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Research Article

BIOCIDAL EFFICIENCY OF CORROSION INHIBITORS

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ABSTRACT

Cooling water systems are extremely vulnerable to microbial contamination. Problems occur when microbes begin to proliferate and attach to system surfaces.Corrosion can also result from unchecked microbial growth. Microorganisms such as bacteria, fungi and algae can combine with organic compounds to form biofilms. The microbes in these films produce products of metabolism that are corrosive in nature. The result is pitting and corrosion of metal components.To eliminate the threat of such potential problems and achieve optimum system efficiency, microbiological activity within a system must be properly controlled. Surfactants are normally added to control microbial activity. This paper is concerned with the comparative study of biocidal efficiencies of CTAB, CPC and SDS in the presence of the inhibitor oxalic acid in carbon steel.

Keywords: Biocide, Biofilm, carbon steel, CTAB (N-cetyl-N,N,N-trimethyl ammonium bromide), CPC (cetylpyridinium chloride). SDS (sodium dodecyl sulphate).

INTRODUCTION

Microbial life affects everything including many industrial processes. The nature and activity of microorganismsdeterminewhethertheirpresenceisbeneficialordestructive.In cooling towers, the destructive capability of these organisms is manifested. The microorganisms that inhibit industrial cooling water systems can adversely affect the efficiency of the operation by their sheer number and diversity, metabolic wastes or deposits and associated corrosion. Microbiologically influenced corrosion is emerging as a serious problem in cooling systems. MicroorganisM such as bacteria, fungi and algae can combine with organic compounds to form bio films. The microbes in these films produce products of metabolism that are corrosive in nature. The result is pitting and corrosion of metal components. To eliminate the threat of such potential problems and achieve optimum system efficiency, microbiological activity within a system must be properly controlled by the addition of suitable biocides.

Most industries are adding inhibitors and biocides at the same point in cooling water systems. The interference between biocides and inhibitors were studied in detail and many researchers evaluated the role of biocides in corrosion in the presence of inhibitors [1]. Many studies are in progress with the development of new bio dispersing antifouling compositions for recirculating cooling water system [2].

N. Muthukumar et al [3] studied the Biodegradation that occurs in the diesel/water interface in petroleum product pipelines. Selection of the biocide/inhibitor plays an important role in the transportation of petroleum products through pipelines. Three biocides (cationic and nonionic) were employed to study the biodegradation in a diesel-water interface. Bronopol (2-bromo-2-nitro-propane-1, 3-diol) was found to have higher bactericidal efficiency than N-cetyl-N,N, N-trimethyl ammonium bromide (CTAB) and cetylpyridinum bromide (CPB). But the cationic biocides (CTAB and CPB) showed good biocidal efficiency at the interface. The data are explained in terms of a model that postulates the formation of a 'micelle' at the diesel-water interface. Rajendran et al [4,5]have studied the influence ofCTAB on the corrosion inhibition of mild steel by ATMP-Zn2+ system, and also the biocidal efficiencyof CTAB in the presence of various phosphonic- Znsystem and reported that CTAB acts as an excellent biocide as monomer and also as micelle. Manimegalai et al [6] have examined the inhibitive property as well as the biocidal properties of the leaf extracts of Azadiracta Indica and reported that the inhibitor has very effective biocidal property as well as inhibitive property for mild steel in fresh water environment. Stefanova [7] has studied the biocidal efficiency of cetylpyridinium bromide (CPB), potassium permanganate and sodium benzoate. He has reported that the CPB has a wide range of effect for microorganisms typical for water media. Linetal [8] have reported that CPC, a quaternary ammonium salt and a cationic surfactant has been used as a biocide in personal hygiene products. It is reported that CPC acts as an antifungal agent [9], and as a biocide [10] for cosmetics, toiletries and pharmaceuticals activity.

The purpose of the present study is to compare the biocidal efficiencies of CTAB, CPC, and SDS in the presence of the inhibitor system.

EXPERIMENTAL

Preparation of the carbon steel specimens

Carbon steel specimens (0.1 per cent C, 0.026 percent S, 0.06 percent P, 0.4 percent Mn and the balance Fe) of the dimensions 1.0×4.0 ×0.2 cm were polished to mirror finish, degreased with trichloroethylene.

