

Case of corrosion control in a closed cooling system

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ABSTRACT

The cooling system of the food is one of the main essential systems to maintain food quality in the food processing plant. The using of corrosion inhibitor for the cooling systems is a familiar practice to control the corrosion which is happening due to a different kind of parameters like water quality and the type of materials for the cooling system, in this work, the case of adding corrosion and scale inhibitor to a cooling system containing carbon steel and stainless steel and copper was investigated. The inhibitor was mixed of two materials which are (Sodium Tripolyphosphate as a scale inhibitor and Sodium Polyphosphate as a corrosion inhibitor). The results demonstrate that there is an improvement in reducing the corrosion rate for iron after adding the inhibitor, and the copper ions in the solution reduced if the PH values below 9.5.

Keywords: Corrosion inhibitor, scale inhibitor, cooling system, Sodium Tripolyphosphate, Sodium Polyphosphate.

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1. Introduction

Corrosion techniques were largely blamed for multiple losses in the manufacturing sphere. Avoidance is the only approach to tackle it. The inhibitor of corrosion is one of the well-recognized corrosion prevention strategies and one of the most effective in the industry, among the different techniques to prevent or avoid surface destruction in metals or deterioration. Owing to the reduced cost and practice process, this technique follows stand up [1]-[4]. Significant research has been carried out on government spending, primarily in broad areas, including the production of new shale gas pipelines and building expansion. Inhibitor applications in water and mortar for the defence of metals have been the subject of these inquiries. Inhibitors [5] were generally recognized in the industry owing to their outstanding anti-corrosive properties. Also, nevertheless, have been found to damage the atmosphere as a secondary result. Thus, the research world started looking for environmentally safe agents, such as organic inhibitors. [6]-[13]. In a range of industrial conditions, for instance, diesel and gas generators, electric transformers, cold water systems for air conditioning, and such, closed aqueous cooling systems have been utilized. Typically, such closed systems are made of several various metals, including copper, bronze, casted iron, mild steel, brass, and others which may contribute to galvanic device corrosion. Sodium chromate has been a commonly utilized corrosion inhibitor for sodium nitrite systems, the latter being typically buffered with sodium borate, rendering it especially appropriate to be used in ferrous metallic materials [15]. Nevertheless, because of their toxicity, the usage of chromate inhibitors has indeed been heavily restricted by Federal and State legislation recently. Nitrite-based inhibitors were also exposed to attack by nitrifying bacteria which even with corresponding microbiological growth and loss of effectiveness concerning ferrous materials, oxidize them into nitrates. Inhibitors based on tolyl triazole, nitrate and molybdate, silicate and polymer-based inhibitors have all been found to be efficient to one degree or another in particular metals, but are commonly utilized in combination with nitrates, phosphates and borates [14]. In "Drew Concepts of Industrial Water remediation [14], Mullins explains in more detail the closed aqueous cooling system reducing agents of corrosion. The effectiveness of different inhibitors and variations of inhibitors in aluminium closed aqueous cooling systems can be found in a paper by Wiggle, et al., entitled "The Effectiveness of

Automobile Engine Coolant Inhibitors for Aluminum [15]. Molybdate, phosphate and borate inhibitors used in tandem with nitrate and tolyl triazole to support aluminium cooling systems have been studied by Vukasovich and Sullivan in an article titled 'The Assessment of Molybdate as an Agent in Automobile Coolants'[16]. The usage of sodium nitrate and sodium borate antagonists in closed cooling systems is disclosed in Nos 2,815,328 and 3,335,096, whereas the use of different polymers in conjunction with silicate, nitrite, nitrate, borate and mercaptobenzothiazole is reported in the United States Pat. Vol. 3,948,792.

In the systems of cooling, corrosion prevention involves a modification in either the metallic or the climate. The first technique, altering the metal, is costly. Highly alloyed materials are often more vulnerable to failure through localized corrosion processes such as stress corrosion cracking, are very sensitive to corrosion attack.

