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Corrosion and its control in sugar industry

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ABSTRACT

Corrosion occurs in sugar industry in various instruments and process equipments like boilers, juice extraction units, cane preparation units, heat transfer equipments etc, because of the corrosive environment created due to processing of sugar. Corrosion rates depend upon various process parameters like pH, temperature, cane juice brix, dissolved oxygen content etc. The losses due to corrosion may lead to unexpected failures, plant breakdown and poor quality & contaminated product. The remedial measures should be taken for the prevention of corrosion like application of protective coatings after the adequate surface preparation or proper selection of the materials of the process equipments.

Introduction

CORROSION is the destructive alteration of a metal caused by chemical or electrochemical interaction with the environment. It is common to all chemical process industries and sugar industry is no exception to it. Corrosion and rapid wear of factory equipment are widely recognized as major production-cost and quality problems in the sugar industry. The short life of equipment and the need for excessively frequent cleaning and maintenance - often involving disruption of crop processing - can make producing sugar an excessively expensive exercise. Even the quality of the sugar is affected.

The problem in the processing of beet and sugarcane in sugar industry is that the materials to be handled are highly corrosive and abrasive. Nature of the steels used to construct the plant equipment is another factor for the corrosion. Since sugarcane juices are acidic and contain sulfites, sulfates etc, which are corrosive in nature hence, due to the raw materials corrosion occurs in sugar industry. Corrosion also takes place due to processing conditions e.g., high temperatures, pH and prolonged contact. Not only corrosion process takes place due to these effects but abrasion and erosion also occur and almost all the equipments are affected to varying degrees. Sugar producers used to use almost exclusively carbon steel for their equipment, on grounds of its low cost but due to its poor performance in terms of corrosion and abrasion resistance, the use of carbon steel proved a false economy. Stainless steel, however, is strong on exactly these two points. The general environment created by abrasive particles, moisture, heat, acidity and exposure to the elements is hostile to conventional steels.

There are two main raw materials from which we make sugar: Sugar cane or sugar beet. Sugar cane accounts for about two-thirds of the world's sugar production.

After Brazil, India is the largest sugar producer in the world and it leads in sugarcane production. However, if alternative sweeteners such as khandsari (sort of raw sugar) and gur (jaggery) are included in the fold, then India would be the largest overall producer of sugar. Brazil accounts for approximately 22 percent of the global sugar production and India contributes almost 14 percent.

Fig. 1- Indian sugar producing states in 2006.

Sugar is a broad term applied to a large number of carbohydrates present in many plants and characterized by a more or less sweet taste. Juices of sugarcane (Saccharum officinarum) and sugar beet (Beta vulgaris) are rich in pure sucrose, although beet sugar is generally much less sweet than cane sugar. These two sugar crops are the main sources of commercial sucrose.

Manufacturing process of Sugar

Generally sugarcane is classified into three varieties early, general and unapproved. Cane is sowed during February and October every year. The first seed growth is known as the plant and subsequent growth after harvesting from the stem is known as Ratoon. The early variety has more sugar content than the general variety. Every farmer within the command area of the Mill is provided with a calendar, which tells him when he can expect a Mill Supply Ticket (Purchy), against which he will deliver the sugarcane. He then harvests the cane and transports it either in a bullock cart or tractor trolley to the mill. Cane is also

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Thermochromic compounds-A review

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ABSTRACT

Thermochromic compounds are one of the major groups of color-changing compounds. This paper aims at discussing general aspects of thermochromism and the materials used in thermochromic compounds. The mechanism of thermochromism which is responsible for change in color upon exposure to heat is also discussed. The thermochromism can be seen either in organic or inorganic, which is discussed here. The application of thermochromism in various areas is mentioned. Thermochromic compounds are used to make various paints, inks and are used widely in semiconductors. These are used for protection purposes in roads and in industries

Introduction

A compound that displays a reversible change in color as a result of a change in temperature is known as Thermochromic compound. Many metal complexes as well as organic compounds exhibit thermo-chromic properties both in the solid phase and when dissolved in water.

Thermochromic behavior arises from many types of rearrangement at the molecular level. They follow mechanisms like phase transition, change in ligand geometry, equilibria between different molecular structure, and change in the number of solvent molecules in the coordination sphere. In this paper, changes in ligand geometry, coordination number, and lattice structure are shown to lead to changes in color.

Thermochromic behavior is generally divided into two classes: continuous and discontinuous. Some color changes are gradual; the color changes slowly as the temperature increases with time. This can be due to the breaking or rearrangement of the lattice. This type of rearrangement is also known as continuous thermochromism. On the other hand, a dramatic change in color can also occur at a specific temperature or over a very small temperature range. This is known as discontinuous thermochromism.

