Electrodeposition of Poly(*o*-toluidine) on Brass from Aqueous Salicylate Solution and Its Corrosion Protection Performance

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ABSTRACT: Poly(*o*-toluidine) (POT) has been electrodeposited on brass from an aqueous salicylate solution by using cyclic voltammetry, and its corrosion protection performance has been evaluated by potentiodynamic polarization technique and electrochemical impedance spectroscopy in aqueous 3% NaCl solution. The corrosion potential was about 0.115 V vs. SCE more positive for the POT-coated brass than that of uncoated brass and reduces the corrosion rate of brass almost by a factor of 800. © 2010 Wiley Periodicals, Inc. J Appl Polym Sci 118: 2084–2091, 2010

Key words: conducting polymers; poly(*o*-toluidine); brass; electrodeposition; cyclic voltammetry; electrochemical impedance spectroscopy

INTRODUCTION

The use of conducting polymers for protection of oxidizable metals against corrosion in aggressive environments is now well established.[1–7] The electrochemical polymerization is a simple and most convenient method for the depositing the conducting polymers on metallic surfaces.[1,8] The electrochemical synthesis of conducting polymer coatings from aqueous solutions containing oxalate ions has been investigated by several groups because this medium inhibits iron dissolution.[9–12] Other electrolytes such as salicylate,[13,14] tartrate,[15] malate,[16] and sulfate[17] have also been used for the electrochemical synthesis of conducting polymers. So far polyaniline (PANI) and its substituted derivatives are found to be the most promising materials for corrosion protection of several oxidizable metals such as iron,[5,16] copper,[13] aluminum,[9] mild steel,[14] and stainless steel.[18]

There are only three reports dealing with the direct electrochemical polymerization of pyrrole on brass. Tuken et al.[19] reported the electrochemical synthesis of polypyrrole (PPY) coatings on brass from an aqueous oxalic acid solution, and they showed that these coatings have potential to protect brass against corrosion in 0.1*M* H_2SO_4 solution. Bazzaoui et al.[20] synthesized homogeneous and strongly adherent PPY coatings on brass from an aqueous tartrate medium by using cyclic voltammetry. They observed that these coatings provide effective protection to brass against corrosion in 0.1*M* HCl solution. The same group has also synthesized PPY coatings on brass from an aqueous saccharinate solution by using galvanostatic, potentiostatic, and cyclic voltammetric modes.[15] They observed that PPY coatings synthesized from saccharinate solution exhibit significant corrosion protection properties in 3% NaCl and 0.1*M* HCl solutions.

More recently, Chaudhari et al.[21] synthesized the poly(*o*-anisidine) (POA) coatings on brass from an aqueous salicylate solution by using cyclic voltammetry and investigated the corrosion properties of these coatings in an aqueous 3% NaCl. It was shown that the POA coatings have remarkable potential to protect brass against corrosion in chloride environment.

In the work reported in this article, we have electrodeposited adherent POT coatings on brass from an aqueous solution containing *o*-toluidine and sodium salicylate and evaluated the ability of these coatings to serve as corrosion protective coatings on brass. To the best of our knowledge, there are no reports in the literature dealing with the direct deposition of POT coatings on brass from aqueous salicylate medium. The objectives of this study are (a) to find potentially good, low cost, and easily available electrolyte for the electrochemical synthesis of adherent POT coatings on brass; (b) to characterize these coatings by using the electrochemical and spectroscopic techniques, and (c) to examine the possibility of utilizing the POT coatings for corrosion protection of brass in aqueous 3% NaCl.

The choice of *o*-toluidine as the monomer for this study was based on the following (a) The *o*-toluidine

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is a substituted derivative of aniline with methyl (—CH$_3$) group substituted at ortho-position, and therefore, this study explores the possibility of utilizing the POT as an alternative to PANI for corrosion protection of brass; (b) The monomer o-toluidine is commercially available at low cost; (c) The o-toluidine monomer has quite good solubility in water, and therefore, the electrochemical synthesis of POT from aqueous bath may provide an alternative for reducing the use of hazardous chemicals as well as the cost of waste disposal; (d) The conversion of monomer to polymer is straightforward process.

EXPERIMENTAL

Materials

Analytical grade o-toluidine and sodium salicylate (NaC$_7$H$_5$O$_3$) were procured from E. Merck (India). The o-toluidine was doubly distilled before being used for the synthesis, and sodium salicylate was used as-received without further purification. Bi-distilled water was used to prepare all the solutions.

