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CORROSION INHIBITION STUDY OF (4-METHOXYBENZYL)-TRIPHENYLPHOSPHONIUM BROMIDE ON CARBON STEEL IN DILUTED SULPHURIC ACID BY GRAVIMETRIC ANALYSIS

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Abstract:
A quaternary phosphonium compound named (4-Methoxybenzyl)-triphenylphosphonium Bromide (MBTPPB) has been positioned to be an efficient inhibitor of carbon steel (CS) corrosion in 0.5 M H_2SO_4 using the weight loss method. It has been discovered that improving inhibitor concentration leads to an increase in inhibition overall performance, whilst improving temperature leads to the reverse pattern. At concentrations (10^{-2}M) at 298 K, the inhibitor had a satisfactory overall inhibition performance of 98.32%, and at recognition (10^{-5}M) at the satisfactory temperature of 328 K, the inhibitor had the lowest overall inhibition performance of

39.76 percent. On a satisfactory recognition of 10^{-2} M, maximum protection is set at 298 K, while the least coverage is set at 328 K on the lowest recognition of 10^{-5} M.

Keywords: Phosphonium compounds; mild steel; weight-loss method; acidic media; corrosion inhibition

Introduction:

Corrosion is the unwanted loss of materials whilst it's lots uncovered to its surrounding environment [1]. It has been considered to be a tough engineering technology trouble from historical times, however, the issue has grown exponentially withinside the modern world era, as the use of metals has elevated to a bigger volume during current times [2-5]. Corrosion failure economy of national/ international scenes is as an enormous percentage in their GDP (GDP). According to media reports, the value of corrosion to the Indian economic system is about 6-7 % of its GDP almost every year [6]. As a result, precise techniques are required to address this one-of-a-serious type trouble, which could in any other case pass unnoticed. The difficulty isn't restricted to specific industries or sectors; rather, it influences nearly every zone and industry, with chemical transportation, automobiles, and maritime being the maximum affected.

Because corrosion is a persistent phenomenon, the intention is to maintain it to the lowest level. Metals/alloys are the spines of any industry, and structural failure can motivate vast operational issues. Carbon steel is the extremely used steel withinside the production of commercial systems because of its extended strength. However, because of the style of corrosive environments, moderate metal suffers from a whole lot of corrosion problems. The technique of putting off-scale/corrosion merchandise from steel surfaces is referred to as acid cleansing or descaling. Because of their low cost, sulfuric acid and hydrochloric acid are first-class alternatives for acid cleansing. Because of the excessive corrosiveness of these acids, the steel is prone to corrosion in addition to the descaling process. As a result, in order to avoid this phenomenon to

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occur or to minimize, some corrosion inhibitors may need to be added to the acid solution.

Various corrosion inhibitors having different classes had been attempted for acidic corrosion, however, naturally occurring eco-friendly compounds or classes of compounds having heteroatoms, aromatic, and repeated pi-bonds have demonstrated to be the maximum inhibiting power against acid corrosion. Better inhibitors are verified through the powerful interface interaction of inhibitor molecules and electron-rich centers with metal's vacant d orbitals. In general, heteroatoms like N, S, O, and P connected to compounds accomplished higher corrosion inhibition. [7-27]. Adsorption of inhibitor molecules on the metal-liquid medium interface is the generally observed mechanism for corrosion protection.

Phosphorous and phosphonium moieties are well known for their biocidal and heat resistance properties [28-29]. An examination of well-known corrosion inhibitor literature reveals that phosphonium compounds are a leading corrosion inhibitor for steel in acidic solutions. xxx-xxxiii. A review of corrosion inhibitor literature reveals that phosphonium compounds are an excellent corrosion inhibitor for mild steel in corrosive acidic solutions. [30-33].

The gravimetric method was used to investigate the adsorption behaviour of (4-Methoxybenzyl)-triphenylphosphonium Bromide (MBTPPB) for carbon steel corrosion in 0.5 M H_2SO_4 at four concentrations of 298 K, 308 K, 318 K, and 328 K. The impact of concentration and temperature on corrosion inhibition, has been observed as well as the calculation of various corrosion parameters, were discussed.