Preparation of inhibitor and biocide solutions

Stock solutions of Oxalic acid and biocides 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

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 liter of double distilled water. The medium was sterilized by applying 15 pounds per square inch for 15 minutes in an autoclave.

Influence of surfactants [CTAB, CPC and SDS] on the IE of OA + Zn2+ system

The corrosion rates of carbon steel in ground water containing Zn2+ + OA inhibitor formulation for various concentrations of surfactants (CTAB, CPC, and SDS) are tabulated in Table A.

Determination of biocidal efficiency of the system:

Inhibitor + Zn2+ formulation that offered the best corrosion inhibition efficiency was selected. The biocidal efficiency of N- cetyl –N, N, N-trimethyl ammonium bromide (CTAB), N-cetylpyridinium chloride (CPC) and sodium dodecyl sulphate (SDS) in the presence and absence of these formulations and also the effect of CTAB, CPC and SDS on the corrosion inhibition efficiency of these systems were determined. Various concentrations of CTAB, CPC and SDS namely 10 ppm, 25 ppm 50 ppm 100 ppm 150 ppm were added to the formulation consisting of the inhibitor system. Polished and degreased carbon steel specimens in duplicate were immersed in these environments for a period of 72 hours. After 72 hours one ml each of test solutions from the environments was pipetted out into sterile Petri dishes containing about 20 ml of the sterilized Zobell medium kept in a sterilized environment inside the laminar flow system fabricated and supplied by CEERI- Pilani. The Petri dishes were then kept for 48 hours. The total viable heterotrophic bacterial colonies were counted using a bacterial colony counter.

Biocidal efficiencies of biocides in ground water

The biocidal efficiencies (BE) of CTAB[11,12], CPC[13]& SDS[14,15]in the presence and absence of inhibitor formulations in ground water after suspending the metal pieces for 72 hours are given in Table – 1,2 & 3. The visuals of the bacterial colonies formed in river water in the presence and absence of the inhibitor system are shown in Figure1-6.

The analysis of the Table –1 shows that in the absence of inhibitor formulation, 50 ppm of CTAB is sufficient to achieve 100 % BE and in the absence of CTAB, the Zn2+/OA formulation offers 99.48 % BE. The addition of 10 or 25 ppm of CTAB to the ground water in the presence of inhibitor formulation decreases the BE due to the precipitation of CTAB by oxalic acid, 50 ppm of CTAB gives 100 % BE and also addition of CTAB, reduces the IE drastically and hence it is inferred that CTAB is not a good additive as biocide for the Zn2+/OA formulation.

Table: A Corrosion rates of carbon steel in ground water containing Zn^{2+} + OA inhibitor formulation for various concentrations of surfactants (CTAB, CPC, and SDS)

Biocides	CTAB		CPC		SDS	
	CR	IE %	CR	IE %	CR	IE %
0	0.42	98	0.42	98	0.42	98
50	18.59	18	14.06	38	1.99	91
100	17.36	23	13.96	38	2.47	89
150	15.64	31	13.60	40	2.11	91
200	12.92	43	13.32	41	2.17	90
250	15.42	32	12.96	43	2.10	91
300	18.39	19	12.75	44	2.15	91

Table 1: Biocidal efficiencies of CTAB in the presence and absence of OA + Zn^{2+} system in ground water.

