International Jour. Chem.
Vol. 10, No. 2, (2000) 177-181

THE USE OF POLYETHYLENE OXIDE-SODIUM THIOCYANATE COMPLEXES AS CORROSION INHIBITORS FOR ALUMINUM

Abdul Rahim A.Samarkandy, Shaeel A. Al-Thabaiti and **Ali M. Gad**
Chemistry Department, Faculty of Science,
King Abdulaziz University, P.O. Box 80203,
Jeddah 21589, Kingdom of Saudi Arabia

Abstract : The effect of polyethylene oxide (PEO) and its complexes with sodium thiocyanate (NaSCN) on the rate of aluminum corrosion under turbulent flow was investigated. The results showed that PEO-NaSCN complexes were more effective than PEO as corrosion inhibitors for aluminum in HCl solution. The percentage reduction in corrosion was 63.5% for solution containing 200 ppm PEO and increased to 88.92% for 200 ppm PEO-NaSCN (4:1) complex. The percentage reduction in corrosion rate of aluminum was dependent on the flow rate and the concentration of the polymer.

Introduction

Recently a new type of corrosion inhibitors namely, drag reducing polymers, has been developed for combating corrosion of metals under turbulent flow.(1-6) The inhibition mechanism is based on the ability of some high molecular weight polymers to damp turbulent eddies(7,8) at the corroding surface with a consequent increase in the diffusion layer thickness across which transfer of dissolved oxygen or corrosion products take place; this gives rise to a considerable decrease in the rate of metallic corrosion. Also, the damping of turbulent eddies leads to reducing the friction between the turbulently flowing fluid and the metallic surface with a consequent decrease in the power required to move the fluids.(7,8) Most of previous studies on the use of drag reducing polymers as corrosion inhibitors have been conducted using turbulent flow in pipelines(1-5). The aim of this work is to extend the use of drag reducing polymer (PEO) and its complexes as corrosion inhibitors to aluminum wall of agitated vessels.

Experimental

The apparatus used consisted of 250 cm^3 cylindrical glass container of 7.0 cm diameter and 12 cm height. The container was fitted with an impeller of a 4-flat blades paddle type. The diameter of the impeller was 2.2 cm and the distance between the impeller and the tank bottom was fixed at 1.10 cm. The ratio between impeller diameter and tank diameter was 1:3:2. The impeller rotation speed was in the range 0-2200 r.p.m and was measured by a tachometer.

Before each run, the wall of the container was lined with a cylindrical aluminum sheet of 7 cm diameter and 3.5 cm height. The sheet back facing the beaker wall was covered with a thin layer of inert plastic adhesive resistant to acids.

The container was filled with 100 cm^3 of 2M HCl solution. Corrosion of aluminum in HCl was allowed to take place for 30 minutes at different rotation speeds. The rate of corrosion was studied by a weight loss technique. Each run was conducted twice using a fresh solution and the temperature was fixed at 30 ± 1^0C. All chemicals used in this work were A. R. grade.

Corrosion inhibitors

Polyethylene oxide (PEO) (BDH, nominal MW $6x10^5$) and its complexes with NaSCN were used as corrosion inhibitors.

Complexes were prepared by cosolution of PEO and NaSCN in dry acetonitrile. The solvent was removed by rotary evaporation followed by high vacuum pumping for several hours. The concentration of NaSCN is expressed as the molar ratio of monomeric unit to salt {[EO]/[NaSCN] = 16, 8 and 4}. The concentration of NaSCN in the PEO complex was checked by atomic absorption.

IR spectra were recorded for PEO, NaSCN and PEO-NaSCN complexes. The spectrum of the complex showed significant differences as compared with the spectra of PEO and NaSCN. The bands due to stretching vibrations of C-O-C (at 1113 and 1149 cm^{-1} in PEO) were shifted to lower frequency in the complex. The stretching vibrations of C=N (2076 cm^{-1}) and C-S (760 cm^{-1}) bonds of thiocyonate showed frequency changes as a result of complex cormation.(9,10)

For preparation of the solution of PEO or its complexes, the required weight was dissolved in distilled water, left for 24 hours and then mixed with HCl solution to obtain the required concentration.

Results And Discussion

Table–1 shows the effect of addition of PEO on the rate of aluminum corrosion at different rotational speeds. The rate of aluminum corrosion was reduced by 26.7-63.5% depending on the flow rate and polymer concentration, the higher the flow rate and polymer concentration the higher the degree of corrosion inhibition. This decrease in the rate of corrosion can be expressed by the fact that polymer molecules damp the small-scale high eddies existing in the hydrodynamic boundry layer. The increase in the thickness of the hydrodynamic boundary layer and diffusion layer leads to a decrease in the rate of diffusion of HCl molecules to the metal surface. The increase in the corrosion inhibition efficiency of PEO with increasing flow rate is consistent with fhe fact that the drag reducing ability of the polymer increases with flow rate.(3) This may be explained by the increase in the extension of the polymer chain with increasing fluid flow rate which improves the ability of the polymer molecules to damp the eddies. The ability of a given polymer to damp turbulent eddies has been found to be directly proportional to its degree of expansion.(11,14)

Table -1 : Effect of PEO concentration on the percentage reduction in the rate of aluminum corrosion at different rotational speeds

Reynolds Number	% reduction in corrosion rate		
	50 ppm	**100 ppm**	**200 ppm**
9,530	32.24	39.5	47.5
16,220	31.74	38.0	46.91
30,250	26.70	42.1	47.83
37,882	33.71	44.0	48.78
71,280	37.45	54.12	63.50

The highest percentage reduction in the rate of aluminum corrosion was obtained using 200 ppm PEO, therefore this concentration was used to investigate the effect of different ratios of Na SCN on PEO complexes.