The practical applications of thermochromic compounds are numerous. They are used to make inks that change color under certain circumstances, are used in applications such as security printing, brand protection, smart packaging, marketing and novelty printing. They have applications in room thermometers, kitchen appliances, and for medical use.

Starting with novelty items such as mood rings, many applications have entered the market in which the thermochromic compounds have become a functional part of the product like battery testers. Smart packages with an irreversible thermochromic color change could show required temperature conditions during storage or transportation of goods such as heat-sensitive pharmaceuticals or frozen food. Smart materials also interest artists and designers, creating the possibilities for the development of new creative design directions towards interaction, response and ultimate functionality. Color change technology thus offers the designer unique and challenging the design opportunities.

There are two major groups of color changing compounds are thermo-chromic and photochromic, as they are presently the most easily applied color-changing materials. Thermochromic compounds change color with exposure to different temperature. It can be manufactured to be reversible or irreversible.[1,3]

Thermochromism

Thermochromism can be defined as "the reversible change in the color of a compound with temperature". This thermochromic color change is quite noticeable, often dramatic and occurs over a small temperature range. Thermochromism is described below:

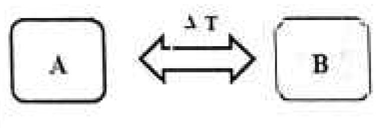

FIGURE 1.Reversible change in color from species A to species B.

From the beginning of 1970, the mechanisms of thermochromism have been investigated and today it is well established.

Different mechanisms are applicable depending upon the type of thermochromic compounds. The following four types of materials have been found to exhibit thermochromism[2,4,6,13]:

1. Organic compounds
2. Inorganic compounds
3. Polymers
4. Sol-gels.

Corrosion and its control in petroleum industry

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ABSTRACT

Corrosion in petroleum industry causes a loss of billions of dollars every year. Many cases of extensive corrosion have occurred in production tubing, valves, and in flow lines from the wellhead to the processing equipment. The reason for this is that oil and gas from the well contain varying amounts of water, which can be precipitated as a separate phase in contact with the material surface, and that this water contains gases such as CO^2 and possibly H^2S, as well as salts. In most cases of severe corrosion, CO^2 plays a major role. Uniform corrosion taking place causes 30% failures and other 70% is caused by localized corrosion. Various methods of controlling corrosion are discussed here.

Key words: Corrosion, Petroleum industry.

Introduction

EVERY industry, even every plant, has its own distribution of corrosion phenomena that occur with different frequency. About 75% of all corrosion failure takes place because of insufficient information and knowledge, as well as inadequate interaction among different groups responsible for the acceptance and approval of anti-corrosion decisions. The human factor is one of the main reasons of corrosion failures. Corrosion problems occur in petroleum industry in three main areas: (1) production, (2) transportation and storage, and (3) refinery operations. Many refineries contain over fifteen different process units, each having its own combination of numerous corrosive process streams and temperature and pressure conditions. The deterioration normally occurs very slowly, unless incorrect or defective materials were initially installed. Refinery corrosion can be also categorized as: (1) Low-temperature corrosion which occurs at temperatures below 260°C and in the presence of water. (2) High-temperature corrosion: occurs at temperatures above 260°C, with no water present.

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Petroleum Industry

The petroleum industry includes the global processes of exploration, extraction, refining, transporting (often by oil tankers and pipelines), and marketing petroleum products. The largest volume products of the industry are fuel oil and gasoline (petrol). Petroleum (oil) is also the raw material for many chemical products, including pharmaceuticals, solvents, fertilizers, pesticides, synthetic fragrances, and plastics. The industry is usually divided into three major components: upstream, midstream and downstream. Midstream operations are usually included in the downstream category.

Petroleum is vital to many industries, and is of importance to the maintenance of industrial civilization in its current configuration, and thus is a critical concern for many nations. Oil accounts for a large percentage of the world's energy consumption, ranging from a low of 32% for Europe and Asia, to a high of 53% for the Middle East, with developed nations being the largest consumers. The production, distribution, refining, and retailing of petroleum taken as a whole, represents the world's largest industry in terms of dollar value.

Corrosion in Petroleum Industry

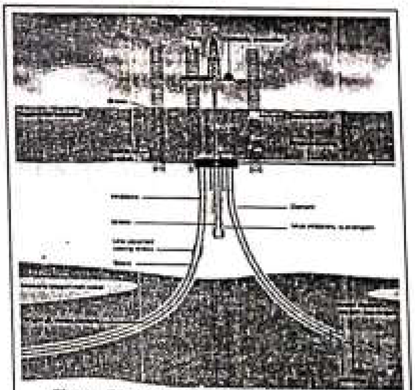

Fig.1. Corrosion in different segments of the petroleum industry

Corrosion in production

Oil and gas fields consume a high amount of iron and steel pipe, tubing, pumps, valves, and sucker rods. Leaks cause loss of oil and gas and also permit infiltration of water and silt, thus increasing corrosion damage. Saline water and sulphides are often present in oil and gas wells. Corrosion in wells occurs inside and outside the casing. Surface equipment is subject to atmospheric corrosion. In secondary recovery operations, water is pumped into the well to force up the oil.

