Development of MOF Based Corrosion Inhibitors

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Abstract:- A variety of corrosion inhibitors including inorganic salts and organic molecules with heteroatoms as well as π – electron clouds were applied as corrosion inhibitors of metals in different corrosive environments. Nanomaterials found numerous applications in the field of corrosion inhibition due to their greater surface area. Nano cages and hollow spheres present in metal organic framework increase their applications in the field of electrochemistry. A short review on the study of MOF as corrosion inhibitors was discussed in this article. Many features of MOF based corrosion inhibitors as well as their current trends and future scope were also discussed.

***Keywords**:- Corrosion, Inhibitor, MOF, Nanomaterials, Electrochemistry.*

I. INTRODUCTION

Metals have properties like good electrical and thermal conductivity, high melting and boiling point, ductility, and malleability. Most of the metals react with humidity, gases and salts present in the environment and form stable compounds of their oxides, hydroxides, or sulphides as the corrosion products [1, 2]. Different techniques are applied to reduce the corrosion of the metals. These methods include painting, cathodic and anodic protection, use of corrosion inhibitors etc. [3, 4]. Nanomaterials found numerous applications in the field of corrosion inhibition due to their greater surface area [5, 6]. Nanomaterials prevent the corrosion by covering the active sites on the metal surface and thus increase their strength and durability [7]. MOF (metal-organic-framework) derived nanostructures have higher specific surface area, good morphology such as nano cages and hollow spheres, compared to other nanostructures.

1.1. MOF as corrosion inhibitors

A few studies are available in literature showing the application of MOF as good corrosion inhibitor. A 3D network of silver based MOF was reported [8] and was found to be suitable for preventing corrosion of carbon steel in 1M HCl solution. The above study reported that, this MOF is a mixed type inhibitor and adsorbed on the metal surface obeying Freundlich adsorption isotherm. Another similar study showed the metal organic framework based on both silver and nitrogen donors were good corrosion inhibitor for copper in HCl solution [9]. MOF containing organic ligand with substituted aryl, heteroaryl or heterocyclic compounds having an exocyclic surphur group for corrosion inhibitor of metals and its alloys [10] was also reported. A new MOF was reported in literature from Cadmium sulphate and 6- methylequinoline in presence of KSCN [11]. The authors of the above study used IR, H-NMR, UV- VISIBLE, TGA and XRD for characterization of MOF and reported that the MOF synthesized in their study consist of cyclic building blocks of (CdSCN)n.

Influence of three metals based MOFs for the corrosion protection of mild steel was reported in 2017 [12]. The metals employed in MOF were Co, Ni and Cu. The prepared MOFs were characterised by XRD, FT-IR and TG analysis. Above study revealed that, both Ni and Cu MOFs were of one dimensional nanorods having foam like morphology whereas that of Co was large chunky particles with etched edges having uniform size and shape [12]. Development in the studies of MOFs leads to use of hydrophobic MOF like ZIF-8 in anticorrosion industry [13]. The conversion of ZnAl-CO_3 layered double hydroxide precursor buffer layers to well inter grown ZIF-8 coatings [13] was employed in that study. The MOF coatings showed a corrosive current which was four orders of magnitude lesser than bare Al substrate [13].The difficulty in controlling the arrangement of inhibitor molecules in MOF pores leads to the application of Cetyltrimethyl ammonium bromide (CTAB) which contains hydrophobic and hydrophilic tails in classic HKUST-1 thin film for bronze conservation [14].

Literature showed the enhancement of anticorrosive properties of epoxy coating with MOF [15]. The BTA-Cu-MOF coating was analysed using FTIR, TG, XRD and SEM and it revealed that MOF was well dispersed in epoxy resin [15]. A recent study prepared an anticorrosive film from Samarium (III) nitrate and [bis(phosphonomethyl)amino] methylphosphonic acid (ATMP) for the protection of mild steel in saline solutions [16]. This thin film forms a uniform coating over steel surface. A novel MOF named as Zeolite imidazolate framework nano structure was reported as corrosion inhibitor for carbon steel in HCl medium [17] and using the ANOVA analysis the authors of the above study reported that temperature was not very significant in inhibition efficiency of the inhibitor. The very good inhibition property of MOF on metal surface was due to chemisorption of MOF on metal surface as revealed by thermodynamic study [17].

1.2. Futuristic Approach

Many of the synthetic organic corrosion inhibitors are known to have been restraining environmental protocols due to their perilous effects. Lot of research works are going on for the development of low cost, eco friendly and high inhibition efficiency inhibitors. The MOF is seems to be a

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promising inhibitor due to the presence of a metal ion and organic frame work. The more electropositive metals like zinc and magnesium can protect the iron articles. The presence of more electropositive metal in organic frame work enhances the inhibition efficiency by sacrificial action. On the other hand, the organic frame work forms a protective layer over metal surface which reduces the corrosion rate. In view of this, green inhibitors such as plant extracts, can further improve the corrosion inhibition efficiency while using along with MOF. These green inhibitors are adsorbed on cathodic / anodic sites on the metal surface preventing the electrochemical reaction. The green corrosion inhibitors can be added along with MOF or can be incorporated in MOF during their synthesis. Another promising aspect in this direction is development of a MOF with a metal ion and organic frame work derived from a plant or other natural substance. Such types of inhibitors are eco friendly in nature and also low cost.

II. CONCLUSIONS

MOF (metal-organic-framework) derived nanostructures were found to be good corrosion inhibitors due to their higher specific surface area and good morphology compared to other nanostructures. MOF forms a mixed type inhibitor and adsorbed on the metal surface obeying Freundlich adsorption isotherm. The chemisorption of the MOF on the metal surface was also reported. The MOF can be used for protecting a variety of metals and its alloys which are exposed to different corrosive environments. The future will be of using a MOF prepared by combining a metal with green substrate as corrosion inhibitor.

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