Substrate preparation

Brass substrates (size $\sim$ 10 mm $\times$ 15 mm and 0.5 mm thick) were cut from a piece of brass foil (purity $\sim$ 99.98% and 0.5 mm thick) procured from Goodfellow Corporation. The substrates were polished with a series of emery papers of different grit size (180, 400, 600, 800, and 1200) followed by thorough rinsing in acetone and double distilled water and dried in air. Before any experiment, the substrates were treated as described and freshly used with no further storage.

Electrodeposition of POT on brass

The POT was electrodeposited on brass substrates in an aqueous solution containing 0.1M sodium salicylate and 0.1Mo-toluidine by using cyclic voltammetry. The electrodeposition experiments were carried out using the set-up as described in our previous article.[21] The cyclic voltammetric conditions were maintained using a SI 1280B Solartron Electrochemical Measurement System (UK) controlled by corrosion software (CorrWare, Electrochemistry/Corrosion Software, Scribner Associates Inc. supplied by Solartron, UK).[22] The electrodeposition was carried out by cycling continuously the electrode potential between –1.0 and 1.8 V vs. SCE at a potential scan rate of 0.02 V/s. After deposition, the brass electrode was removed from the electrolyte and rinsed with double distilled water and dried in air.

Characterization of POT deposits

The POT deposits were characterized by cyclic voltammetry, UV–visible absorption spectroscopy, Fourier transform infrared (FTIR) spectroscopy, and scanning electron microscopy (SEM). The FTIR transmission spectrum of the POT in the powder form (compressed KBr pellets) was recorded in the spectral range 4000–400 cm^{-1} using a Perkin Elmer spectrometer (1600 Series II). The UV–visible absorption spectroscopy study was performed with a microprocessor controlled double beam UV–visible spectrophotometer (Model U 2000, Hitachi, Japan). The UV–visible absorption spectrum of POT was recorded ex situ in DMSO solution in the wavelength range 300–1100 nm. The sample was placed in 10 mm quartz cell having inner dimensions of 10 mm in width (optical path), 10 mm in depth, and 45 mm in height. SEM images were recorded with a Leica Cambridge 440 Microscope (Cambridge, England, UK). The adhesion of the coating was determined by the standard sellotape test (TESA-4204 BDF), which consists of cutting the coating into small squares, sticking the tape, and then stripping it. The percentage adherence was calculated by taking the ratio of the number of the remaining adherent coating squares to the total number of the squares. The thickness of the coatings was measured by a conventional magnetic induction based microprocessor controlled coating thickness gauge (Minitest 600, ElectroPhysik, Germany). The error in the thickness measurements was less than 5%.

Evaluation of corrosion protection performance

To evaluate the corrosion protection performance of POT, potentiodynamic polarization and EIS measurements were carried out in an aqueous 3% NaCl solution. The POT-coated brass substrate was encased in a teflon holder to maintain an exposed working area of $\sim$ 40 mm^2 to the solution. The potentiodynamic polarization measurement was performed by sweeping the potential between –0.25 and 0.25 V vs. SCE from open circuit potential (OCP) at the scan rate of 0.002 V/s. A stable open circuit potential was established within 1 h before each measurement. The potentiodynamic polarization curves were analyzed by using Corrview software which performs the Tafel fitting and calculates the values of the corrosion potential (E_{corr}), corrosion current density (j_{corr}), and corrosion rate (CR) in mm per year.[22] All the measurements were repeated at least four times, and good reproducibility of the results was observed. The EIS measurements of the uncoated brass and POT-coated brass were carried out in an aqueous 3% NaCl solution at the OCP with an amplitude of 0.01 V vs. SCE in the frequency range from 0.1 Hz to 20 kHz. The analysis of

impedance spectra was done by fitting the experimental results to equivalent circuits using Z-view software from Scribner Associates.[23] The quality of fitting to equivalent circuit was judged first by the chi-square value (χ^2, i.e., the sum of the square of the differences between theoretical and experimental points) and second by limiting the relative error in the value of each element in the equivalent circuit to 5%.

