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The Complex of PASP and Tungstate as Inhibitors of Cupronickel B10's Corrosion in 3% NaCl Solution

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聚天冬氨酸和钨酸钠复配对 3% NaCl溶液中白铜 B10的缓蚀作用

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摘要: 应用交流阻抗法和极化曲线法,研究了两种环境友好型水处理药剂,即聚冬天氨酸(PASP)和钨酸钠的单一配方及其复配对白铜(B10)在 3% NaCl溶液中的缓蚀效果. 研究表明:单一聚冬天氨酸或钨酸钠配方对 B10均具有一定的缓蚀效果,其中聚冬天氨酸以浓度为 40 mg/L,钨酸钠以浓度为 60 mg/L时的缓蚀效果最佳. 总浓度为 40 mg/L的两者复配具有更加明显的缓蚀效果并显示出协同效应,其中以聚冬天氨酸与钨酸钠配比为 3∶1的缓蚀效果最佳.

关键词: 聚天冬氨酸;钨酸钠;白铜 B10;缓蚀剂;交流阻抗

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研发金属缓蚀剂是以高效绿色环保为主要目标. 钨酸盐因其毒性低,对环境、人体和作物几乎没有危害,也不引起微生物滋生,属环境友好型缓蚀剂,已引起人们的广泛兴趣[1-6]. 但单一使用钨酸盐其缓蚀效率还不够高,而且用量较大,对此可利用不同缓蚀剂之复配来提高缓蚀效率. 聚天冬氨酸(PASP)是新近发现的一种绿色水处理药剂[7-8],具有优异的阻垢分散性能和良好的可生物降解性,以其作为阻垢剂方面的研究与应用已受到各方面的重视,但有关它的缓蚀性能研究还不多[9],特别是用于白铜(B10)缓蚀剂的研究国内外还未见报道. 本文试将钨酸钠和聚天冬氨酸这两种环境友好型水处理药剂相结合,初步研究其单一及复合的配方对白铜(B10)在 3 % NaCl溶液中的缓蚀作用,并优化其最佳的缓蚀剂配方.

1 实 验

交流阻抗和极化曲线测试: PAPC M283恒电位仪, PARC 1025频谱分析仪,配套软件为 PARC M398, PARC M352,阻抗测试频率范围 0.05 Hz～100 kHz,激励信号峰值 5 mV. 极化曲线测试扫描速率 1 mV/s.

电极制备: B10电极用环氧树脂密封. 面积 1 cm^2,测量前电极表面经金相砂纸逐级打磨抛光,无水乙醇除油,去离子水冲洗干净后放入电解池. 三电极体系,工作电极为 B10电极;铂电极作辅助电极;参比电极是双液接饱和甘汞电极.

试剂:实验药品均为分析纯,溶液用去离子水配制.

交流阻抗和极化曲线实验均是先将 B10电极浸入含一定浓度缓蚀剂的 3 % NaCl溶液中,经浸泡 1h后再于开路电位下测其阻抗谱图或在给定电位范围内测定极化曲线.

2 结果与讨论

2.1 单一 PASP和 Na_2WO_4对 B10的缓蚀效果

图 1为 B10电极分别浸入含有不同浓度 PASP的 3 % NaCl溶液中经 1 h后测得的 Bode图谱. 鉴于该体系的阻抗谱图均属同一类型,故可根据低频

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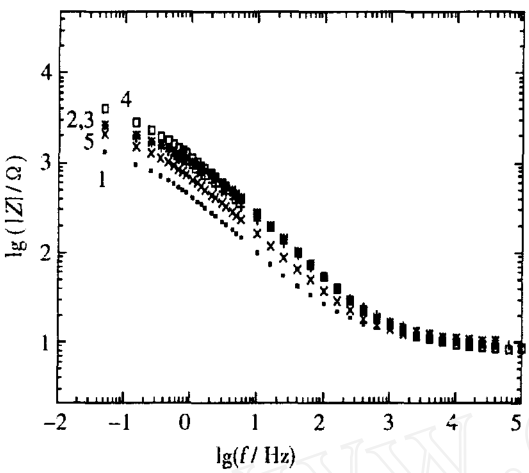

图 1 B10电极分别浸入含有不同浓度 PASP的 3% NaCl溶液中经 1 h后的 Bode图

Fig 1 Bode plots of the B10 electrodes immersed in 3% NaCl solution with different concentrations of PASP

