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Chapter 10

CARBOHYDRATES AS CORROSION INHIBITORS

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All-natural processes tend towards the lowest possible energy state by a spontaneous reaction. Corrosion is a perpetual deterioration of metal or material owing to its reaction with different aggressive environments causing massive economic loss, primarily in the petroleum industries, and in aerospace. Metals can be protected against corrosion by introducing an inhibitor in an aggressive aqueous environment at a small concentration. Traditional

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corrosion inhibitors have made great contributions to metal corrosion protection. However, environmental pollution caused by them is becoming more serious. Natural polymers are environment-friendly; they occur in huge quantities and are available at reasonable prices, and they have many adsorption sites, making them highly absorbable on the metal substrate. Carbohydrate Polymers are most abundant in plants which have great potential as industrial corrosion inhibitors [1]. Therein, Starch, cellulose, chitosan, pectin, and other naturally occurring carbohydrates as representative green corrosion inhibitors have been reported without pollution to the environment[2]. The corrosion protection efficiency of these biopolymers depends on their molecular weight, availability of Π electrons for contribution to metal, and adhesion among substrate and film coating [3]. This chapter summarizes various carbohydrate polymers as corrosion inhibitors.

1. CELLULOSE

Cellulose, a crystalline polysaccharide, is the largest biopolymer obtained by photosynthesis. It is a linear long chain polymer of β (1→4) linked D-glucose units (5,000-10,000), that condense through β (1→4) glycosidic bonds. Cellulose and its derivatives showed unique advantages because they are the most abundant natural polysaccharide with low cost, better biodegradability, and biocompatibility. Abundant O atoms in cellulose can form coordination bonds with metal atoms, preventing contact between corrosive media and metal. HEC (Hydroxy Ethyl Cellulose) is a representative derivative of cellulose with excellent water solubility and biocompatibility. HEC is manufactured by reacting alkali-treated cellulose with ethylene oxide at which a series of hydroxyethyl cellulose is produced. With many active groups in the molecule, cellulose can be chemically modified to improve its solubility and corrosion inhibition, so functionalized cellulose is a concern for researchers.

2. STARCH

Starch is a carbohydrate consisting of several glucose units joined together by glycosidic bonds; starch is a low cost, renewable and biodegradable natural polymer. It consists of two types of molecules, amylose (linear) and amylopectin (branched). When used at low pH, starch shows low water solubility and poor stability. Thus, for improved performance as a corrosion inhibitor certain physical and chemical modifications become necessary [4]. These involve the reaction of their hydroxyl groups with functional groups of synthetic polymers such as carboxylic acids, anhydrides, epoxies, urethanes, oxazolines, and others. Another

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alternative method is via free-radical ring-opening polymerization occurring between their glucose rings and vinyl monomers.

3. LIGNIN

Lignin is the second most common organic polymer. About 50 million tons of lignin is produced worldwide annually as residue in paper production processes. It consists of methoxylated phenyl propane structures. The biosynthesis of the complex structure of lignin is thought to involve the polymerization of three primary monomers; monolignols, p-coumaryl coniferyl, and sinapyl alcohols, which are linked together by different ether and carbon-carbon bonds forming a three-dimensional network. A huge amount of it is considered a waste product; however, it has the potential to be converted into a valuable one. Lignin has different applications such as agricultural, cement, oil well drilling, batteries, ceramics, pharmaceutical, etc. Moreover, it is noted that the process by which the Lignin is extracted can impact its corrosion inhibitory properties. The availability, environment-friendly nature, and effectiveness of the Lignin in suppressing corrosion make it a great candidate for corrosion resistant coatings and corrosion inhibitors [5]. Hydroxyl, methyl, and carboxyl groups in Lignin play key roles in suppressing corrosion through adsorption on the surface.