RESULTS AND DISCUSSION

Cyclic voltammetry results

The electrochemical synthesis of POA coatings on brass in an aqueous salicylate solution has been studied recently by Chaudhari et al.[21] They have shown that the polarization of the brass electrodes by cycling continuously the electrode potential between −1.0 and 1.8 V vs. SCE versus SCE at a potential scan rate of 0.02 V/s in 0.1M aqueous sodium salicylate solution (without monomer) results into the passivation of the electrode surface via the formation of copper oxide, zinc oxide, and salicylate complex. Therefore, in this study, we have made an attempt to electrodeposit the POT on brass in an aqueous salicylate solution by cycling continuously the electrode potential between –1.0 and 1.8 V vs. SCE at a potential scan rate of 0.02 V/s.

The cyclic voltammogram of the first scan recorded during the electrodeposition of the POT on brass in an aqueous solution containing 0.1M sodium salicylate and 0.1M o-toluidine is shown in Figure 1(a). The first positive cycle is characterized by a broad and negligibly small anodic peak A at ∼ 0.232 V vs. SCE and an oxidation peak (B) at ∼ 1.20 V vs. SCE. During
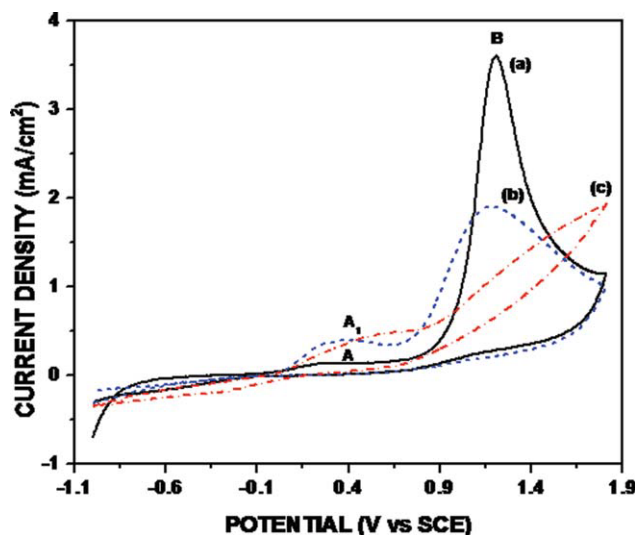

Figure 1 Cyclic voltammograms of (a) first, (b) second, and (c) tenth scan recorded during the electrodeposition of POT on brass. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

the reverse cycle, the anodic current density decreases rapidly and a negligibly small current density is observed until the end of the negative cycle.

In accordance with the results reported by Chaudhari et al.[21] the anodic peak A is attributed to the formation of the passive layer, consisting of copper oxide, zinc oxide, and salicylate complex. This passive layer reduces the further dissolution of brass without preventing the electrochemical polymerization of o-toluidine and allows the deposition of the shiny and smooth POT film. The oxidation peak B corresponds to the oxidation of o-toluidine and formation of radical cations.[7] Thus, the simultaneous brass dissolution and oxidation of o-toluidine is observed during the first scan.

During the second scan [Fig. 1(b)], the anodic peak A corresponding to the dissolution of brass is not observed. However, a new anodic peak A_1 at ∼ 0.348 V vs. SCE is observed, which is assigned to the conversion of amine units into radical cations. The voltammograms of the subsequent scans are identical to that of second scan. However, the current density corresponding to the anodic peaks decreases gradually with the number of scans. The cyclic voltammogram of the tenth scan [Fig. 1(c)] does not show well-defined redox peaks.

The visual inspection of brass electrode after tenth scan reveals the formation of a black colored uniform, shiny, and strongly adherent coating on brass surface. The coating adherence estimated by the standard sellotape was found to be ∼ 100%.

The coating thickness was also estimated by using the equation:

$$d = \frac{QM}{2F\rho} \qquad (1)$$

where Q is the specific overall charge for the electrochemical polymerization, ρ is the density of the POT (1.34 g/cm^3), and M is the molar mass (107.15 g/mol) and F is the Faraday constant (96500 C). The thickness of POT layer (20 scans) calculated by using this equation was found to be ∼ 8 μm, which is fairly in agreement with that measured by using a conventional magnetic induction based microprocessor controlled coating thickness gauge.