PASP concentration/mg · L^{-1}: 1) Blank, 2) 20, 3) 50, 4) 40, 5) 60

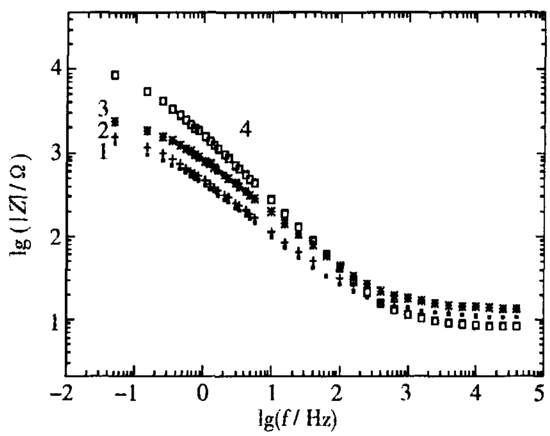

图 2 B10电极分别浸入在含有不同浓度 Na_2WO_4的 3% NaCl溶液中经 1 h后测定的 Bode图谱

Fig 2 Bode plots of the B10 electrodes immersed in 3% NaCl solution after 1 h with different concentrations of Na_2WO_4

Na_2WO_4 concentration/mg · L^{-1}: 1) Blank, 2) 20, 3) 40, 4) 60

阻抗值的高低来判断缓蚀剂性能,即阻抗值越大说明其对金属的缓蚀效果越好[10]. 图 1示出其于低频处显示的阻抗因 PASP浓度的变化而不同,而且含有不同浓度 PASP的各曲线阻抗均比未添加 PASP(曲线 1)的阻抗高,可见 PASP的存在对 B10起到了一定的缓蚀作用,或者说 B10的耐蚀性能增加;增加 PASP的浓度至 40 mg/L时,其对应的阻抗值也明显上升并达到最大,说明此时缓蚀效果最好, B10表现出来的耐蚀性能最佳;继续增加 PASP浓度至 50或 60 mg/L,阻抗值反而有所下降,即 B10耐蚀性能降低,这可能是缓蚀剂的浓度极值现象[11]所引起的.

图 2为 B10电极分别浸入含有不同浓度钨酸钠的 3 % NaCl溶液中经 1h后测得的 Bode图谱. 如图可见,各曲线的变化规律与图 1均相似,当 Na_2WO_4的浓度增至 60 mg/L时,对应的阻抗值明显增大,表明此时的缓蚀效果,从而也是 B10的耐蚀性能较好.

2.2 PASP和钨酸钠复配对 B10的缓蚀效果

以上表明,虽然与不添加缓蚀剂的空白试验相比,单一聚天冬氨酸或单一钨酸钠对 B10的缓蚀性能均有提高,但效果还不臻理想. 为此本文尝试以 PASP与 Na_2WO_4复配 B10缓蚀剂,并参照浓度为 40 mg/L的单一 PASP缓蚀效果最好,选择两者总浓度为 40 mg/L按不同比例进行复配,结果发现,当 [PASP] ∶[Na_2WO_4]以 3 ∶1复配时缓蚀效果最佳. 图 3示出,由复配得到的阻抗值比空白及单一配方的都有明显增加,约大 2个数量级,可见复配对 B10缓蚀作用显著而且具有缓蚀协同效应.

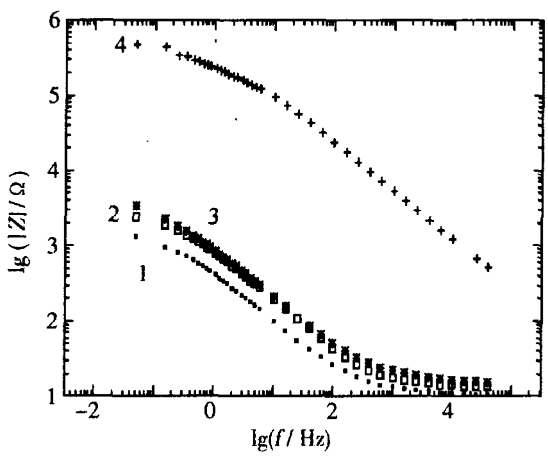

图 3 B10电极浸入在含不同缓蚀剂的 3% NaCl中经 1 h后的 Bode图

Fig 3 Bode plots of the B10 electrodes immersed in 3% NaCl solution after 1 h with various inhibitors