Experimental:

The molecular structure of (4-Methoxybenzyl)-triphenylphosphonium Bromide (MBTPPB) is shown in Fig 1:

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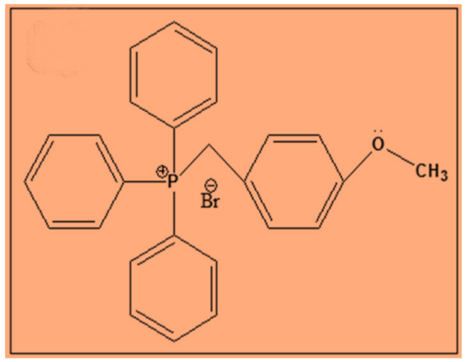

Fig. 1: The inhibitor structure of (4-Methoxybenzyl)-triphenylphosphonium Bromide (MBTPPB)

The Carbon steel under consideration is used for structural applications. The weight loss studies were carried out on mild steel specimens with the chemical composition (in weight percent of mild steel) as follows:

C	***Si***	***S***	***P***	***Mn***	***Fe***
0.15	0.31	0.025	0.025	1.02	Balance

All findings were recorded in the corrosive acidic solution. AR-grade H_2SO_4 was used to make the acidic solutions (test solutions). The acid concentration was 0.5 molar after diluting AR compounds with double distilled water. As received, the phosphonium compound MBTPPB (Aldrich, > 98 percent) was used as an inhibitor. Various concentrations of MBTPPB (10^{-2},10^{-3},10^{-4}, and 10^{-5}) molar were prepared by dissolving the calculated masses by the Molarity formula in 0.5 M H_2SO_4 solution.

Weight Loss Study:

The gravimetric research was conducted at four temperatures: 298, 308, 318, and 328 2 K, for four concentrations of the phosphonium compound MBTPPB throughout a sixhour plunging period. For each series of measurements, a well-polished cubic coupon with a surface area of $1cm^2$ was immersed in 50 mL of test acidic solution; two sets of the experiment were done under similar experimental circumstances to replicate the outcome. The corrosion rate CR is computed using the formula CR=W/At, where W (mg) is the actual weight loss of coupons with a surface area of A (cm^2) and t is the exposure period (in hours) [34]. Using the following formula, the corrosion inhibition efficiency IE_{WL} (%) was calculated: $IE_{WL}(\%) = \frac{C_R - C_R(i)}{C_R} x100$ (1)

Where C_R is the corrosion rate in the presence of 0.5 M H_2SO_4 solution only and C_R (i) is the corrosion rate with the addition of the inhibitor in 0.5 M H_2SO_4 solution. The degree of surface coverage (θ) of phosphonium molecules on the mild steel surface was calculated by using the following equation:

$\theta = IE_{WL}(\%)/100$ (2)

Where IE is the inhibition efficiency of MBTPPB

Results And Discussion:

Effect of Concentration on Inhibition Efficiency:

Various corrosion parameters by weight loss technique for mild steel corrosion in 0.5 M H_2SO_4 for all studied concentrations of MBTPPB at four considered temperatures (298 K, 308 K, 318 K, and 328 K) are tabulated in Table 1, and variation of percentage inhibition efficiencies (IE %) against the concentration of inhibitor and temperature is also tabulated. The variation of corrosion inhibition efficiencies at all studied concentrations against the increasing concentrations is specified in Fig.2. It is observed from Table 1 that weight loss due to corrosion decreases with the addition

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of inhibitor consequently IE % increases although the trend is not a regular one. The highest Inhibition efficiency of 97.26% was observed at the concentration (10^{-2}M) at 298 K and minimum Inhibition efficiency of 45.16% was shown by inhibitor at the concentration of (10^{-5}M) at the highest temperature of 328 K. The values of inhibition efficiencies up to 95 and above clearly indicate that adsorption of phosphonium compound molecules on the vacant site of the mild steel surface and maximum surface coverage up to 90%, Following a thorough examination of Table 1, it was discovered that the weight loss decreases once the inhibitor is added to the corrosive solution, and the degradation rate lowers as the concentration of MBTPPB increases in comparison to the blank acid solution at all four temperatures. The inhibition efficiency rises when more additives are added, therefore the inhibition efficiencies are highest for the highest concentration of 10^{-2} and lowest for the lowest concentration of 10^{-5} temperature for each set of experiments.