FTIR spectroscopy results

The FTIR spectrum of POT electrodeposited on brass recorded in the powder form (compressed KBr pellets) is shown in Figure 2. This spectrum exhibits the following spectral features[24]: (i) the broad band at ∼ 3360 cm^{-1} due to the characteristic N—H stretching vibration suggests the presence of —NH— groups in o-toluidine units; (ii) the band at ∼ 2912 cm^{-1} is associated with the C—H stretching due to
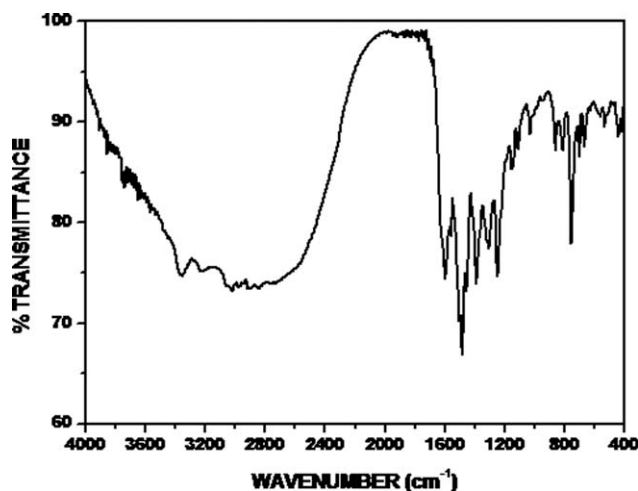
Figure 2 FTIR spectrum of POT electrodeposited on brass.

Figure 3 UV–visible absorption spectrum of POT electrodeposited on brass. (The spectrum was recorded *ex situ* in DMSO solution.)

methylene group; (iii) the band at ~ 1595 cm^{-1} is an indicative of stretching vibrations in quinoid (Q) rings; (iv) the band ~ 1486 cm^{-1} represents the stretching vibrations of the benzoid (B) rings; (v) the presence of the bands at 1245, 1307, and 1387 cm^{-1} are attributed to the C—N stretching vibrations which is consistent with the results reported by Tang et al.[25] who have also observed the similar bands for POT; (vi) the presence of the bands at 1150 and 1025 cm^{-1} reveal the 1–4 substitution on the benzene ring; (vii) the observation of the bands between 800 and 700 cm^{-1} reveal the occurrence of the 1–3 substitutions. Thus, the FTIR spectroscopic study indicates that the electrochemical polymerization of *o*-toluidine has occurred and results into the deposition of POT on the brass surface.

UV–visible absorption spectroscopy result

The UV–visible absorption spectrum of POT electrodeposited on brass is shown in Figure 3. It exhibits a well-defined peak at ~ 560 nm and a shoulder at 740 nm. The absorption peak at 560 nm is attributed to the formation of pernigraniline base (PB) form of POT. The PB is the fully oxidized form of POT, and it is insulating in nature.[26] The presence of the shoulder at ~ 740 nm reveals the formation of emeraldine salt (ES), which is the only electrically conducting form of POT.[26] Thus, the UV–visible absorption spectroscopy study reveals the formation of mixed phase of PB and ES forms of POT.

Surface morphology

The SEM image of the POT electrodeposited on brass is shown in Figure 4(a). The surface morphology of the POT coating is compact, relatively uniform, and featureless.
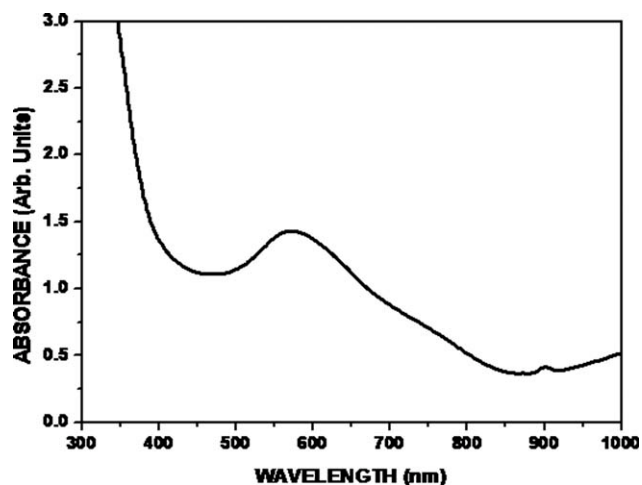
Evaluation of corrosion protection performance

