of a C60 steel electrode in absence and presence of 4 Mpy monolayer in aqueous solution of 3.5 wt% NaCl.

The inhibition efficiency (η %) was determined using the following formula:⁴⁷

$$\eta(\%) = [1 - (R_p^0/R_p)] \times 100. \quad (3)$$

The polarization resistances, the calculated surface coverage and the inhibition efficiencies are collected in table 5.

3.5 Influence of 4-mercaptopyridine on the corrosion of C60 electrode

Figure 13 shows the complex plane plot of the impedance data of a C60 steel electrode in the absence and presence of 4 Mpy monolayer. The Randles equivalent circuit for the modified electrode is the same as that of the bare steel electrode. The presence of adsorbed 4 Mpy yields a higher polarization resistance value than a bare electrode indicating that also 4 Mpy can serve as corrosion inhibitor for steel in NaCl solution. However, 4 Mpy shows a smaller inhibition efficiency than 2 Mpy (see table 5), which might be due to the presence of a chelate structure in case of 2 Mpy.

These results encourage further studies of the mercaptopyridines under different conditions to select the best corrosion inhibition efficiency for steel and metals in different electrolyte solutions.

4. Conclusion

Both 2- and 4-mercaptopyridines can be oxidized in acidic medium on the surface of polycrystalline gold electrode. 2 Mpy can form a S–Au–N chelate with the Au surface while 4 Mpy is bonded only through the S-atom. The presence of the SAMs of 2 Mpy and 4 Mpy inhibits the electrodeposition of copper to a great extent. 2 Mpy has higher inhibition efficiency for corrosion of C60 steel than 4 Mpy.

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