Gelcoat used in fibre reinforced composite structure and effect of including nanofillers in it.

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ABSTRACT

Most surface coating application begins with the structure or article to be coated. The surface needs to be prepared so as to remove contaminants that would detract the adhesion of the coating. However, there are one type of surface coating system that is used in quite opposite manner. These coatings are called gelcoats. They are used in such a way that substrate is built up onto the coating so that the gelcoat becomes an integral part of the article to be produced. The optimal dispersion of the nanofillers in the resin is a key factor for achieving the aforementioned properties.

Introduction

A GELCOAT is a material used to provide a high quality finish on the visible surface of a fibre-reinforced composite material. The most common gelcoats are based on epoxy or unsaturated polyester resin chemistry. Gelcoats are modified resins which are applied to moulds in the liquid state. They are cured to form crosslinked polymers and are subsequently backed up with composite polymer matrices, often mixtures of polyester resin and fibreglass or epoxy resin with glass, kevlar and/or carbon fibres. The manufactured component, when sufficiently cured and removed from the mould, presents the gelcoated surface. This is usually pigmented to provide a coloured, glossy surface which improves the aesthetic appearance of the component. Gelcoats are designed to be durable, providing resistance to ultraviolet degradation and hydrolysis. These require very high levels of durability to overcome the mechanical and thermal stresses encountered during the curing and demoulding processes.

Gelcoat

Gelcoat is a polyester resin specially formulated with thixotropic ingredients for increased viscosity and non-sag properties. It incorporates pigments for desired colour and contains additives for controlling flow-out, gel and cure times. Polyester resin is one part of the two-pack system other being Methyl Ethyl Ketone Peroxide (MEKP). Most high quality marine gelcoats use ISO/NPG (Isophthalic/Neopentyl Glycol) resins, which are higher quality polyesters.

Standard polyester resin should not be used as a gelcoat, because it is not a coating. Standard resin does not have the same ingredients as gelcoat and has very little strength on its own. Standard polyester resin must be used in conjunction with a fiberglass material to reinforce the resin for structural integrity.

Composition of gelcoats

Gelcoat is the outer most resin rich layer over FRP moulding. It has the main function of protecting fibre and laminate from harsh environment and gives freedom to choose various colours. The actual end use decides the composition of gelcoats.

Polyester Resin

In general, polyester resins result from the reaction between a diprotic acid and a polyhydric alcohol. The cured product occurs due to both type of polymerization which are:

- Condensation polymerization: In early part of the reaction monomer concentration decreases rapidly, the molecular weight increases in an en masse fashion with time with the formation of by product.
- Addition polymerization: Polymerization occurs in a fast way reaction occur over whole period unlike condensation reaction. No by-product is formed.

Main component of unsaturated polyester are:

- **Unsaturated polyester:** fumaric acid and maleic anhydride, these compounds forms polymer backbone which have sites for cross linking.
- **Saturated acid:** Degree of spacing or concentration of unsaturated acid is determined by it, e.g. phthalic anhydride or isophthalic acid.
- Glycol for bridging of acid, e.g. propylene glycol or neopentyl glycol.
- Unsaturated monomers such as styrene, at end of reaction they react with backbone unsaturation to form cured product, until then it act as a solvent.

Condensation polymer occur with first three of the above components and

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Corrosion due to microorganisms

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ABSTRACT

Corrosion due to microorganisms is also known as biocorrosion or Microbiologically Influenced Corrosion (MIC). There are several types of microorganisms present in environment that cannot be seen individually with the unaided human eye like bacteria, archaea, fungi etc., which are responsible for corrosion of metals via electrochemical mechanism and deterioration of non-metallic materials. The biocorrosion takes place due to the fixation of bacteria, release of metabolites and formation of biofilms that induce or accelerate the corrosion process. This type of corrosion takes the most severe form in soils, saline environment and humid environment. It is estimated that about 20% of all damages caused by corrosion are influenced by microorganisms; hence it is very important to understand the basic mechanism of microbial corrosion in order to minimize the losses and accidents due to corrosion in various industries. This review describes the types of microorganisms which are responsible for bio corrosion and the mechanism behind this corrosion.

Introduction

CORROSION is the deterioration of metal as a result of chemical or electrochemical reactions on the metal/solution interface. The electrochemical process is the most common in nature and consists of irreversible redox reactions which results in the formation of corrosion cell. In non-metals the corrosion takes place in the form of deterioration for which several factors are responsible like temperature, humidity, UV light etc. Microorganisms are one of the biggest factors for the corrosion in metals as well as non metals. Microbiological corrosion may be defined as the deterioration of a metal by corrosion process which occurs directly or indirectly, as result of the metabolic activity of microorganisms.