A commonly utilized, realistic technique of avoiding corrosion is the second solution, modifying the setting. There seem to be three methods to effect an environmental improvement in aqueous environments to controlling operations:

1. Utilizing the alkalinity and natural calcium in the water to create a protective layer of calcium carbonate on the surface of the metal.
2. Removing the oxygen that caused corrosive from the surrounded water, by either chemically or mechanically deaeration.
3. Adding the antagonists of corrosion.

Azaza et al., (2014) have identified reducing agent for corrosion as any material that applied to an atmosphere effectively reduces the corrosion intensity. Concerning its role, an enzyme may be defined more efficiently: corrosive material elimination, adsorption, precipitation, or passivation. For industrial coolers, lab coolers, process coolers or for other cooling devices, passivation fits well. A defensive oxide layer on the surfaces of metal forms passivating inhibitors. Since they could be utilized at economical amounts, they are the strongest antioxidants, and their defensive layer is tenacious and tend to be restored easily if affected. In addition to choosing the right, reducing agent for corrosion, the consumer must be mindful that certain systems require low conductivity fluid utilized for cooling, and when the inhibitor is chosen, they need to prepare accordingly. If the cooling device has biological, algae, or bacteria growth, it could be contacted the cooling manufacturer for instructions [17]. The experiment named (Sodium tripolyphosphate (STPP) as an innovative oxidizing agent for mild steel in 1 M HCl) has been performed by FAHIM et al. (2013). They clarified that the findings of loss in weight and Tafel polarization measurement revealed that this material has surprisingly strong inhibitory characteristics for corrosion of steel in an acidic liquid, with 87 percentage inhibition efficiency at appropriate amount 10⁻³ M. There is a combined anodic-cathodic nature of the inhibition. Langmuir adsorption isotherm is observed to follow the adsorption activity of the studied drug. The negative magnitude of the adsorption energy, showing the spontaneity of the adsorption process, was determined. Complex formation of metallic ions and sodium triphosphate is often suggested as an extra mechanism of mild steel corrosion inhibition [18]. It is necessary to describe processed cheese as a viscoelastic matrix, the raw content of which is made of cheeses at various maturity levels. It is processed utilizing a wide variety of milk products ingredients, and additives (for example, caseinate, whey powder, milk powder, curd, anhydrous milk fat, butter, cream) and non-dairy ingredients and additives (for example, active sensory mixtures, colouring agents, hydrocolloids) used to adjust the material (for example, the amount of protein, amount of fat, amount of DM) or the functional characteristics of the food (for example, firmness, reliability). Emulsifying salts (ES), typically sodium salts of phosphates, citrates or polyphosphates, are essential components in the processing of refined cheeses. The discontinuous production of processed cheeses includes (1) determining the composition of ingredients (concerning the desired parameters of the final product); (2) placing the determined amounts of ingredients and additives into the melting device and the actual melting process (at a usual temperature of 85 to 105°C with a dwell time of several minutes); and (3) packaging in different wrapping materials [19]. In the cheese casein matrix (gel), the important function of ES is the sodium ions exchange for the ions of calcium; insoluble calcium paracaseinate transforms into more soluble paracaseinate sodium, the molecules (chains) of which will pass inside the melt structure, therefore enhancing fat emulsification and water-binding [20]. The ability of individual ES to support the exchange of sodium for calcium ions can vary. Generally, the ability to support ion exchange occurs in the following order (considering sodium salts): citrates \approx monophosphates < diphosphates < triphosphates < short polyphosphates (<10 phosphorus atoms in a molecule) < long polyphosphates (>10 phosphorus atoms in a molecule) [21-22] stated that citrates support ion exchange to a greater extent than monophosphates.

