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CORROSION INHIBITION USING NANOMATERIALS - AN OVERVIEW

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Abstract:

Corrosion processes are responsible for huge losses in industry and society. Though organic, inorganic and mixed material Inhibitors were used for a long time to combat corrosion. The use of Nanomaterials as inhibitors has gained the importance because of its increased corrosion efficiency due to increased surface to volume ratio. This paper summarizes the recent trends and advancement in the applications of nanomaterials to inhibit corrosion.

Key Words: Nanomaterials, Inhibition, Alloys, Ceramics & Coatings

High Lights:

- ✓ Different metal oxide nanoparticles used as corrosion inhibitors have been discussed.
- ✓ Effect of Nanocontainers on corrosion inhibition has been highlighted.
- ✓ Nanocontainers have been recommended for future studies

Introduction:

Nanostructured materials possess unique mechanical, electronic, physical, chemical and physiochemical properties due to their high surface area which in turn increases the active centres [1]. These properties have urged to prepare coatings of greater wear and tear resistance. The nanomaterials undergo physisorption / chemisorption to the corrosion metal surface and inhibit the corrosion efficiently. The nanomaterials as corrosion inhibitor in the coatings will enhance the active corrosion protection and prolonged lifetime.

Nanomaterials are good corrosion inhibitors because it possess many advantages such as high inhibition efficiency, low cost, low toxicity and easy production [2]. Nanomaterials and nanostructures can serve as excellent carriers for corrosion inhibitors. The advantages of the nanomaterials are controlled and triggered release of corrosion inhibitors to protect corrosion. The present article reviews on the recent reports of Corrosion inhibitors. The manuscript throws a light on

- ✓ Metal/metal oxide nanoparticles as corrosion inhibitor
- ✓ Nanocomposites as corrosion inhibitor
- ✓ Nanoreservoirs

Metal/Metal Oxide Nanoparticles as Corrosion Inhibitor:

Metal nanoparticles are interesting for a wide range of applications due to their anti-corrosion behaviour. Recent reports on metal nanoparticles for the corrosion inhibition are discussed below. Honey was used for the first time as reducing and capping agent to prepare silver nanoparticles. The prepared silver nanoparticles was investigated for the first time as corrosion inhibitor for mild steel in HCL solution by Obot et al. [3] Migahed et al investigated the corrosion behaviour of dodecyl cysteine hydrochloride self -assembled on gold nanoparticles [4]. Ch-g-PEG stabilized Ag nanoparticle showed higher corrosion inhibition than Ch-g-PEG[5].

Metal oxide nanoparticles have been successfully employed as corrosion inhibitor. A few reports and its efficiency are discussed below. Vegetable oil (linseed oil

and olive oil) stabilized iron oxide nanoparticles are green synthesized and formulated in paint, which effectively inhibits the corrosion of steel [2]. Recently, Atta and his co-workers modified magnetite nanoparticles with rose amidoxin (oxime) and studied the corrosion inhibition efficiency for mild steel [6]. A TiO2 nanoparticle has been successfully applied as corrosion inhibitor to steel, carbon steel and stainless steel [7]. Nanosized CeO_2 has been reported as anticorrosive inhibitor for mild steel in different acid mediums (HCl & H_2SO_4) [8]

Hollow Zinc Phosphate nanoparticles were prepared by Sonochemical method in the presence of surfactant (SDS). The prepared nanoparticles was used as a nanocarrier to hold effectively the imidazole and release to inhibit corrosion [9]. Currently, researchers have found that spinel based pigments are distinctive to thermal, weather degradation resistance and environment friendly[10].The application of spinel based ferrite pigments in paints are more beneficial due to its anticorrosion efficiency at high temperature and aggressive environment[11] Anticorrosion property of Nickel Zinc ferrite was investigated over API 5L X80 steel in sulphuric acid. A very small concentration of Nickel Zinc ferrite developed corrosion resistant coatings on steel [12].

Nanocomposites as Corrosion Inhibitor:

Polymer coatings and Nanostructures have shown to be good corrosion inhibitor but the disadvantageous in them is poor adhering capacity of the polymer to the metal surface and inherent porosity of the nanostructure which allows water and metal ions to penetrate the coating and corrode the metal surface [13-15]. To overcome these drawbacks polymers and nanomaterials are utilised to develop nanocomposite. The agglomeration of the metal oxide nanoparticles will decrease the efficiency of anti - corrosion behaviour. So there is a need to disperse the metal oxide nanoparticles in solution and coatings which lead to the development of nanocomposites. El Mahdy dispersed TiO_2 nanoparticles in PNa-AMPS composite and showed good protective property for the corrosion of steel in acid chloride solution [16] Graphene/PEI (Polyetherimide) composite represent a solution as well as a replacement for hexavalent chromium in anticorrosive coatings [17] Silver nanoparticles stabilized hybrid polymer nanocomposite has been investigated as corrosion inhibitor towards steel in acid medium [18]. Similarly, Poly sodium acrylate modified magnetite nanocomposite has been tested as corrosion inhibitor for Carbon Steel Alloy by Atta et al [19].

Nanocontainers as Corrosion Inhibitors:

The Corrosion inhibitors cannot be added directly to the barrier coating due to its undesirable leaching and inactivation. This disadvantage can be overcome by using nanocontainers encapsulating the corrosion inhibitor and uniformly dispersing in coating [20]. Nanocontainers are smart intelligent materials which release the corrosion inhibitor in quick response to environmental pH changes. Nanocontainers should have the good compatibility to the passive coating matrix. Nanocontainers should be able to accommodate the corrosion inhibitor without leakage and release the inhibitor after the coating has breached. Nano container based coating acts as a key for self -healing of corrosion process.

Considering the factors such as nano container capacity, prevention of premature release, low cost, compatibility of the container in the matrix functionalization of the container was found to be a better solution by Zheng et al [21]. Non porous metal oxide nanoparticles as nanocontainers were facing some complexities which limits their industrial application [22]. Hollow mesoporous nanoparticles can

functionalize as better nano container to load corrosion inhibitors which will release the inhibitors intelligently upon demand by trapping the Corrosion [23]. Mesoporous silica nanoparticles are considered to be a promising candidate for various delivery applications [24] .Recently, hollow mesoporous functionalised nanocontainers acts as nanovalves [25]. Cesia A´ vila-Gonzalez and his co-workers reported that silica nanotubes acts as nanocontainer and control the corrosion efficiently [26]. A comparative report on the three types of nanocapules (polyelectrolyte modified halloysite nanotubes (PHN), polyelectrolyte modified SiO2 nanoparticles (PSN) and polyelectrolyte nano-capsules (PNC)) for enclosing benzotriazole corrosion inhibitor and the increasing order of inhibitor release was reported by Jafari et al [27]. Dodecylamine encapsulated silica nanoparticles was informed as nanocontainer for active protection of carbon steel [28]. Polyelectrolyte encapsulated haematite nanoparticles has been tested as nanocontainers for the controlled release of benzotriazole by Radeva et al [29] Jaysingh jadev et al revealed the ultrasonic assisted synthesis of Zinc Phosphate nanoparticles as a core and functionalized with polyelectrolyte (poly aniline and polyacrylic acid)for the development of nanocontainer for the corrosion inhibition applications [30].

Conclusion:

This review work has elaborately discussed the inhibition of corrosion using Nanocontainers, Nanocomposites, Nanometals / Nanometaloxides found in the literature. Corrosion inhibitors containing Nanocontainers are best understood. Furthermore, Nanocontainers should replace toxic chromate corrosion inhibitors and exihibit negligible impact on human health and environment.

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