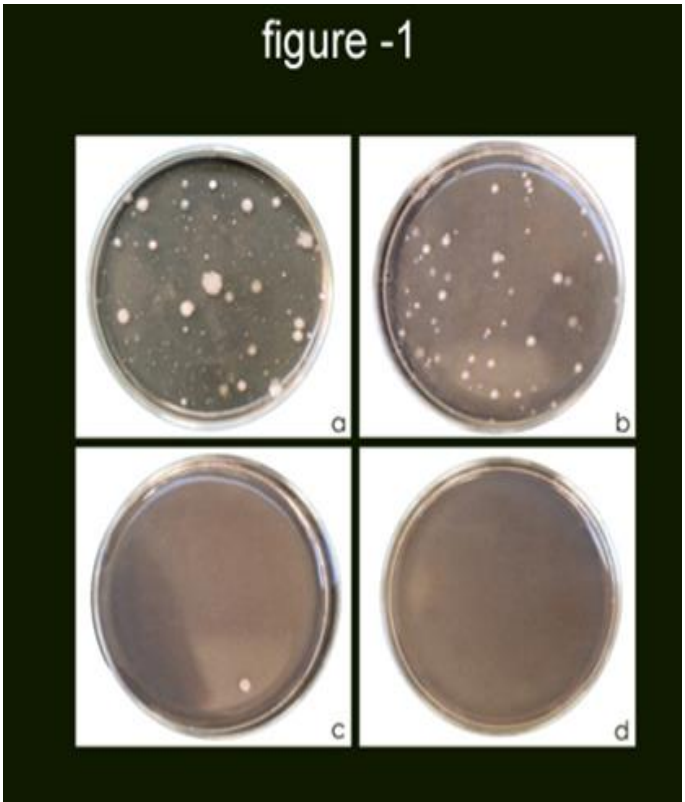
S. No	Oxalic acid, ppm	Zn^{2+}, ppm	CTAB, ppm	Colony Forming units/ml	Biocidal Efficiency, %
1	0	0	0	773	-
2	0	0	10	64	91.72
3	0	0	25	1	99.87
4	0	0	50	0	100
5	40	25	0	4	99.48
6	40	25	10	98	87.32
7	40	25	25	10	98.71
8	40	25	50	0	100
9	40	25	100	0	100

Table 2: Biocidal efficiencies of CPC in the presence and absence ofOA + Zn^{2+} system in ground water

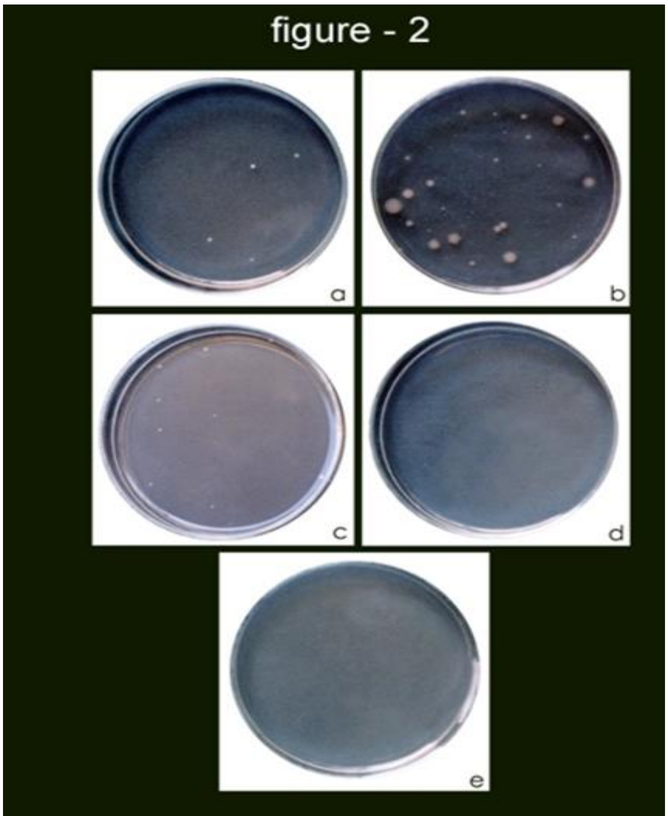
S. No	Oxalic acid, ppm	Zn^{2+}, ppm	CPC, ppm	Colony Forming units/ml	Biocidal Efficiency, %
1	0	0	0	773	-
2	0	0	10	3	99.61
3	0	0	25	0	100
4	0	0	50	0	100
5	40	25	0	4	99.48
6	40	25	10	4	99.48
7	40	25	25	1	99.87
8	40	25	50	0	100
9	40	25	100	0	100

Table 3: Biocidal efficiencies of SDS in the presence and absence of OA + Zn2+ system in ground water.