2. Experimental work

In one food production plant, there was a problem of corrosion in a closed cooling system contain stainless steel (cooler and tanks), carbon steel (pipes), and copper (chillers), as shown in figure (a) below. It has been tried to use an inhibitor to control the corrosion in one laboratory cooling circle similar to that cooling system and then move the trial to the plant cooling system. The water used in this circle is reverse osmosis (RO) water before adding the inhibitor. It has been analyzing the water in this circle by using PH meter Figure 2 (a), and we test the iron and copper ions by using DR900 Figure 2 (b).

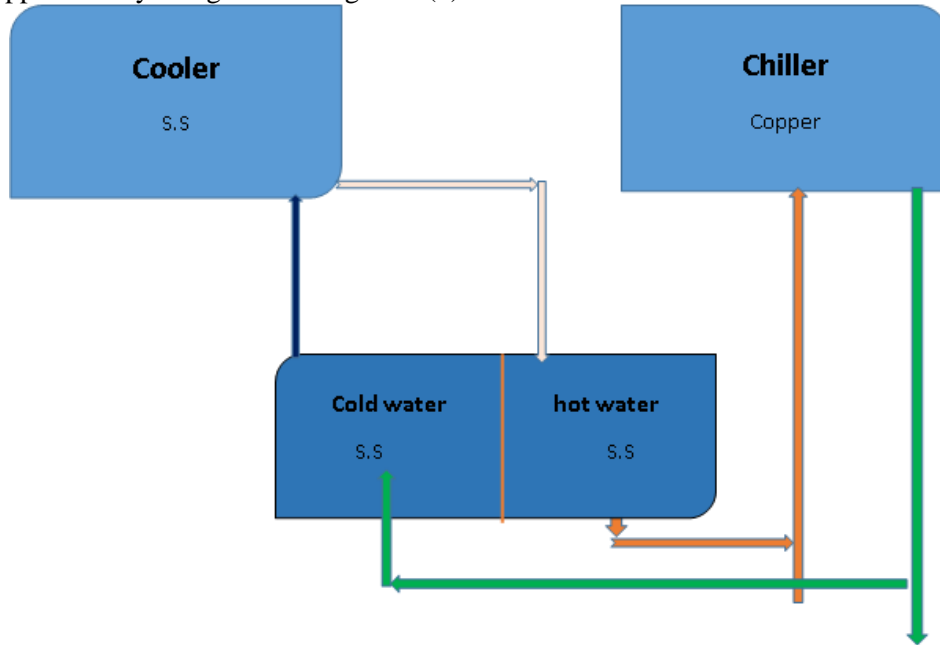


Figure 1. Cooling system

The system in the plant is in direct contact with the food, so we tried to choose an inhibitor which must be food grade, base on that we used (NALCO CL-50) which is Corrosion and Deposit Inhibitor and it is a liquid inhibitor formulated to control corrosion and scale build-up in municipal water systems, industrial service water, or cooling water systems and the maximum dosed to use as a food grade is 28 ppm as per the manufacturer recommendations.

The active constituents for this inhibitor are:

Active Function

Sodium Tripolyphosphate

Scale Inhibitor

CAS Number

7758-29-4

Sodium Polyphosphate

Corrosion Inhibitor

68915-31-1



Figure 2. The devices used in the experimental work (a) PH meter (b) DR900

It used three different inhibitor concentrations (1 ppm, five ppm, 10 ppm) and analyzed for iron ions and copper ions related to the phosphate and PH.

3. Results

The circling water analysis before adding the inhibitor, which indicated the iron ions are increasing gradually from (5 to 18.8) ppm with the decreasing of PH from (8.5 to 7.3), as shown in fig. (3). Besides, copper ions were decreased from (0.5 to 0.2) ppm with decreasing PH from (8.5 to 7.3), as shown in fig. (4).

