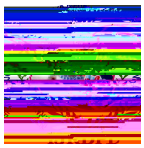

International Journal of Research and Development in Pharmacy and Life Sciences
Available online at http//www.ijrdpl.com
December - January

influenced corrosion is emerging as a serious problem in cooling systems. Literature survey has exposed a number of biocides used along with corrosion inhibitors. Rajendran et al. [3,4] have studied the influence of CTAB on the corrosion inhibition of mild steel by ATMP-Zn2+ system, and also the biocidal efficiency of CTAB in the presence of various phosphonic- Zn2+ system and reported that CTAB acts as an excellent biocide as monomer and also as micelle. It is reported that most of the biofilms are sensitive to the detergent biocide SDS [5,6]. Iwalokun et al. [7] have suggested to use urea and SDS in the laboratory to reduce the risk of infection with virulent proteus strains. Richard et al. [8] have investigated the effect of the surfactants such as alcohol ethoxylates, amine ethoxylates, amine oxide and SDS on bacterial cell membranes using EPR spectroscopy.

The purpose of the present investigation is (i) to assess the biocidal efficiency of SDS in chloride ion solution in the presence and absence of the inhibitor systems. (ii) to examine the influence the biocide on the inhibition efficiency of inhibitor systems such as CMC–Zn2|+ and PVA–Zn2|+.

Carbon steel specimens (compositions 0.1% C, 0.026% S, 0.06% P, 0.4% Mn and balance Fe) of dimensions 1.0 × 4.0 × 0.2 cm were polished to mirror finish, degreased with trichloroethylene and used for mass-loss studies. Carbon steel specimens in duplicate were immersed in 100 ml of the solutions containing various concentrations of the inhibitor systems in the absence and presence of SDS for one day. The weight of the specimens before and after immersion were determined, using a ACCULAB Electronic top loading balance, with readability/sensitivity of 0.1 mg in 210 g range. The IE was then calculated.

Stock solutions of sodium chloride, carboxy methyl cellulose (CMC), poly vinyl alcohol (PVA) were prepared by dissolving 1 g of the respective compounds in double distilled water and made up to 100 ml. Zinc sulphate solution is prepared by dissolving 1.1 g in double distilled water and made up to 250 ml in a 250 ml standard measuring flask. Zobell medium was prepared by dissolving 5 g of peptone, 1 g of yeast extract, 0.1 g of potassium dihydrogen phosphate and 15 g of agar–agar in 1 litre of double distilled water. The medium was sterilized by applying 15 pounds per square inch for 15 minutes in an autoclave.

The biocidal efficiencies of SDS at various concentrations in the presence and absence of the inhibitor systems 1 (CMC–Zn2+) and 2 (PVA–Zn2+) were determined after immersing the specimens for one day in 120 ppm chloride solution. Polymer systems such as CMC–Zn2+ and PVA–Zn2+ formulations that offered the best corrosion inhibition efficiency were selected. After one day, 1 ml each of test solutions from the environments was pipetted out into sterile petri dishes each containing about 20 ml of the sterilized Zobell medium. The petri dishes were then kept in a sterilized environment inside the laminar flow system fabricated and supplied by CEERI-Pilani, for 48 h. The total viable heterotropic bacterial colonies were counted using a bacterial colony counter.

It is noted from Table 1 that increase in the concentration of Zn2+ alone, increases the IE for the corrosion of carbon steel in 120 ppm Cl- ion solution and it is found that 100 ppm of Zn2+ offers 40% inhibition efficiency. It is also noted that CMC itself is a very poor inhibitor and 250 ppm of CMC gives a maximum of 6% IE. Perusal of the table reveals that a combination of Zn2+ and CMC shows a better IE. For example, 100 ppm of Zn2+ gives an IE of 40% and 250 ppm of CMC gives 6%, but their combination offers an IE of 97%, which is found to be the maximum IE offered by the system. This suggests the existence of synergistic effect between Zn2+ and CMC. The synergism may be due to the formation of complex between Zn2+ and CMC. Due to the complex formation the inhibitor molecules are readily transported from the bulk to the metal surface.

Table 2 points out that the IE of carbon steel immersed in Zn2+ increases with an increase in the concentration of Zn2+ ions and offers 40% IE for 100 ppm of Zn2+. It is clear from the table that the IE of 50 ppm PVA is 16% and the IE is found to increase marginally with the increase in the concentration of PVA and reaches a maximum of 22%. However, perusal of Table 2 reveals that the combination of both shows a better IE. For example, carbon steel immersed in 300 ppm of PVA offers 22% IE and 75 ppm of Zn2+ solution gives 30% while the combination of 300 ppm of PVA and 75 ppm of Zn2+ gives 80%. This is found to be the maximum IE offered by the system. This clearly suggests that Zn2+ and PVA mutually enhance the inhibition efficiency of

each other in controlling the corrosion of carbon steel.

Table 3 shows that IE of the inhibitor formulation 1 (CMC + Zn2+) slightly decreases on the addition of 50 ppm of SDS. However, further addition of SDS increases the IE of the system and at 150 ppm of SDS, a maximum IE of 98% is achieved. The decrease in IE at lower concentration of SDS may be due to the competition between SDS and CMC for Zn2+ ions. As CMC + Zn2+ is a better inhibitor formulation than SDS + Zn2+ that is evident from Table 1, the IE of the CMC + Zn2+ system decreases for want of Zn2+ ions. However, at higher concentration of SDS, synergistic behaviour is noticed. This may be due to the co-participation of both CMC and SDS in complex formation with Zn2+ that enhances the IE. Hence it is concluded that the lower concentration of SDS exhibits antagonistic behavior and higher concentrations of SDS shows synergistic behavior with CMC + Zn2+ system. For the formulation 2 (PVA-Zn2+ system) the addition of SDS decreases the IE tremendously.

%-2(V-30(A34(n)31(p)45C14Tfm 0 [(T)6(h)6(i)-9(s)3( )-512a)19(ry81 0 0 1 ([(i)-9.76 1)6(i)-9(gb81 0 0 1 198.7(T)6(h)6(i)-9(s)3( )-512a)19(t)17( )-53(b)198

biocidal efficiency is achieved. Even though SDS has biocidal effect with PVA + Zn2+ system, as the IE is drastically reduced on the addition of SDS, it is not suitable biocide for PVA + Zn2+ system. But the inhibitor formulation CMC- Zn2+ gives 42% biocidal efficiency in the absence of SDS. But the addition of SDS to this inhibitor formulation completely eradicates the microbes. Interestingly, the same formulation with SDS offers a maximum inhibition efficiency of 98%. Therefore CMC-SDS-Zn2+ system is ideal for cooling water system for the control corrosion as well as microbial growth.

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How to cite your article:
Yamuna J., Antony N., "Role of SDS as corrosion inhibitor and biocide in polymers - Zn^{2+} system in aqueous solution", Int. J. Res. Dev. Pharm. L. Sci., 2015, 4(1), pp. 1357-1361.