S.No	Oxalic acid, ppm	Zn^{2+}, ppm	SDS , ppm	Colony Forming units/ml	Biocidal Efficiency, %
1	0	0	0	773	-
2	0	0	10	680	12
3	0	0	50	72	90.68
4	0	0	100	2	99.74
5	40	25	150	0	100
6	40	25	0	4	99.48
7	40	25	50	23	97.02
8	40	25	100	2	99.74
9	40	25	150	0	100
10	40	25	200	0	100

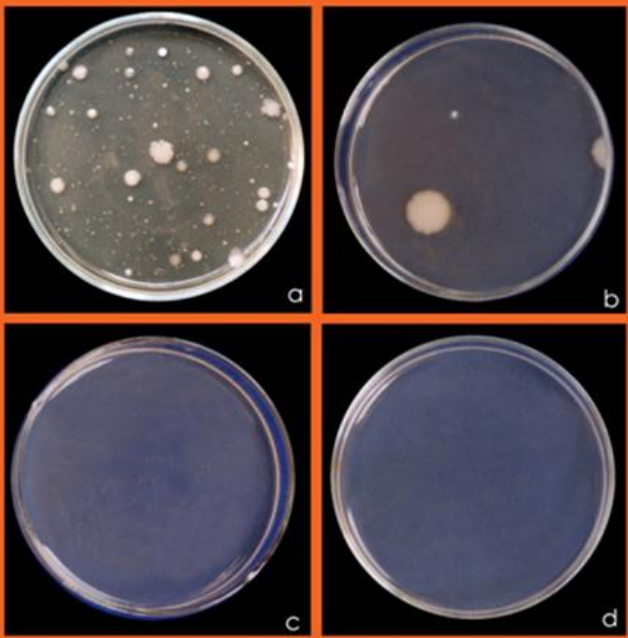


Bacterial colonies formed in ground water in the presence of various concentrations of CTAB
a) 0 ppm b) 10 ppm c) 25 ppm d) 50 ppm



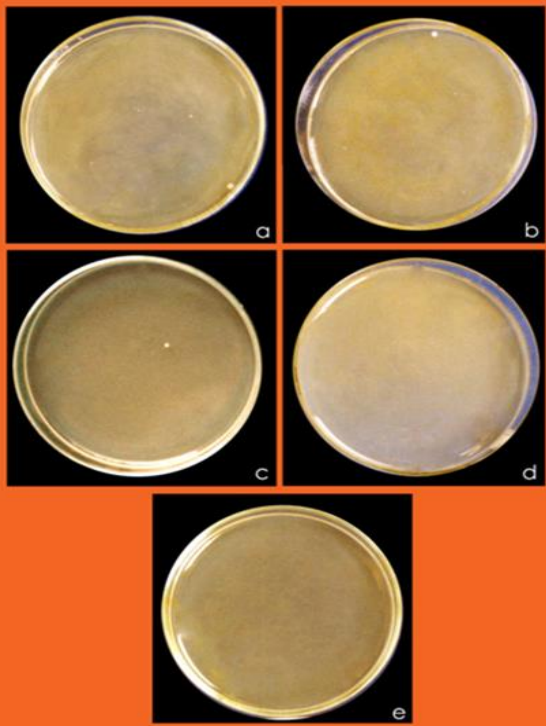
Bacterial colonies formed in ground water containing 25 ppm of Zn^{2+} and 40 ppm of oxalic acid in the presence of various concentrations of CTAB
a) 0 ppm b) 10 ppm c) 25 ppm d) 50 ppm

figure - 3



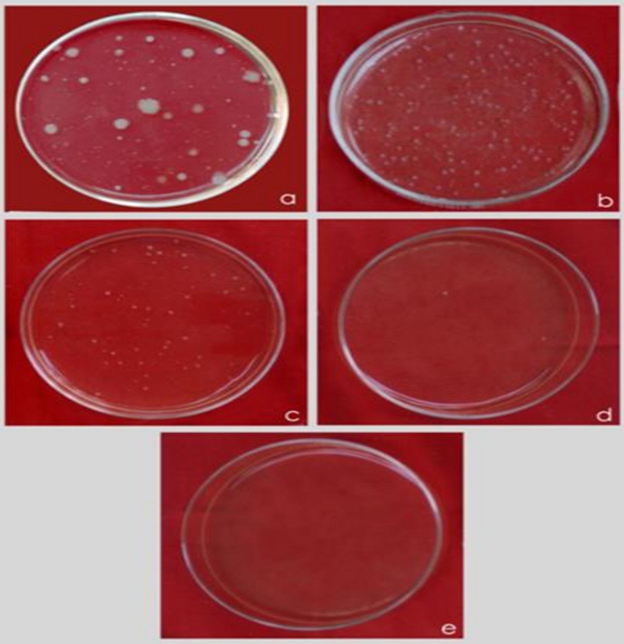
Bacterial colonies formed in ground water in the presence of various concentrations of CPC
a) 0 ppm b) 10 ppm c) 25 ppm d) 50 ppm