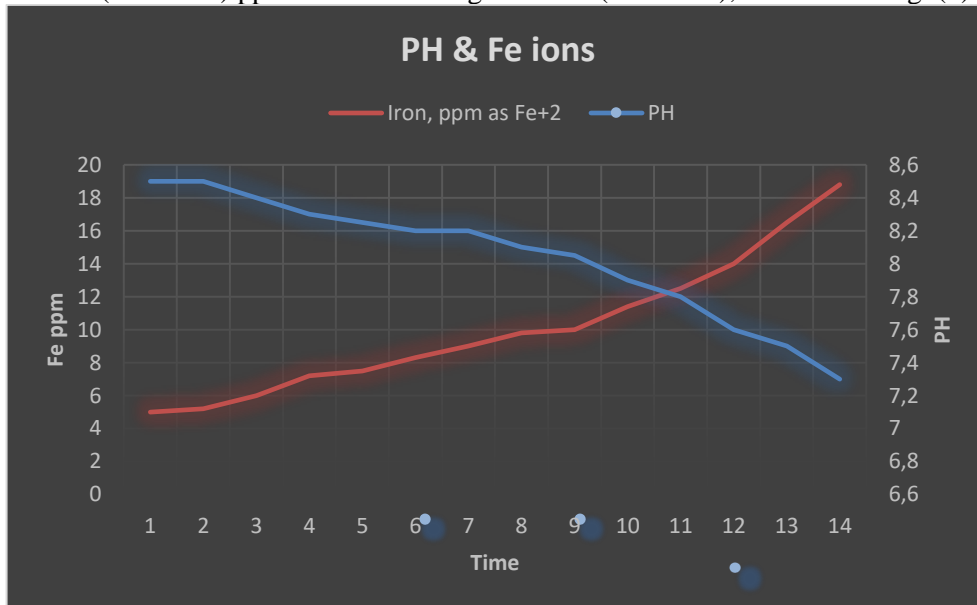


Figure 3. Fe ions and PH before adding the inhibitor

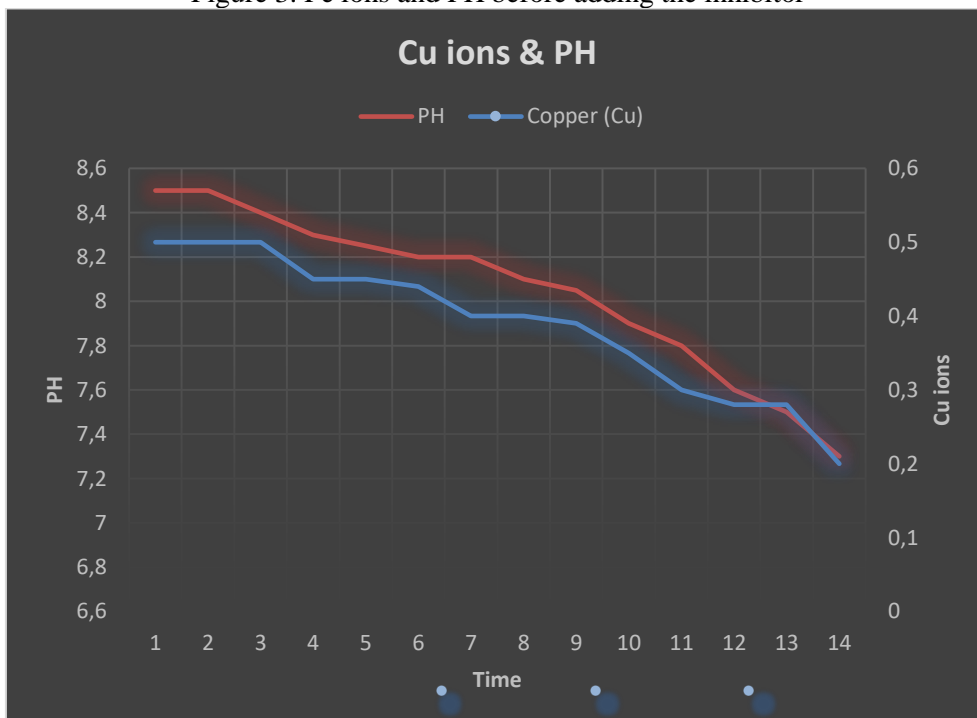


Figure 4. Cu ions and PH before adding the inhibitor

- 1- Adding the inhibitor to the circling water after that starting analyze the water every day and found that with increasing the inhibitor dose (1 to 10 ppm), the corrosion of iron was decreased from (9.5 to 5.2) ppm as shown in Figure 6. In other experiments, the PH value was also increased, and Fe ions were reduced from (20 to 11) ppm after adding the inhibitor, as shown in Figure 5.