4. CHITOSAN

Chitin and Chitosan are polysaccharides. They are chemically like cellulose, differing only by the presence or absence of nitrogen. Chitosan is deacetylated chitin obtained from the outer shell of crustaceans (crabs, lobsters, and shrimps). Chitosan primarily consists of β linked 2-amino-2-deoxy-β-D-glucopyranose units. Chitosan shows biocompatibility, low toxicity, biodegradability, osteoconductivity, and antimicrobial properties. Modified chitosan is less susceptible to moisture and prevents the penetration of corrosive electrolyte species, providing good corrosion protection to the substrate [6].

5. EXUDATE GUMS

Gums from natural sources are effective corrosion inhibitors, because of their greener, and renewable. And unique chemical composition. and their evolution has greatly attracted attention considerably in the corrosion field.

5.1. GUAR GUM

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Guar Gum is an important high molecular weight commercial biopolymer with linearly bonded mannose units and alternate lateral branched galactose groups (Fig. 1). The presence of a considerable number of flexible hydroxyl groups in the polymeric structure entertain Guar Gum and derivatives for drug delivery, metal ion sorbents, wound healing applications, and as thickeners/emulsifiers in food products. Guar Gum can be employed as a green corrosion inhibitor owing to its non- toxic nature, biodegradability, low cost, and metal ion sorbent action [7].

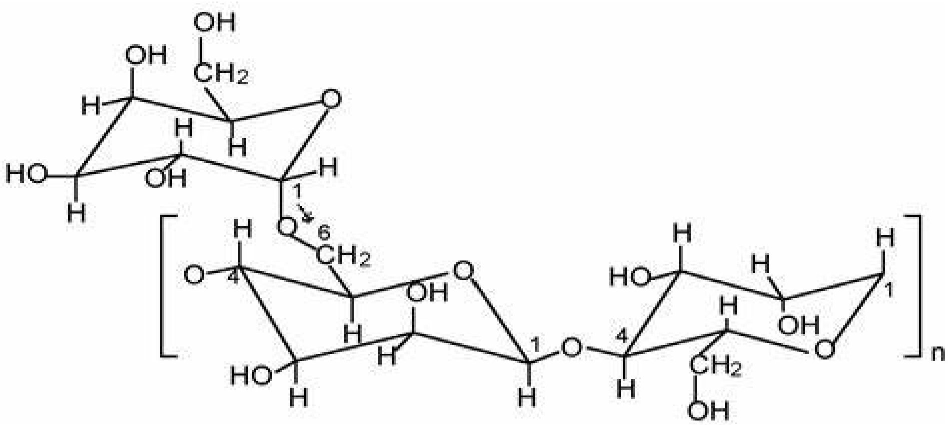

Fig.1. Molecular structure of Guar Gum

5.2. XANTHAN GUM

The natural polymer, Xanthan Gum is a microbial desiccation-resistant polysaccharide, prepared commercially on a large scale by aerobic submerged fermentation of corn, soy, or other plant materials using Xanthomonas campestris as the fermenting agent. It is composed of pentasaccharide repeat units, comprising glucose, mannose, and glucuronic acid in the molar ratio of 2:2:1. The backbone of the polymer is like that of cellulose. The side chains are -d-mannose, 1,4 -d glucuronic acid and 1,2 -d-mannose (Fig. 2). The polymer is soluble in cold and hot water but needs intensive agitation upon introduction into the aqueous medium to avoid agglomeration. The chemical structure of the polymer suggests that it can act as a good corrosion inhibitor [8].