Table - 2: Effect of PEO -NaSCN complexes on the percentage reduction in the rate of aluminum corrosion at different rotational speeds (concentration of the complex=200ppm)

Reynolds Number	% reduction in corrosion rate		
	EO/NaSCN		
	16 : 1	**8 : 1**	**4 : 1**
9,530	26.82	45.20	72.69
16,220	32.92	56.53	79.39
30,250	27.65	61.32	80.52
37,882	33.89	67.95	78.0
71,280	34.20	81.24	88.92

Table-2 shows the effect of PEO complexes ([EO]/[NaSCN] = 16,8 and 4) on the rate of aluminum corrosion. It has been shown that the rate of aluminum corrosion in HCl was reduced by 26.82-88.92% depending on the flow rate, and ratio of salt/PEO. As the flow rate and salt/PEO ratio increased, the degree of corrosion inhibition increased. The highest percentage reduction in the rate of aluminum corrosion weas achieved using PEO-NaSCN(4:1) complex.

This may be explained on the basis that the high ratio of NaSCN in the complex will increase the electrostatic repulsion between associated Na^+ ions along the polymer chain, which will increase the degree of expansion of PEO and hence the degree of corrosion inhibition.

Table –3 shows the effect of different concentrations of PEO-NaSCN (4:1) complex on the rate of aluminum corrosion. The results showed that the percentage reduction in corrosion of aluminum increased with increasing the concentration of PEO-NaSCN (4:1) complex.

Table - 3 : Effect of concentration of PEO -NaSCN (4:1) complex on the percentage reduction in the rate of aluminum corrosion at different rotational speeds

Reynolds Number	% reduction in corrosion rate		
	50 ppm	100 ppm	200 ppm
9,530	61.32	69.73	72.69
16,220	60.30	65.50	79.39
30,250	62.87	73.61	80.52
37,882	70.92	75.53	78.0
71,280	72.43	76.43	88.92

The inhibition effect of PEO-NaSCN complex on aluminum corrosion was more significant than the inhibition effect of PEO. Parker et al.(15) studied the conformation of PEO-NaSCN complex and proposed a double helical model. They proposed that Na^+ ions are incorporated within the space between the double helix of the PEO whereas SCN anions are found outside PEO double helix. On the basis of the above mentioned model, the inhibition effect of PEO-NaSCN complexes on the aluminum corrosion in HCl can be attributed to the adsoption of SCN anions on the surface of aluminum and isolating it from the corrosive media as well as the effect of PEO on damping the formed eddies.(16-20)

REFERENCES

1. G.H. Sedahmed, M.N. Soliman and N.S. El-kholy, : J.Appl.Electrochem,12,(1982),479.
2. G.H. Sedahmed, B.A. Abd El-Nabey and A. Abdel-Khalik, : Corrosion Science, 17,(1977),365.
3. G.H. Sedahmed, M.S. Abdo, H.A. Farag and S.G. Tantawy, : Surface Technology, 9,(1979), 359.
4. G.H. Sedahmed and M.A. Fawzy, : Br. Corr. J., 21, (1986),225.
5. G.H. Sedahmed, B.A. Abdel Naby and S.G. Tantawy, : Br. Corrs. J., 25,(1990),205.
6. E.M. Moawed, : M.Sc. Thesis, Institute of Graduate Studies & Reserch, Alex. Univ, (1993)
7. R.H. Sellin, : J.Hydraulic Res., 20, (1982),235.
8. R.H. Sellin, J.W. Hoyt, J.Pollert and O, Scirvener, : J. Hydraulic Res., 20, (1982), 235.
9. K. Nakamoto : "Infrared spectra of inorganic and coordination compounds" John Wiley and Sons, N. Y. (1970).
10. E.A. Bektrov, S.E. kudaibergenov, Z. Kh. Bakauova, V. Zh. Ushanov and G.S.Kanapyanova, : Polymer communications, 26, (1985), 81.
11. D. White and R.J. Gordon, : AlChE. J., 21, (1975), 1027
12. R.C. Little and R.L. patterson, : J. Appl. polym, Sci., 18, (1974) 1529.
13. R.C. Little, : Nature, 242,(1973), 79.
14. V.R. Rande and J.J. Ulbrecht, : AlChE. J., 24, (1978), 796.
15. J.M. Parker, P.V. Wright and C.C. Lee, : Polymer communications, 22,(1981),1305.
16. R.C. Little, : Ind. Eng. Chem. Fundam. 8, (1969), 557.
17. R.C. Little, R.J. Hansen, D.L. Hunston, O.K.Kim, R.L. patterson and R.Y. Ting : Ind. Eng, Chem., 14,(1975),283,
18. A.Gyr and A. Mueller, : Chem. Eng. Sci., 29, (1974) 1057,
19. J.W. Hoyt, : J. Basic Eng., 94, (1972), 258.
20. P.S. Virk, : AlChE, J., 21, (1975), 625.