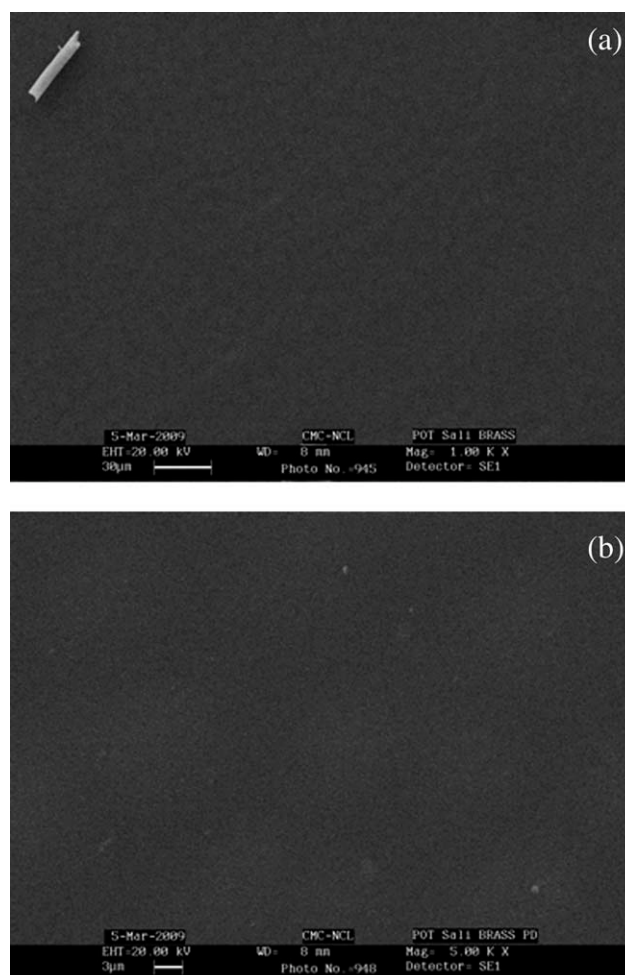The potentiodynamic polarization curves for uncoated brass, polarized brass substrate (in $0.1M$

Figure 4 SEM images of POT-coated brass (a) before and (b) after potentiodynamic polarization measurements.
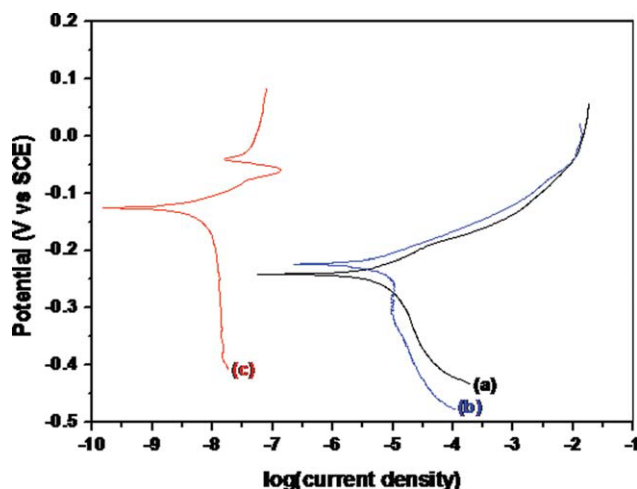
Figure 5 Potentiodynamic polarization curves for (a) uncoated brass, (b) polarized brass substrate in 0.1M aqueous salicylate solution, and (c) POT-coated brass recorded in aqueous 3% NaCl solution. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

sodium salicylate in the potential range between -1.0 and 1.8 V vs. SCE at a scan rate of 0.02 V/s), and POT-coated brass ($\sim$ 8 μm thick) recorded in aqueous 3% NaCl are shown in Figure 5. The values of the E_{corr}, j_{corr}, Tafel constants (β_a and β_c), polarization resistance (R_{pol}), and CR obtained from these curves are given in Table I. The potentiodynamic polarization curve for polarized brass substrate in 0.1M aqueous salicyalte solution is shown in Figure 5(b). Although the E_{corr} is shifted slightly in the positive direction until -0.224 V vs. SCE, the j_{corr} is higher than that observed for uncoated brass. This observation reveals that the passive layer formed at the brass surface provides poor corrosion protection to brass.

The E_{corr} value increases from -0.240 V vs. SCE for uncoated brass to -0.125 V vs. SCE for POT-coated brass. The positive shift of 0.115 V versus SCE in E_{corr} indicates the protection of the brass surface by the POT. Further, the j_{corr} value for POT-coated brass is observed to be $\sim$ 641 times lower than the corresponding values for uncoated brass indicating the corrosion resistant feature of the POT. The CR of POT-coated brass is found to be $\sim$ 0.0001

mm/year which is $\sim$ 800 times lower than that observed for uncoated brass. The protection efficiency (PE) was calculated by using the expression:

$$PE\% = \left[\frac{R_{pol}(coated) - R_{pol}(uncoated)}{R_{pol}(coated)}\right] \times 100 \quad (2)$$

where R_{pol} (uncoated) and R_{pol} (coated) denote the polarization resistances for uncoated and coated brass, respectively. The PE calculated from potentiodynamic polarization data is found to be $\sim$ 99%. It is observed that the CR decreases with an increase in the coating thickness. Thus, it seems that the coating thickness significantly affects the corrosion protection properties of the POT coating.