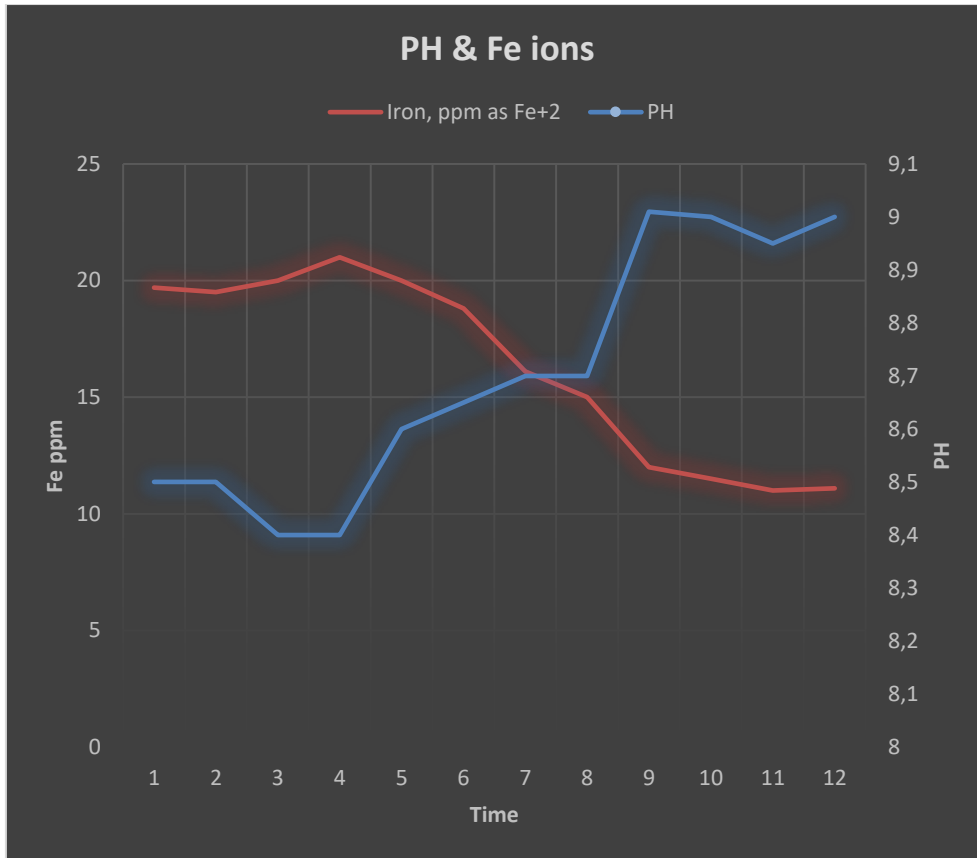


Figure 5. Fe ions and PH after adding the inhibitor

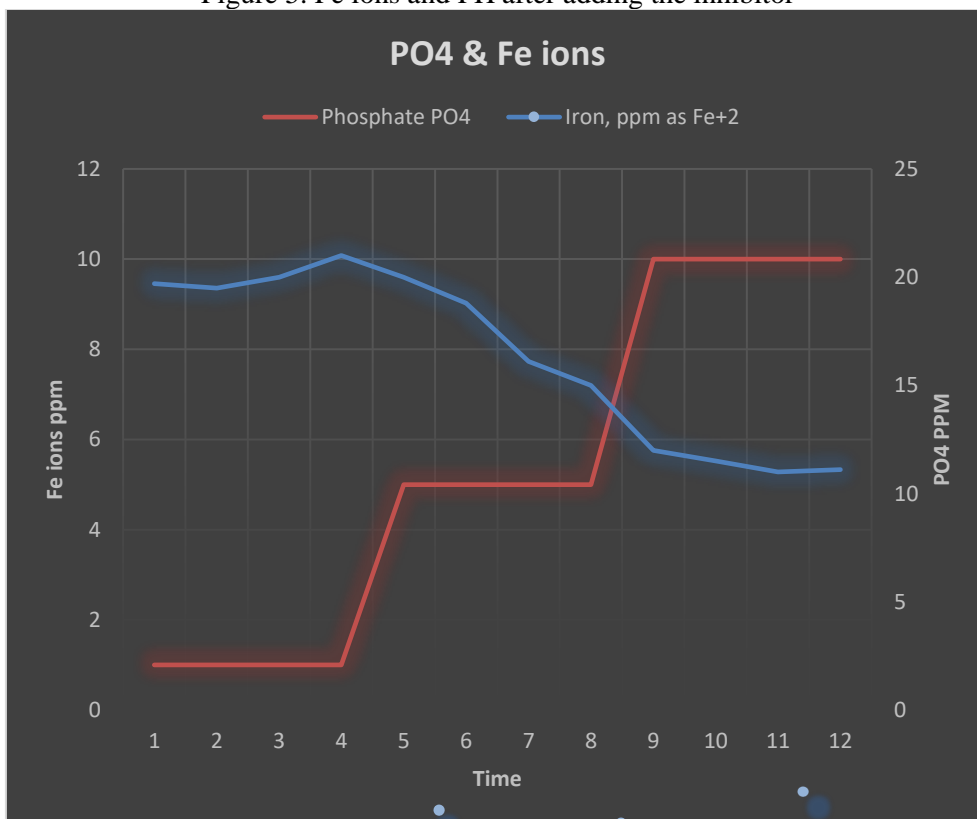


Figure 6. Fe ions and PO₄ after adding the inhibitor

3- After the addition of the inhibitor found that with increasing the inhibitor dose (1 to 10 ppm), the copper ions did not affect more (just increased from 0.6 to 0.8 ppm) as shown in Figure 7. In another experiment, the PH

value was also increased after adding the inhibitor, and copper ions increased slightly (0.6 to 0.65) ppm, as shown in Figure 8.