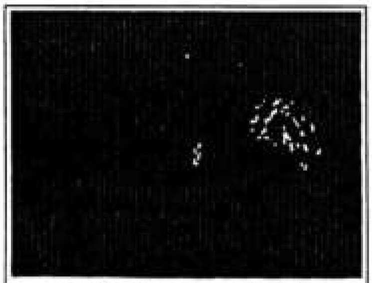

Fig.1: A typical figure of Microbial corrosion on iron surface.

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Microorganisms of interest in microbial corrosion belong to many types such as sulfur-sulfide oxidising, sulfate-reducing, iron oxidising, acid producing, manganese fixing and ammonia and acetate producing bacteria and fungi. It is essential to understand here that microbiological aspects of corrosion are different from microbiological fouling which are often encountered in water pipelines and on the metallic surfaces exposed to miscellaneous aqueous environments.

The Influence of Microorganisms on Corrosion Process

Microorganisms contribute to the corrosion by one or more of the following factors, each of which is dependent upon the physiological characteristics of the microorganism:

1. Direct influence on the rate of cathodic or anodic reaction.
2. Change of surface metal film resistance by their metabolism or products of metabolism.
3. Creation of corrosive environment.
4. Establishment of barrier by growth and multiplication so as to create electrolytic concentration cells on the metal surface.

Microorganisms supply oxygen, carbon, nitrogen, hydrogen, or sulfur which is necessary to their metabolic process hence they must have certain inorganic and organic chemical compounds to develop and grow. These compounds vary in terms of quantity and chemical composition depending upon the necessity of specific microorganisms.

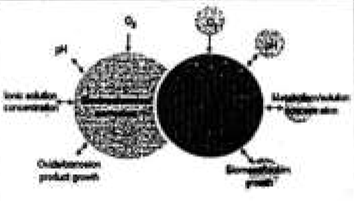

Fig.2: Microbilogical process and electrochemical corrosion.

The microorganisms associated with corrosion should not be considered in any sense as being restricted to a soil or soil type as compared with an aqueous environment, or vice versa. Availability of various inorganic and organic nutrients in a given environment together with other factors, such as pH, oxygen concentration, and temperature will determine whether or not microbiological development can take place.

The role of Biofilms

The term biofilm describes a range of microbial associations. In aquatic environments, microbial cells attach to solids, including metals. Immobilized

Corrosion in food processing industry

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ABSTRACT

One of the most important parts in food chain is to consume safe and hygienic food with a good quality. It is really important to keep the food safe from beginning i.e. during its production and all other stages in food distribution, storage, and consumption. Food processing industry is one of the largest manufacturing industries around the world. In a typical food processing plant, equipment of varying ages, constructed of a myriad of materials, including carbon steel, aluminum, stainless steel, copper and plastics can be found. Corrosion is an enemy of many of these materials. The maintenance department of food processing plant battle against the effects of corrosion constantly for necessary food quality requirements. The requirements of food quality lead most plants to use stainless steel as the main material for equipment.

Introduction

THE economic development of any region, state or country, depends not only on its natural resources and productive activities, but also on the infrastructure that account for the exploitation, processing and marketing of goods. Irrigation systems, roads, bridges, airports, maritime, land and air transport, school buildings, offices and housing, industrial installations are affected by corrosion and therefore susceptible to deterioration and degradation processes.

Corrosion is a worldwide crucial problem that strongly affects natural and industrial environments. It is generally accepted that corrosion and pollution in some areas are interrelated harmful processes since many pollutants accelerate corrosion and corrosion products such as rust, also pollute [illegible] bodies. Both are pernicious [illegible] that impair the quality [illegible] environment, the efficiency [illegible] industry and the durability [illegible] infrastructure assets. Therefore [illegible] essential to develop and apply [illegible] engineering control methods [illegible] techniques.

General considerations

The chemical composition of the metals and food processing environment is crucial as it will determine the possible corrosion reactions, the corrosion product formed and hence its ability to adhere to the metal and reduce metal loss or enter the food media, exposing more metallic surface and enhance metal loss. Food stuff contains a lot of chemicals (mainly organic), and which when allowed to stand can become substrates for much microbial activity which may lead to the production of chemical products that may be more aggressive to metallic material. The organic acids present in foods are the most important corrosion agents. The effects of these chemicals can be influenced by the environmental conditions of processing such as [illegible]erature, flow rate, viscosity of the [illegible] media, and presence of stresses in [illegible]tem.