As a result, it's reasonable to imagine that as more inhibitor molecules are added, protected layers of the molecules build unless an optimum concentration is reached, and the metal substrate's contact with the corrosive solution is hampered to a large extent which stops the corrosion process by controlling of either anodic or cathodic mechanisms. At low levels of concentrations, the degree of surface coverage is not enough to protect the complete corrosion process, so there is an unprotected surface that is prone to further corrosion, resulting in less inhibition efficiency.

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Table 1: Corrosion parameters of mild steel in 0.5 M H_2SO_4 in the presence (4-Methoxybenzyl)-triphenylphosphonium Bromide (MBTPPB)

Temp. (K)	**Conc. (M)**	**Initial Weight I_w (g)**	**Final Weight F_w (g)**	**Weight Loss (g)**	**C_R (mgcm^{-2}h^{-1})**	**IE (%)**
			H_2SO_4			
298	0.5	11.6341	11.6211	0.0130	2.16	-
308	0.5	12.4602	12.4430	0.0172	2.86	-
318	0.5	10.2503	10.2320	0.0183	3.05	-
328	0.5	11.6562	11.6356	0.0206	3.43	-
			MBTPPB			
298	10^{-2}	10.4695	10.4693	0.0002	0.0362	98.32
	10^{-3}	10.6456	10.6451	0.0007	0.0935	95.67
	10^{-4}	11.3340	11.3334	0.0006	0.109	94.91
	10^{-5}	10.3493	10.3477	0.0016	0.267	87.62
308	10^{-2}	10.3447	10.3441	0.0006	0.108	96.21
	10^{-3}	11.5581	11.5573	0.0008	0.139	95.12
	10^{-4}	11.4535	11.4535	0.0023	0.396	86.12
	10^{-5}	10.1538	10.1510	0.0028	0.470	83.55

318	10^{-2}	11.0978	10.0967	0.0011	0.183	93.98
	10^{-3}	11.8825	11.8809	0.0016	0.272	91.05
	10^{-4}	11.4836	10.4811	0.0025	0.419	86.24
	10^{-5}	12.0884	12.0835	0.0049	0.822	73.02
328	10^{-2}	10.6530	10.6511	0.0019	0.323	90.56
	10^{-3}	10.6660	10.6629	0.0031	0.512	85.07
	10^{-4}	11.9207	11.9123	0.0084	1.398	59.23
	10^{-5}	10.7430	10.7306	0.0124	2.066	39.76

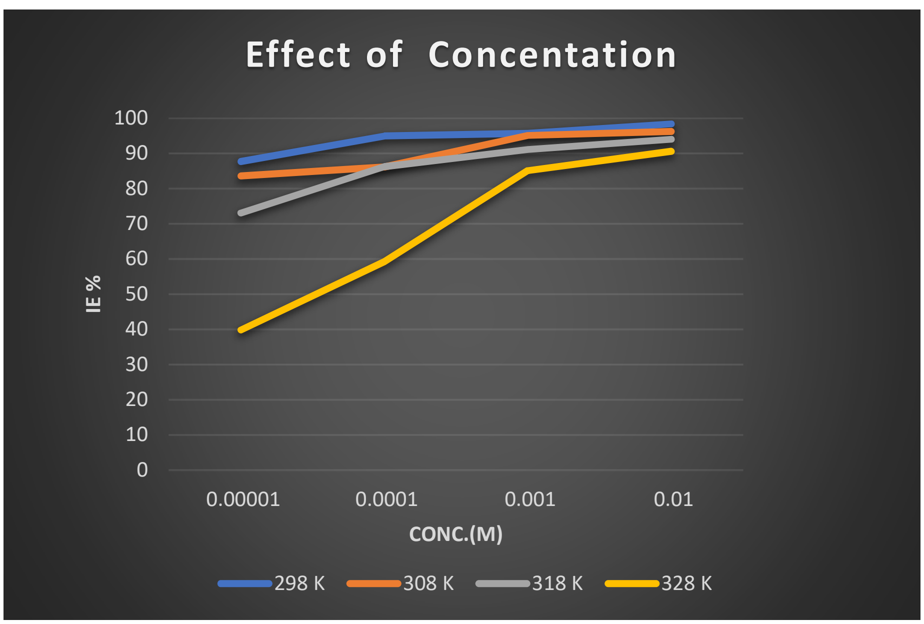

Fig 2. Effect of inhibitor concentration on corrosion inhibition efficiency for MBTPPB at 298 K, 308 K, 318 K, and 328 K