The porosity in the coating is very important parameter to determine whether a coating is suitable or not to protect the substrate against corrosion. To calculate the porosity in the POT, we have used the relationship[27]:

$$P = \frac{R_{pol}(uncoated)}{R_{pol}(coated)} 10^{-\left(\frac{|\Delta E_{corr}|}{\beta_a}\right)} \quad (3)$$

where P is the total porosity, ΔE_{corr} is the difference between corrosion potentials, and β_a the anodic Tafel slope for uncoated brass substrate. The porosity in POT coating ($\sim$ 8 μm thick) was found to be $\sim$ 6.03 $\times$ 10^{-4} %. Table I also shows the porosity values of the POT coatings. As can be seen, there is a correlation between porosity and thickness of the coating. It is observed that the porosity in the coating decreases with an increase in thickness of the POT coating. The lower values of the porosity in POT coatings permit an improvement of the corrosion resistance by hindering the access of the electrolyte to the brass substrates.

The SEM image of POT-coated brass after the potentiodynamic polarization measurement in aqueous 3% NaCl is shown in Figure 4(b). No apparent change in the surface morphology of POT-coated brass electrodes before [cf. Fig. 4(a)] and after potentiodynamic polarization measurements was observed which reveals its corrosion protective character.

The corrosion behavior of uncoated brass and POT-coated brass was also investigated by EIS. The

TABLE I
Potentiodynamic Polarization Measurement Results

Sample	E_{corr} (V vs. SCE)	j_{corr} (A/cm^2)	β_a (V/dec)	β_c (V/dec)	R_p (Ω cm^2)	CR (mm/yr)	P(%)
Uncoated brass	-0.240	6.60×10^{-6}	0.052	0.182	10.64×10^2	0.08	–
Polarized brass in aqueous salicylate solution	-0.224	9.19×10^{-6}	0.0.54	0.805	9.56×10^2	0.11	5.48×10^1
POT-coated brass (4 μm)	-0.184	1.03×10^{-8}	0.040	0.248	5.80×10^5	0.0001	1.50×10^{-2}
POT-coated brass (5.9 μm)	-0.168	5.89×10^{-8}	0.054	0.556	14.50×10^4	0.0004	3.00×10^{-2}
POT-coated brass (8 μm)	-0.125	1.03×10^{-8}	0.068	1.159	10.83×10^5	0.0001	6.03×10^{-4}

Figure 7 Equivalent circuit used to model the impedance plots in Fig. 6.
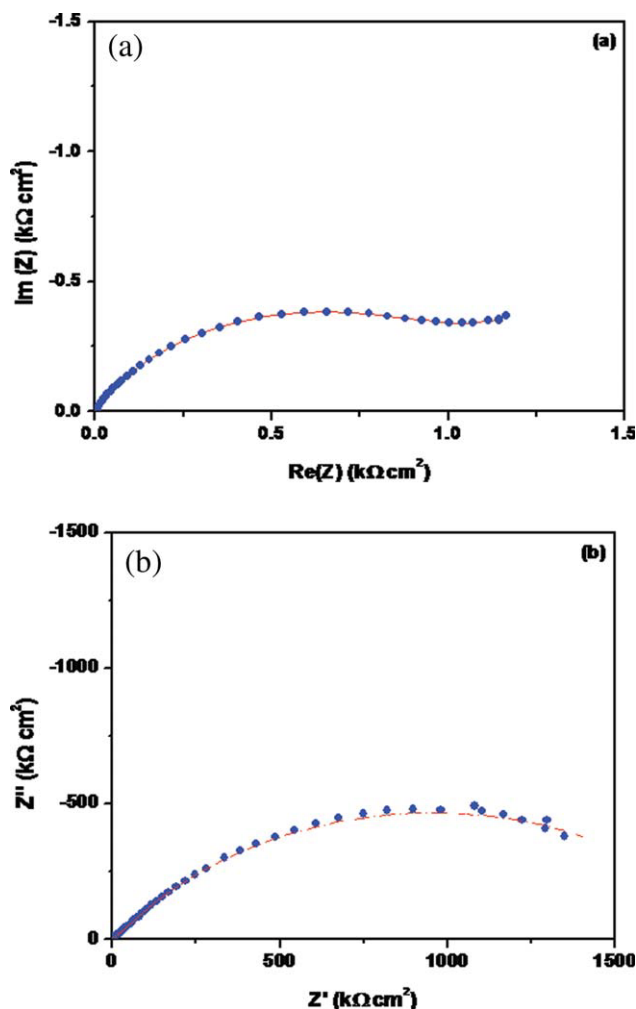