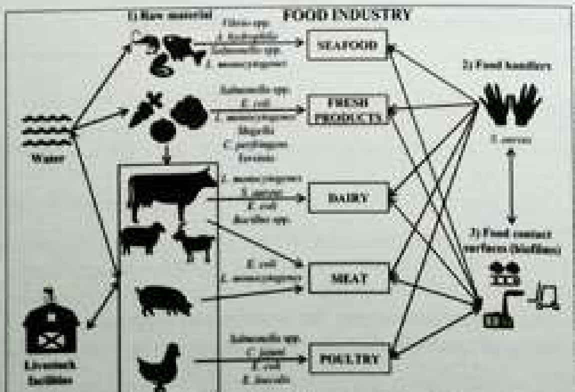

Fig.1: Schematic representation of the main sources of contamination in food industries.

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[illegible]ble toxic effects

Metals are capable of resisting corrosion. Tin coated cans and aluminum cooking utensils has established its non toxic nature in short and long term. Coated steel is also used for processing plant and for cans but a little health hazard is created when the iron is exposed by breakdown of the protective film. Hence, stainless steel is widely used in large scale food industries. Nickel, Chromium, Molybdenum as alloy component are considered safe. Similarly magnesium is used as an alloy component with aluminum for beverage cans. Copper was used before advent of stainless steel and now used as piping for domestic water distribution. Lead and cadmium are very toxic substances and are prohibited from contact with food.

Hygiene

We know that food contains beneficial bacteria but the food poisoning caused by entry of harmful bacteria must be prevented by regular removal of food residues and by proper designing of food contact surfaces so that the sites for colonization (e.g.

Corrosion in non-ferrous metals - Part-2

Corrosion and protection of Aluminium

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ABSTRACT

Corrosion in any form is dangerous whether it is on iron or other metals or even non metallic materials also. Some metals are known for their high corrosion resistance properties. Aluminium forms an oxide layer which protects itself. Degradation of this oide layer causes further corrosion in aluminium. Hence, the metals other than iron also corrode significantly which we will discuss in this paper. In this paper we will discuss about alumina, process and types of corrosion taking place on aluminium surfaces and a little about automotive paint shops for aluminium substrates.

Introduction

CORROSION is normally observed on iron and steel surfaces in our day to day life in the form of brown oxide layer of iron. When it comes to the other non ferrous metals, generally the extent of corrosion is less as compared to ferrous metals. Apart from ferroos metals, aluminium is one of the most producrd metals worldwide because of its numerous beneficial properties. Earlier aluminium was not in very much use because of the difficulties faced in its extraction. By the end of 19th century the electrolytic reduction of aluminum oxide suggested by Hall & Heroult made the extraction of aluminium very easy and this method was accepted globally. The reason behind the large usage of aluminium are its very useful properties like:

1. Light weight and electrical conductivity e.g., applications in electrical industry and aircraft manufacturing.
2. Wide range of strengths and ease of fabrication e.g., application in automobile industry. Almost all engine parts are made of aluminium by casting in various shapes.
3. Corrosion resistant, non-toxic, recyclable etc.

But corrosion of aluminium also takes place as it is the law of nature. When aluminium surfaces are exposed to atmosphere, a thin invisible layer of aluminium oxide is formed on its surface which protects it from further corrosion. High corrosion resistance of aluminium is due to its self protecting characteristic.

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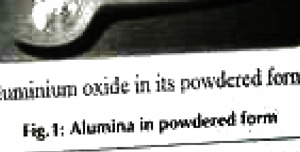
Aluminium Oxide

It is commonly known as alumina and have different names depending upon forms and applications. Natural form of aluminium oxide is corundum. Rubies and sapphires are gem-quality forms of corundum, which owe their characteristic colors to trace impurities. Rubies are given their characteristic deep red color and their laser qualities by traces of chromium. Sapphires come in different colors given by various other impurities, such as iron and titanium.



Aluminium oxide in its powdered form.

Fig.1: Alumina in powdered form

Aluminium oxide is amphoteric in nature and hence it shows activity both towards acids and bases, the reactions are given below:

$Al_2O_3 + 6 HF \rightarrow 2 AlF_3 + 3 H_2O$

$Al_2O_3 + 2 NaOH + 3 H_2O \rightarrow 2 NaAl(OH)_4$ (sodium aluminate)

This layer of aluminium oxide provides protection to the metal from further degradation. Unless exposed to some substances or conditions that destroy this protective layer, the metal remains fully protected. Aluminium is highly resistant to weathering, even in industrial atmospheres that often corrode other metals. This naturally forming film is made up of two layers which normally have a total thickness of about 7 nanometers. The lowest layer is termed the barrier layer & it is amorphous and has no structure. The layer that grows on top of this is hydrated & less compact. It tends to grow at high humidities or with contact with water. The air formed passive layers are very stable & result in very low corrosion rates in neutral environments.