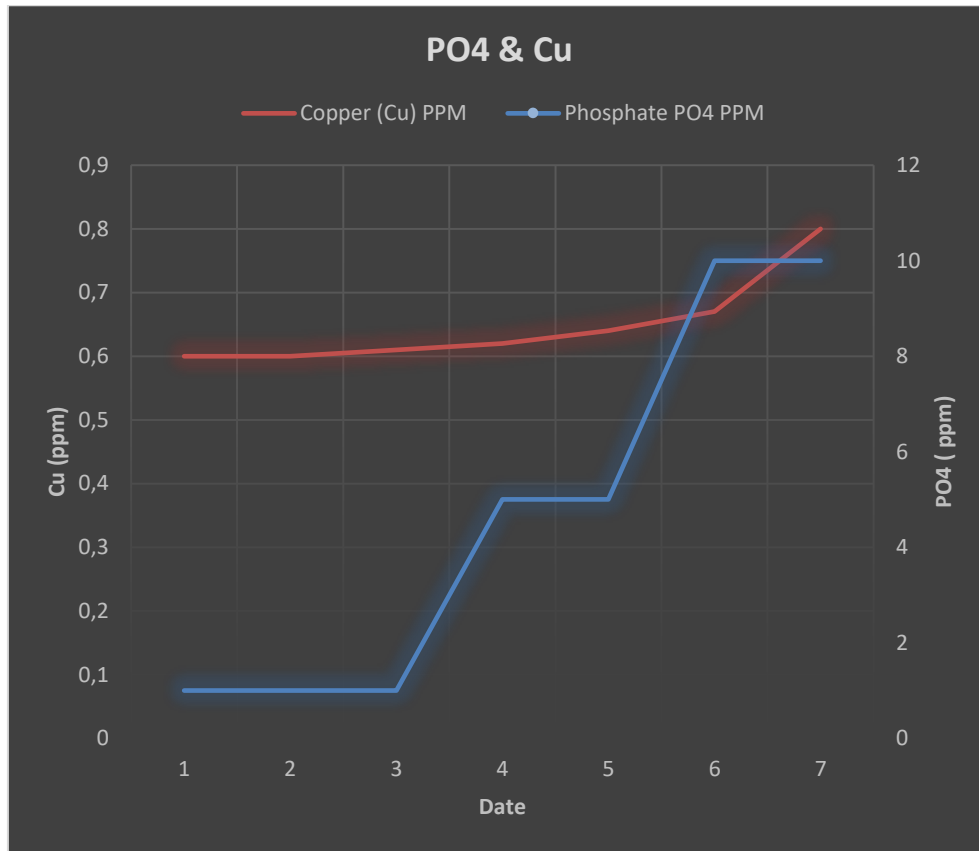


Figure 7. Cu ions and PO4 after adding the inhibitor.

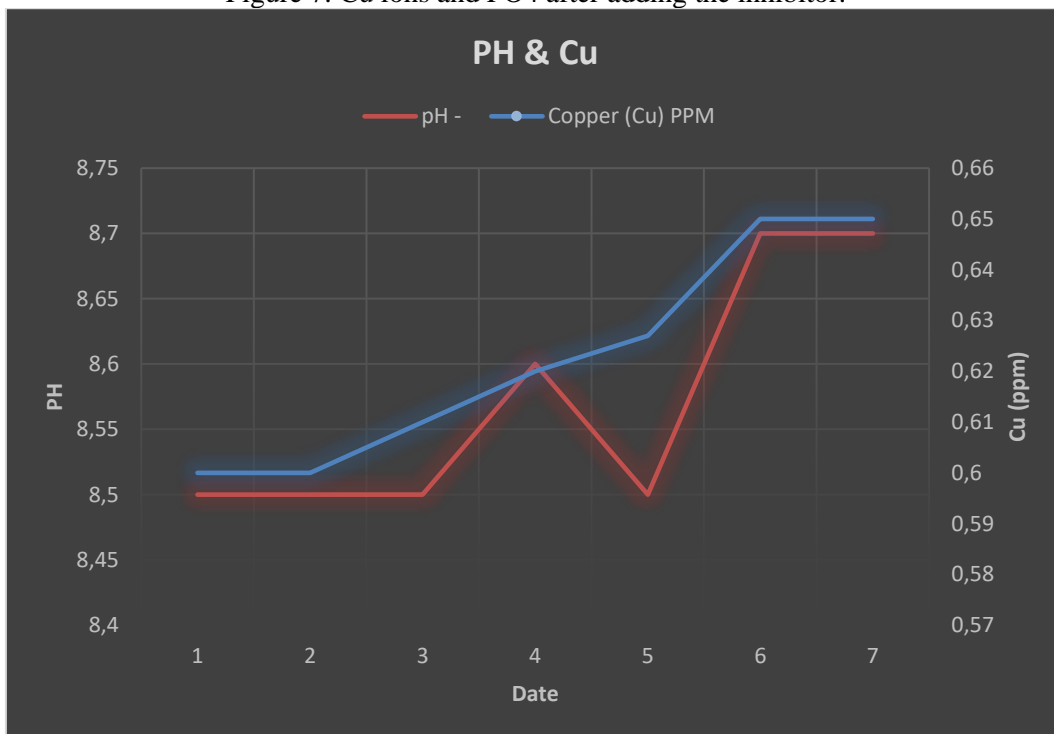


Figure 8. Cu ions and PH after adding the inhibitor.