Figure 6 Nyquist impedance plots for (a) uncoated brass and (b) POT-coated brass. [Color figure can be viewed in the online issue, which is available at www.interscience. wiley.com.]

Nyquist impedance plot recorded in an aqueous 3% NaCl for uncoated brass [Fig. 6(a)] was analyzed using an electrical equivalent circuit depicted in the Figure 7. It consists of R_s represents the electrolyte resistance, CPE_c the constant phase element connected with coating capacitance, R_p the coating pore resistance, CPE_p the phase element that represents all the frequency dependent electrochemical phenomena, namely double layer capacitance and diffusion processes, and R_{ct} the charge transfer resistance connected with corrosion processes in the bottom of the pores. The constant phase element, CPE, is intro-
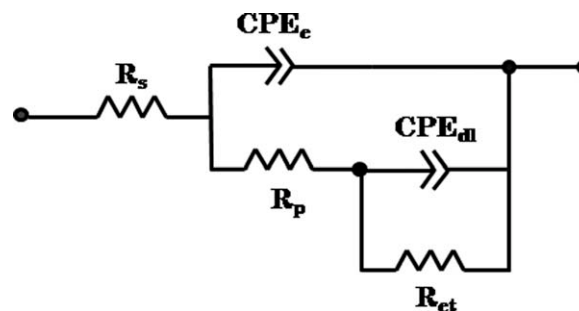
duced in the circuit instead of a pure capacitor to give a more accurate fit. Thus, the Nyquist impedance plot of uncoated brass can be fitted with two semicircles, a smaller one at high frequency range followed by a larger one at lower frequencies. The first semicircle is attributed to the formation of the corrosion film and the second one to the processes occurring underneath the corrosion film. Thus, the impedance plot of uncoated brass is a characteristic of a system undergoing dissolution with the precipitation of a corrosion film at the electrode surface.

The Nyquist impedance plot of POT electrodeposited brass [Fig. 6(b)] is also modeled by using the same equivalent circuit shown in the Figure 7. However, the parameter values of the best fit to the impedance plot are significantly different when compared to those obtained for uncoated brass. The values of the impedance parameters of the best fit to the experimental impedance plots for uncoated brass and POT-coated brass are given in Table II.

In this case, the first capacitive loop is attributed to the characteristics of the POT/electrolyte interface, and it is characterized by the pore resistance (R_p) and the coating capacitance (C_c).[28,29] The second semicircle in the low frequency region is attributed to the POT/brass interface, and it is characterized by the charge transfer resistance (R_{ct}) for the charge transfer reactions occurring at the bottom of the pores in the coating and the double layer capacitance (C_{dl}).[28,29]

The R_p value is significantly higher ($\sim$ 495 times) than that of the uncoated brass. This indicates that the porosity in the POT coating, as already noted, is considerably lower. The R_{ct} value is found to be of the order of 6.14×10^5 Ω cm^2, which is higher than that of the uncoated brass by three orders of

TABLE II
Impedance Parameter Values Extracted from the Fit to the Equivalent Circuit for the Impedance Spectra Recorded in Aqueous 3% NaCl Solution

Sample	R_s (Ω cm^2)	R_p (Ω cm^2)	C_c (F)	n	R_{ct} (Ω cm^2)	C_{dl} (F)	n
Uncoated brass	1.48	5.04	3.00×10^{-5}	0.80	6.10×10^2	2.13×10^{-4}	0.5
POT-coated brass (8μm)	5.70	2.50×10^3	1.15×10^{-8}	0.97	6.14×10^5	2.20×10^{-7}	0.58

magnitude. The higher value of the R_{ct} is attributed to the effective barrier behavior of the POT coating. The lower values of C_c and C_{dl} for the POT-coated brass provide further support for the protection of brass by the POT. Thus, the higher values of R_{ct} and R_p and lower values of C_c and C_{dl} indicate the excellent corrosion performance of the POT coating. The PE was also calculated by using the expression (2) from the EIS data with the $R_{pol} = R_p + R_{ct}$. The PE calculated from EIS data is found to be $\sim$ 99%, which is in fairly agreement with the potentiodynamic polarization results.