Corrosion of aluminum in water

Corrosion of metals is an electrochemical reaction which involves oxidation of the anode into a positive ion, which is released from the solid metal. Aluminium acts as the anode and the water as the electrolyte in the system of aluminium and water. Cathodic reactions common in the system are reduction of hydrogen ions to hydrogen and reduction of oxygen to either hydroxide (in alkaline or neutral media) or water (in acidic media). Copper ions from the water can also be reduced. The oxidised aluminium results in $Al(OH)_3$, which is insoluble in water and having secondary metabolites, which is responsible for a certain pharmacological activity. Persistent exposure to heavy metals can cause deleterious health effects in humans. Molecular understanding of plant metal accumulation has various biotechnological implications also, prolonged effects of which might not be yet known. Universal discussion is on the use of Ayurveda metallic preparations and their use. The use of herbal medicine in developing countries has been increasing recently. Some of the herbs specifically absorb the toxic heavy metals from the soils, which in turn can be operated to clean the soils. Numerous metallic preparations are in clinical practice since 12th century. They have selective procedures for detoxification and *Bhasma* preparation, which becomes appropriate for clinical practice. Since centuries these preparations are supporting themselves in clinical practice, thus one cannot just merely write off its practice just by supposing that heavy metals are toxic. Correct systematic certification is the request of time to authenticate the claims about these metallic preparations. It has now been made mandatory according to WHO guidelines that herbal products should be tested for their heavy metal content prior to export.

Keywords: Ayurveda, heavy metals, toxicity, phytoremediation

CH-08

STUDIES ON THE EFFECT OF STRUCTURE AND THICKNESS OF COATINGS AND CONTAMINANTS ON THE CORROSION OF STEEL SURFACES

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The presence of soluble salts *(chloride, sulphate & nitrate)* and their effect at the coating-metal interface was studied along with the chemistry of coating, water and oxygen permeability, coating thickness and metal surface preparation. Of course, the macroscopic defects, caused due to improper designing, handling, etc. can also not be over looked. What so ever the coating be the surface anomalies have their own role in deciding the coating life. Nevertheless there are still some coating systems which can reduce or postpone corrosion mechanism. Five different popular, coating systems (e.g. phenolic, polyurethane, cardanol, vinyl & alkyd) were exposed to humidity for different time, 100 and 400 hours, and the under film corrosion was determined. The study reveals that carefully designed coating systems applied on the substrate with some fundamental knowledge can significantly improve the performance of coating and metal protection as well.

Keywords: Soluble Salts, Corrosion, Metal protection, Film defects.

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Preparation and characterisation of acrylic resin for electro-deposited mono-coat coatings

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ABSTRACT

Acrylic resins are known for their multifarious characteristics. Diversified properties of acrylic resins have been utilised for the development of acrylic cationic electrodeposition multicolour mono-coat corrosion protective coatings by acrylic graft polymer of methyl acrylate, butyl acrylate, styrene, and methyl methacrylate in the presence of hydroxy propyl acrylate at 113–117°C in the presence of AIBN (Azo-bis iso-butyronitrile) as the initiator. The concept was to develop acrylic graft polymer wherein chemical bonds are protected against UV radiation 400 h or 18-month outdoor exposure. Developed acrylic resin has special characteristic e.g. excellent metal protection against corrosion 500 h salt spray test as per ASTM B117, excellent durability, economical primer, and finish coat in single application and meeting the International and National legislation. Resulting polymers were characterised by using FTIR spectroscopy, particle size analyser and other Morden instrumental techniques. Thus the obtained polymers have high solid content (72 ± 1%) and can be used in electrodeposition emulsion paint as a binder. The coatings are mono-coat prepared and their anticorrosion behaviour is discussed in this paper. The experimental results depict that the resin thus synthesised has high anticorrosive property, UV light stability, and excellent weather resistance.

KEYWORDS
Acrylic resins; emulsion paint; corrosion protective coatings; mono-coat

Nomenclature

AIBN	Azo-bis iso-butyronitrile
DTBP	Di tertiary butyl peroxide
UV	Ultra Violet
VOC	Volatile Organic Compound
FTIR	Fourier Transformed Infra-Red Spectroscopy
TBC	Tertiary Butyl Catechol
MMA	Methyl Methacrylate
BA	Butyl Acrylate
MIBK	Methyl Iso Butyl Ketone
MEK	Methyl Ethyl Ketone
ASTM	American Society for Testing and Materials

1. Introduction

Acrylic resin has been used in almost all auto industry in primer paints and topcoat paints [1]. The synthesis and application of electro-depositable acrylic resin is a breakthrough in the paint industry as mono-coat coatings. Acrylic-based electro-depositable mono-coat is newer technology which is

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Non isocyanate polyurethane using glycidyl acrylate monomers