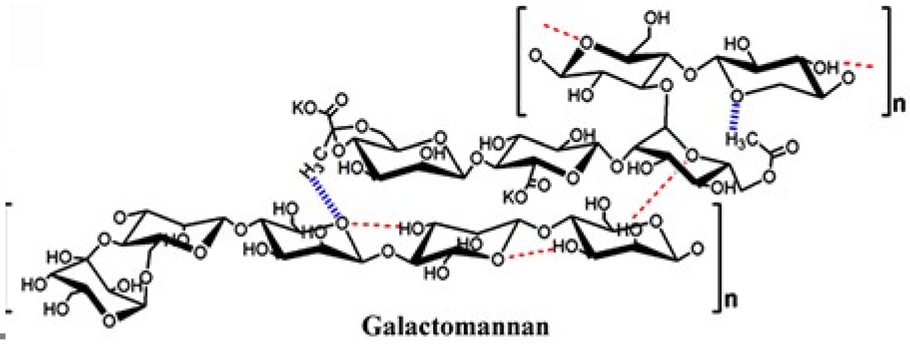

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Fig.2. Molecular structure of Xanthan Gum

5.3. GUM ARABIC

Gum Arabic (Fig.3) is water soluble, a dirty sticky, and wet exudate extracted from Acacia tree (Leguminosae) sap material; and it is a mixture of some polysaccharides, sucrose, oligosaccharides, arbinogalactan and glucoproteins conceived to have the needed corrosion inhibition potential for metal substrate protection[9].

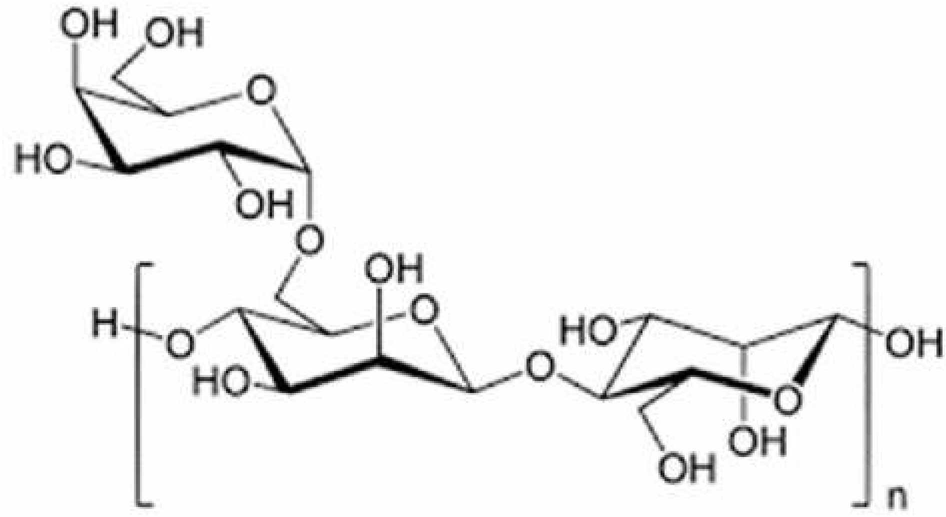

Fig.3. Molecular structure of Gum Arabic

6. PECTIN

Pectin (Fig.4), a type of polysaccharide polymer, originates from natural plants. It is widely used in the food industry as a food additive. Owing to its carboxylic and carboxymethyl functional group made it as a promising candidate for corrosion inhibition studies [10]. Pectin is a biodegradable, benign, and green corrosion inhibitor.

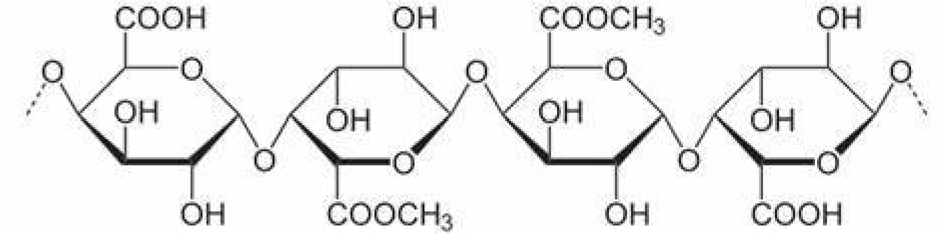

Fig.4. Molecular structure of Pectin

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Chapter 11

INDOLE - A PROMISING SCAFFOLD IN BIOCHEMISTRY

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ABSTRACT

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