As mentioned earlier, other researchers have electrochemically synthesized PPY coatings on brass from an aqueous media and investigated the corrosion protection performance of these coatings in corrosive environments. In these studies, the electrochemical polymerization route was used to synthesize the PPY coatings. As discussed, the POT is a substituted derivative of PANI with methyl (—CH$_3$) group substituted at *ortho*-position. In this study, the POT was electrodeposited on brass to explore the possibility of utilizing it as an alternative to PANI for corrosion protection application. Bazzaoui et al.[20] synthesized the PPY coatings on brass from an aqueous tartrate medium and investigated the corrosion behavior in 0.1M HCl by using DC polarization and weight loss measurements. The DC polarization measurements indicate the positive shift $\sim$ 0.523 V (vs. Ag/AgCl reference electrode) in E_{corr} of the PPY-coated brass and the j_{corr} values are $\sim$ 186 times lower than that of the uncoated brass. These authors concluded that the PPY coating acts as a protective coating on brass against corrosion in 0.1M HCl.

Bazzaoui et al.[15] also reported the electrochemical synthesis of the PPY coatings on brass from an aqueous sodium saccharinate solution. They investigated the corrosion protection performance of PPY-coated brass in 3% NaCl and 0.1M HCl by using DC polarization and EIS. They observed that the similar behavior of PPY-coated brass in aqueous 3% NaCl and 0.1M HCl solutions. Although the remarkable positive shift $\sim$ 0.321 and 0.538 V (vs. Ag/AgCl reference electrode) in E_{corr} of the PPY-coated brass was observed in 3% NaCl and 0.1M HCl, respectively, the j_{corr} values are $\sim$ 4.8 and 1.07 times higher than that of the uncoated brass. They observed that the R_{ct} values of the uncoated brass are greater ($\sim$ 40 and 10 times in 3% NaCl and 0.1 HCl, respectively) than that of the PPY-coated brass. These authors concluded that the PPY coating synthesized on brass from sodium saccharinate solution improve the corrosion resistance of brass.

Tuken et al.[19] also reported the formation of PPY coatings on Cu and brass from an aqueous oxalic acid solution by using cyclic voltammetry. They investigated the corrosion performance of PPY-

coated brass in 0.1M H$_2$SO$_4$ solution by using EIS, anodic polarization, and OCP measurements. They observed that the OCP of PPY coating decreases with the initiation of water up-taking process and after 200 h of exposure, its value was found to be very near to that of the uncoated brass. Also, the j_{corr} value of the PPY-coated brass was $\sim$ 30 times lower than that of the uncoated brass. These authors also performed the long-term immersion experiments and shown that after 170 h of exposure, the zinc content of brass undergoes dissolution and, consequently, lowers the adhesion of the coating.

In this study, the potentiodynamic polarization measurements indicate the positive shift of $\sim$ 0.115 V (vs. SCE) in the E_{corr} of the POT-coated brass and significantly ($\sim$ 640 times) lower j_{corr} values than that of the uncoated brass. The CR of POT-coated brass is found to be $\sim$ 800 times lower than that observed for uncoated brass. The EIS study indicates that the R_{ct} value of POT-coated brass is higher ($\sim$ 1005 times) than that of the uncoated brass. Thus, it is possible to deposit strongly adherent POT coating on brass using sodium salicylate as a supporting electrolyte, and it can be considered as a potential coating material to protect brass against corrosion in aqueous 3% NaCl.

CONCLUSIONS

The POT was successfully electrodeposited on brass in an aqueous salicylate by using cyclic voltammetry. The UV–visible absorption spectroscopy study reveals the formation of mixed phase of PB and ES forms of POT. The FTIR spectroscopic study confirms the electrochemical polymerization of *o*-toluidine, which results into the deposition of POT on the brass. The potentiodynamic polarization and EIS studies indicate that the POT acts as a corrosion protective layer on brass in 3% NaCl. The corrosion rate of POT-coated brass is found to be $\sim$ 800 times lower than that observed for uncoated brass.

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