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ABSTRACT

Green Chemistry enables us to think beyond the conventional materials synthesized for different applications. One such approach is the development of polyurethanes via an isocyanate free route. The chemistry is broadly based on the reaction of cyclocarbonate groups and primary diamines. The cyclocarbonate groups are synthesized by carbonation of epoxy moieties. This opens a door for new possibilities of structure property variation in the Non Isocyanate PolyUrethanes (NIPU) and also leads to synthesis of hybrid acrylic PU and hybrid epoxy NIPU. The two monomers mainly discussed in this paper are Glycidyl acrylate and Glycidyl methacrylate which are synthesised by the reaction of epichlorohydrin with acrylic acid and methacrylic acid respectively. These monomers are then polymerized via free radical polymerization to produce glycidyl acrylate simultaneously reaction with carbon dioxide to synthesize a polymer having both epoxy groups and cyclocarbonate groups in the side chains. NIPU can also be synthesized from renewable resources also. NIPU has wide applications and can be replacement of conventional PUs in future.

Keywords: *cyclocaronate, hydroxyurethane, glycidyl acrylate, Glycidyl methacrylate*

Introduction

GREEN Chemistry principles 3, 4, and 12 are 'Less hazardous chemical synthesis', 'Designing safer chemicals' and 'Safer chemistry for accident prevention' respectively. These suggest us to think beyond the conventional methods of material synthesis. Since some conventional methods are not only less efficient but also hazardous for health and life. The toxic and health hazard materials must be replaced with safer ones and if possible some renewable sources must be chosen for synthesis of materials as per Green Chemistry principle[1].

Polyurethanes are synthetic polymers which are produced by reaction of diisocyanates and polyols. The repeating unit of polymer contains carbamate linkage, also called urethane linkage (figure below). The monomers cannot be manufactured without elaborate safety devices and huge investment.

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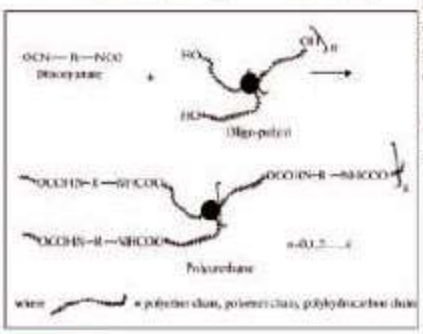
Isocyanates are also considerably toxic and moisture sensitive. Growing global awareness of the need to protect our environment and continually strive to ensure the safety, health and well-being of those in the industry and consumers has created a demand for environment-friendly products.

Polyurethanes based coatings are very popular due to their excellent chemical and mechanical properties. Apart from coatings PU find vast applications in various foams, elastomers, adhesives and sealants. The demand in PUs is growing continuously and it is expected to reach a worldwide production level of more than 22.5 million tons by 2024, which was 18.4 million tons in 2019. PU coatings are mainly used as top coats over primed surfaces or an intermediate coats because of various properties like (a) High gloss colour finish (b) Tough and abrasion resistance, excellent in area of high wear (c) Hardness and flexibility is very good (d) Good chemical resistance (e) Excellent weather ability; resistance to high levels of UV and extremes of weather. In addition the PU coatings are also recently being used directly on the cleaned metal surface without any primer. This is one of the most popular high performance coatings especially in pipeline coatings, sea-shore applications and, marine coatings.



Problems in conventional PUs

1. **Isocyanate Toxicity** : Isocyanates are synthesized from an even more toxic predecessor, phosgene, which causes environmental hazards. Exposure to isocyanates can result in

A review of different smart coatings

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ABSTRACT

Today's coatings are becoming smarter day by day. They hold answers to some of unmet demands in different markets like automotive, industrial, marine, aerospace etc. And, it's really well sustained by intense growth of smart additives and new preparation methods. Smart Coatings are coatings, but with predefined properties and special films, which make them sense and respond to environment and other external stimuli. Smart coatings are made of programmable materials with a variety of physical, chemical, electrical and mechanical properties. These materials can changes in light, pressure, chemical, heat along with other stimuli. Several smart coating systems have already been developed and examined, as a result they are currently under investigation by numerous laboratories and industries across the world. Examples of smart coatings include stimuli responsive, antimicrobial, antifouling, conductive, self-healing and super hydrophobic systems.

Keywords: *Smart Coatings, Nano-Coatings, Trends in Coatings, Advance Technologies, Pigment*

Introduction

PAINT was among the very first innovations of humanity. Some cave paintings with red or ochre colours, that is hematite, yellow manganese oxide, and charcoal might have been produced by extremely early Homo sapiens as long as 40,000 years straight back.