1) Blank, 2) 40 mg/L Na_2WO_4,

3) 40 mg/L PASP,

4) 30 mg/L PASP + 10 mg/L Na_2WO_4

2.3 极化曲线法对 B10缓蚀性能的研究

图 4给出白铜 (B10)电极在含有不同缓蚀剂的 3 % NaCl溶液中经浸泡 1 h后测得的极化曲线. 表 1列出各试验体系的腐蚀电位和腐蚀电流密度. 如表,与空白试验比较,尽管白铜 (B10)在 3 % NaCl溶液中的腐蚀电流于加入 40 mg/L 的 Na_2WO_4或 40 mg/L PASP后均有不同程度的降低,但比起由 30 mg/L PASP + 10 mg/L Na_2WO_4复配的缓蚀剂,后者的腐蚀电流更是大幅度明显降低 (仅为 0.08 μA/cm^2),可见复配对 3 % NaCl溶液中的白铜 (B10)具有明显的缓蚀效果,而且表现出缓蚀协同效应. 这一结果和应用交流阻抗法得出的结论相一致. 另从图 4极化曲线也可看出,聚天冬氨酸及钨酸钠复配后其阴极极化和阳极极化均受到抑制,说明复配缓蚀剂对 B10的作用机理是混合型缓蚀剂. 其中,钨酸钠为阴极型缓蚀剂,聚天冬氨酸为阳极型缓蚀剂.

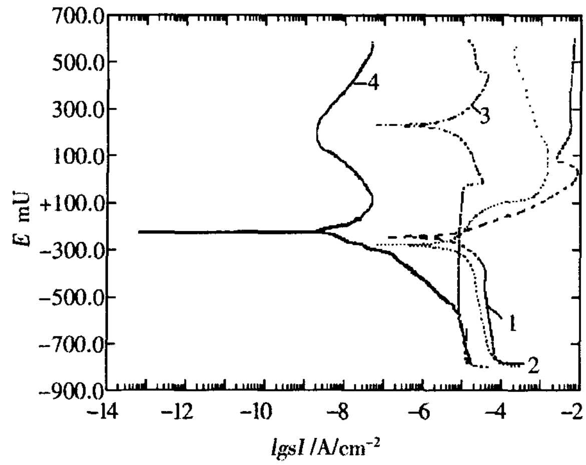

图 4 B10电极浸入在含不同缓蚀剂的 3% NaCl中经 1 h后的极化曲线

Fig 4 Potentiodynamic polarization curves of the B10 electrodes immersed in 3% NaCl solution after 1h with various inhibitors 1) blank, 2) 40 mg/L Na_2WO_4, 3) 40 mg/L PASP, 4) 30 mg/L PASP + 10 mg/L Na_2WO_4

表 1 白铜 (B10)在含不同缓蚀剂的 3% NaCl中浸泡 1 h后的腐蚀电位和腐蚀电流

Tab. 1 Electrochemical parameters of the B10 elestrodes immersed in 3% NaCl solution after 1 h with various inhibitors

inhibitors	E_{corr} /mV	I_{corr} /μA · cm^{-2}
Blank	- 239.8	24.7
[Na_2WO_4] = 40 mg/L	- 291.8	15.1
[PASP] = 40 mg/L	273.4	0.8
30 mg/LPASP + 10 mg/LNa_2WO_4	- 213.6	0.1

4 结　论

1)单一聚冬天氨酸和单一钨酸钠对白铜 (B10)均具有一定的缓蚀效果,其中聚冬天氨酸在浓度为 40 mg/L时,钨酸钠在浓度为 60 mg/L时缓蚀效果最佳.

2)将聚冬天氨酸与钨酸钠以 3 ∶1复配,总浓度为 40 mg/L时,对 B10表现出明显的缓蚀效果且具有缓蚀协同效应.

3)聚冬天氨酸与钨酸钠复配对 B10的缓蚀显示为混合型缓蚀剂.

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The Complex of PASP and Tungstate as Inhibitors of Cupronickel B10's Corrosion in 3% NaCl Solution

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Abstract: AC impedance and polarization curve measurements were conducted to study the effects of environment-friendly inhibitors PASP, Na_2WO_4 and their complexes on the corrosion of cupronickel B10 in 3% NaCl solution. The results indicate that PASP or Na_2WO_4 alone does inhibit the corrosion of B10, and most effective concentrations are 40 mg/L and 60 mg/L for PASP and Na_2WO_4, respectively. With the total concentration of 40mg/L for the complex inhibitors, the optimum complex ratio of PASP to Na_2WO_4 was 3: 1. The complex of such a combination showed a significantly synergetic inhibition effect on the corrosion of B10.

Key words: PASP, Sodium tungstate, B10, Inhibitor, AC impedance