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Effect of Temperature on Inhibition Efficiency:

It was observed generally that the rate of reaction is fast at higher temperatures due to increased randomness of inhibitors on the metal surface, also mobility of inhibitors and other ions present the corrosive medium increases so the also shield the absorption of additive molecules. Even at the highest experiment temperature of 328 K, the inhibitory efficiency for the greatest and lowest quantities, respectively, is 77.27 percent and 45.16 percent, as shown in Fig. 3. At lower temperatures, the adsorbed molecules of phosphonium compounds generate a protective thin coating on the mild steel surface. Furthermore, as the temperature rises, as extra ions both from electrolyte and inhibitor intermingle with inhibitor molecules, increasing the randomness of molecules and causing more or less layer or breakdown of protective thin films, affecting corrosion prevention to some level. Additionally, lower surface protection at high temperatures suggests that the thick layer on the metal surface disperses at high temperatures due to the quick ionic mobility. The inhibitor's tendency to be adsorbed on the mild steel surface could explain the significant drop in inhibition efficacy as temperature rises [35]. Corrosion can be accelerated by dissolving a thin layer of inhibitor molecules, but it's been indicated that the corrosion inhibitors efficiency of phosphonium compounds is significantly greater than that of other organic compounds, which could be attributable to the fact that phosphonium compounds are thermally more stable and do not dissociate at the elevated temperature examined. As a result, this inhibitor can mitigate corrosion at higher temperatures as well.

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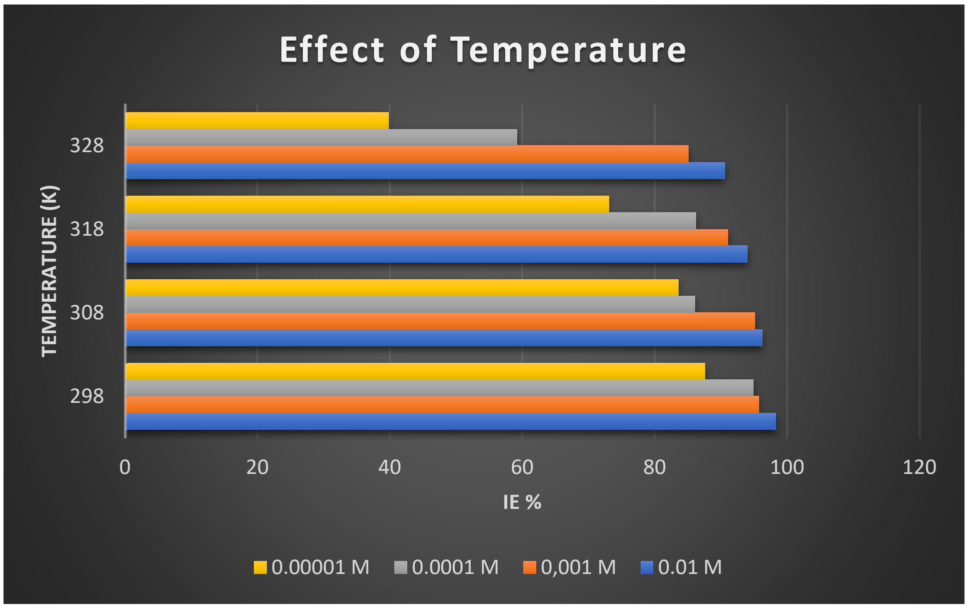

Fig 3. Effect of temperature on corrosion inhibition efficiency for MBTPPB at, 10^{-2} M, 10^{-3} M, 10^{-4} M, and 10^{-5} M

CONCLUSION

In 0.5 M H_2SO_4, the phosphorus additive MBTPPB exhibited potent inhibitor characteristics against mild steel corrosion at all four temperatures studied: 298 K, 308 K, 318 K, and 328 K. Compound has established its efficiency at both low and high temperatures. When the inhibitor concentration is increased, the inhibition effectiveness increases regularly, and when the temperature is increased, the inhibition efficiency decreases irregularly.

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