In the last 25 years numerous coatings technologies have evolved influenced by the necessity to lower Volatile Organic Contents (VOC) alongside to cut back the usage of expensive petroleum based solvents. Waterborne, powder, UV-curable and solids being huge have actually had development this is actually significant. Usually, these coatings had the principal functions of protecting and substrates which are enhancing. As well as VOC decrease, significant efforts have-been directed to understanding the standard clinical concepts that control coating formulation, residential property enhancement, and its particular toughness. It is certainly interesting in past years, coatings studies have taken an alteration. Nanotechnology, is the usage of matter for an atom[ic], molecular, and scale that supramolecular professional function[s]. It is the major technology driver in the area. Such impact is mainly as a result of development of innovative particle systems such as: polyelectrolyte, these are the polymers whose repeating units are an electrolyte group.

Polycations and polyanions are also the polyelectrolytes. These groups dissociate in aqueous solutions (water), making the polymers charged. Liquid crystals (LCs) are a state of matter in which particle properties existsin between conventional liquids and solid crystals. As an example, a liquid crystal may flow like a liquid, but its molecules can be oriented in a crystal-like way. Liquid Crystal technology is employed in pressure vulnerable paint and many other paint systems. Conductive polymers are those whose repeating units can conduct electricity.Such substances may have metallic conductivity or can be semiconductors. These innovations are enabling the look of coatings unique with exceptional properties and also at the same time, [pe]rmitting the control over the [ma]nufacture/design of the coating on [mo]lecular scale.

Recently, there has been [de]velopment in study and development [t]ogether with commercial product of coatings which have novel functions. The products sense and communicate with their environment. Much more especially, a smart coating is the one which detects changes in its environment, interacts and responds to modifications while keeping its compositional integrity. The modifications it may respond feature light, pH, biological elements, stress, temperature, polarity, etc. Therefore, a good coating is tailored in a way any particular one or more associated features could be "switched in" or "switched down' with respect to the type and strength of a outside signal.

Self-cleaning coating

Self-cleaning coatings, while the name suggests, have a special functional property and after this the word Lotus effect and self-cleaning are synonymous. Although these surfaces could be soiled and manual cleansing is needless and

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Synthesis and Characterization of Glycidyl Esters of Acrylic and Methacrylic acids for NIPU Coatings

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Abstract: *Glycidyl acrylate (GA) and Glycidylmethacrylate (GMA) are the reaction products of the epichlorohydrin (ECH) with acrylic acid (AA) and methacrylic acid (MAA) respectively. These monomers were synthesized via two different routes i.e. direct reaction of AA and MAA with ECH and second by reaction of AA and MAA with Sodium hydroxide to form sodium salt of the acid followed by reacting with ECH. The polymerization inhibitor used was tert-butyl hydroquinone (TBHQ) and catalysts used were triethylamine (TEA) and quaternary ammonium salt. Experimental results show that first route is suitable for synthesizing GA and second route is suitable for synthesis of GMA. The catalysts also have drastic effect on the conversion to the respective glycidyl esters. The study of the effect of catalyst and polymerization inhibitor has been carried out via both routes.*

Keywords: Diethylamine, Epichlorohydrin, Glycidyl acrylate, Glycidyl methacrylate, Triethylamine, Tert-butyl hydroquinone

I. Introduction

Glycidyl acrylate and glycidyl methacrylate are very important monomers and they find application in industrial polymers, surface coatings etc. One of their uses is in synthesis of non isocyanate polyurethanes. These monomers have a characteristic double bond and epoxy ring in the same molecule. Double bond is utilized in the radical polymerization of these monomers and epoxy functionality is used for reaction with carbon dioxide to create cyclic carbonate groups. In this paper these monomers have been synthesized by two different routes. These are one of the very starting raw materials for the synthesis of Non Isocyanate Polyurethanes (NIPU).Polyurethanes based coatings are very popular due to their excellent chemical and mechanical properties, but due to some drawbacks like toxicity of isocyanates, moisture-sensitivity and environmental regulations, a need of development of an environment friendly polyurethane was felt in across the coating world. Non isocyante routes for synthesis of PU are very important step which is mostly based on cyclic carbonate + aliphatic/cycloaliphatic amine chemistry[1]. The main challenge is to retain the positive characteristics of conventional PU in the new chemistry.PU coatings are mainly used as top coats over primed surfaces or an intermediate coats because of various properties like (a) High gloss colour finish (b) Tough and abrasion resistance, excellent in area of high wear (c) Hardness and flexibility is very good (d) Good chemical resistance (e) Excellent weather ability; resistance to high levels of UV and extremes of weather[2]. In addition the PU coatings are also recently being used directly on the cleaned metal surface without any primer. This is one of the most popular high performance coatings especially in pipeline coatings, sea-shore applications and, marine coatings.

Polymeric epoxides can be converted into corresponding five-membered cyclic carbonates effectively by reacting with carbon dioxide and this process is called carbonation of epoxy rings. It is one of the most inexpensive methods to incorporate CO_2 into organic compounds. The general reaction of epoxy ring and CO_2 is shown in figure (Fig.1)[3].