After adding the inhibitor, the watercolour of the cooling system improved and became clear. The reason for that is the iron ions in the water reduced as it was a frequent behaviour to change the water when the colour

becomes bad as a result of corrosion of the system, but after the addition of the inhibitor, the corrosion rate decreased, and the colour improved



Figure 9 (a): Water of the circle before adding the inhibitor, (b): Water of the circle after adding the inhibitor

5- The copper's corrosion rate will decrease when we reduce the water PH below 9.5, and this thing was proved by using water with a PH around 9.3 for many days, and no effect appeared on the copper. However, the copper ions increased in the water after increasing PH to 9.8 after the inhibitor addition, as shown in fig. (8). Therefore, the PH must be controlled if the copper is part of the system where the inhibitor must be used.

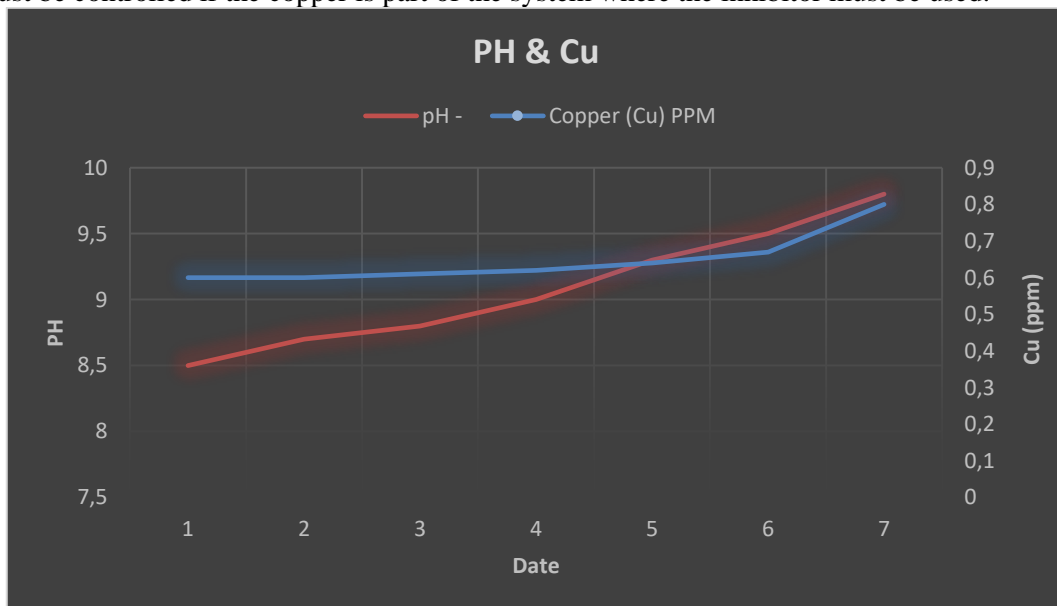


Figure 10. Cu ions and PH after increasing the PH

4. Conclusions

- 1- By adding the inhibitor (10 ppm as PO_4), the iron's corrosion rate was decreased by around 50%.
- 2- The addition of the inhibitor was increased the PH value around 0.5 degrees.
- 3- By the increasing of PH value, the copper ions in water have increased by around 0.3 ppm.
- 4- The addition of the inhibitor has reduced the turbidity and the colour of the water.

5. Recommendations

- 1- Increase the dosage of the inhibitor and notice the corrosion rate.
- 2- Change the water frequently after adding the inhibitor the first time until removing the solution's colour for the corroded parts.
- 3-Controlling the PH and TDS values to achieve the best conditions for adding the inhibitor and reducing copper and iron corrosion.
- 4-Change the water quality by changing its source, which may match the inhibitor to reduce the corrosion rate.

5-Try to add the inhibitor to a pressurized system (no air can enter the system) and notice the results.

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