figure - 4



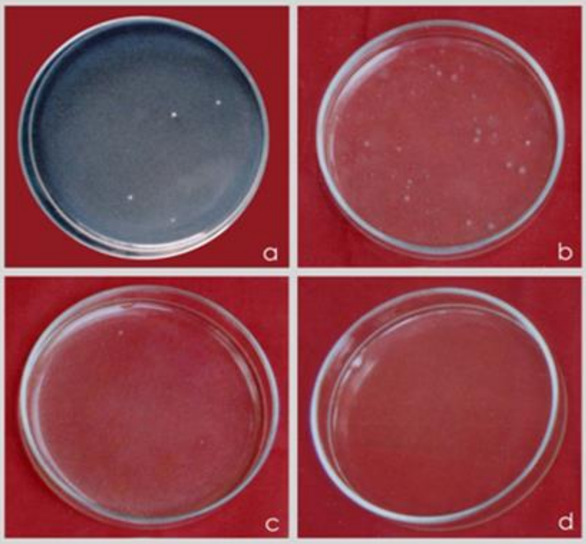
Bacterial colonies formed in ground water containing 25 ppm of Zn^{2+} and 40 ppm of oxalic acid in the presence of various concentrations of CPC
a) 0 ppm b) 10 ppm c) 25 ppm d) 50 ppm e) 100 ppm

figure - 5



Bacterial colonies formed in ground water in the presence of various concentrations of SDS
a)0 ppm b)10 ppm c)50 ppm d)100 ppm e)150 ppm

figure - 6



Bacterial colonies formed in ground water containing 25 ppm of Zn^{2+} and 40 ppm of oxalic acid in the presence of various concentrations of SDS
a) 0 ppm b) 50 ppm c) 100 ppm d) 150 ppm

The analysis of the Table –2 shows that in the absence of inhibitor formulation, 25 ppm of CPC is sufficient to achieve 100 % BE and in the absence of CPC, the Zn2+/OA formulation offers 99.48 % BE. However, the addition of 25 ppm of CPC to the ground water in the presence of inhibitor formulation does not give 100 % BE. This is due to the precipitation of CPC by oxalic acid. Hence a higher concentration of CPC is required to achieve 100 % BE. Also as a steep fall in the IE is observed on the addition of CPC, it is concluded that CPC is not compatible with the inhibitor Zn2+/OA formulation.

Table-3 shows that 150 ppm of SDS in the presence and absence of the inhibitor system controls the microbial activity in ground water. As addition of SDS is not affecting the corrosion inhibition efficiency much, SDS is a suitable biocide for the corrosion and microbial growth control in ground water.

CONCLUSION

Among the three biocides (CTAB, CPC and SDS) tested for ground water in the presence and absence of the inhibitor system,biocidal action is maximum for CPC. A concentration as low as 25 ppm of CPC completely eradicates microbial growth in ground water in the absence of the inhibitor system and 50 ppm is needed in the presence of the inhibitor system.Biocidal action is minimum for SDS. A concentration of 150 ppm of SDS is required to give 100 % biocidal efficiency in the presence and absence of the inhibitor system.50 ppm of CTAB is required to arrest microbial growth in ground water in the presence and absence of the inhibitor system. The corrosion inhibition of inhibitor system is drastically reduced on the addition of CTAB and CPC. However the corrosion inhibition efficiency of oxalic acid-Zn2+ is only slightly reduced by the addition of SDS.Along with the inhibitor combination, 50ppm of CTAB offers 18 %IE and 100% BE and 50ppm of CPC offers 38% IE and 100% BE and whereas 150ppm of SDS offers maximum of 91% IE and 100% BE. Hence it is concluded that SDS is the most suitable biocide for corrosion inhibition of carbon steel in ground water in the presence of the inhibitor combination Zn2+ and oxalic acid.

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