Investigating the Properties, Applications and Dynamic Factors of Conductor Polymers as anintelligent Material

Abstract

There arenumerous cases of materials responsive to the actuator in the nature that have been an inspiration to researchers in various fields over the years. Existing samples in the natural systems cause scientists to synthesize intelligent polymers with wide, emerging and useful applications in order to simulate the performance of these organisms such as the leaves of a kind of plant (Mimosa Pudica) whose leaves are shrunk as a result of touching, sunflower that is turned towards the sun, pine tree fruit whose blades are opened because of the humidity of the environment and are shrunk in the dry environment, chameleon skin whose color is changed with the change of environment.

Although the nature has put forward endless ideas for the design and production of new materials, but creation of artificial systems with the controlled responsive ability and pre-determined process is a huge challenge for scientists. Conductor polymers are a new generation of conductor materials that have consolidated their position among the materials. Conductivity and resistance of these polymers are changed with the absorption of gas or liquid vapor. This paper examines the properties and applications of conductor polymers as anintelligent material.

1- Introduction

Intelligent polymers are a class of synthetic polymers with unique physical-chemical properties that have many applications in the technical and commercial fields since the creation. Stimuli-responsive polymer, environmentally-sensitive polymer and intelligent polymers are another letter from this category. A unique feature of these polymers includes rapid macroscopic structural changes, often physical or dimensional reversible of color, permeability, shape and the so on due to their exposure to the slightest effect of a certain stimulus [4].

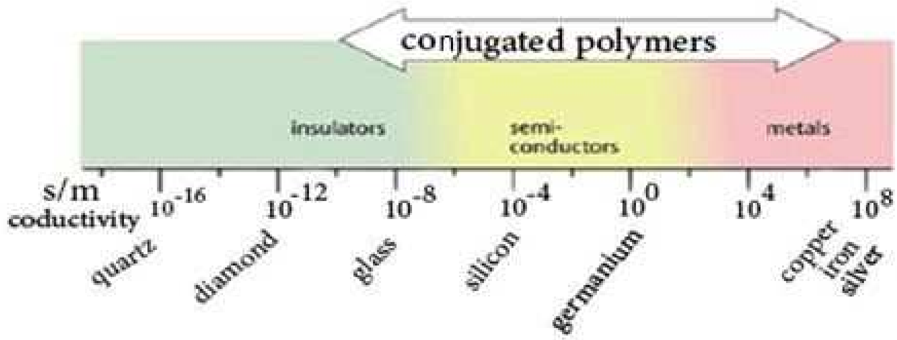
The researchers of the University of Michigan in the America were the first group who made intelligent polymer in 1988 using electro rheological fluids. Viscosity of this intelligent polymer almost suddenly changed by applying the smallest electric current. This was the first time that “intelligent” word was used for a polymer. Environmentally-sensitive materials are gradually used [3].

Until about forty years ago, all of the carbon-based polymers are considered an insulator and the idea of the electrical conductivity of plastics was meaningless and they are used extensively in the plastics electrical industry as an insulator. This narrow view quickly changed with the discovery of conductor polymers. Shirakawa et al (1958) are prepared black powder of acetylene. They found that the obtained product has the semi-conductive or conductive properties between $7\times10^{-9}-7\times10^{15}\,s.m$ according to its preparation requirements. It remained as a scientific mystery until 1976, when student of the Mr. Shirakawa tried to synthesize the poly acetylene and a thin film of silver was synthesized as a mistake. His error was that he has taken the Ziegler-Natta catalyst $(Ti(O-n-But)_4-Et_2Al)$ a thousand times more.The study of this film represents that its conductivity is about black powder of poly acetylene. However, it is found that by halluzination of this film, its conductivity become one billion time more.

Silver non-doped polymer is insoluble and its conductivity is about semiconductors but its poor oxidation with compounds such as iodine caused to become a gold film that had a conductivity of about $10^4 s.m^{-1}$. In later years, other polymers were synthesized with this feature. Conductive polymers are polymers with conjugate π electrons (such as conjugated bonds C = C) which have electronic properties.

This group of polymers are easily oxidized and reduced compared to the conventional polymers. Conductor polymers such as polypyrrol, polythiophene and polyaniline polymers have complex dynamic structures that are used in intelligent materials research [5]. The application of electric stimulus can cause severe changes in the chemical, mechanical and electrical properties of the conductive polymers. If there isa correct understanding about the synthesis of conductive polymers as well as the rate of properties change by an electric actuator, the complex properties can be controlled. Figure 1 shows the conductivity span of the conductor polymers compared to the other conventional materials.

Figure 1: Conductivity of the conductor polymers compared to the product materials [8].



The properties of conductor polymers are as follows:

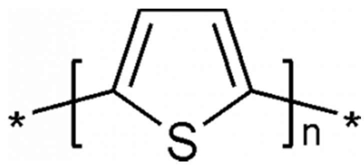
- Electrical properties
- Magnetism properties
- Optical properties
- Wettability properties
- Mechanical properties
- Absorption properties of electromagnetic waves

2. Types of Conductor Polymers

• Polythiophene

Polythiophene is taken into consideration during the last twenty years because of interesting properties and diverse applications. Yet, a lot of Poly-alkyl derivatives are synthesized using chemical and electrochemical methods that lead to better solubility and higher energy storage capacity of these polymers [6]. Polythiophene can be used as garment distribution in electron beam lithography as well as active semiconductor material in the organic thin film transistors because of the electrical properties and thermal stability and good environment.

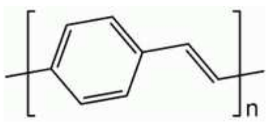
Figure 2: Polythiophene structure



• Poly (para phenylene vinylene)

Poly (para phenylene vinylene) is a conductive polymer from hard polymers family with high crystallinity. Poly (para phenylene vinylene) is one of the important polymers in electronic applications such as photo-voltaic devices and LEDs. Also, by entering the functional groups into the polymer, its physical and electronic properties can be changed.

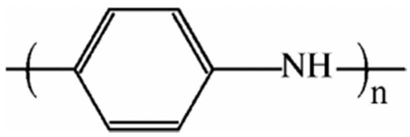
Figure 3: Poly (para phenylene vinylene) structure



• Polyanilin

Polyanilin is one of the oldest artificial conductive polymers that its high electrical conductivity has attracted much attention. In fact, Polyanilin is known as a polymer redox and it is prepared by chemical and electrochemical in the acidic environment and the selection of the method is dependent on its type of application. If thin films, better properties are required then the electrochemical method is recommended. Polyanilin is used for batteries due to a variety of structures, radiation and thermal stability, low cost, ease of synthesis and conductivity properties in various fields including microelectronics, corrosion coatings, sensors and electrodes.

Figure 4: Polyanilin structure

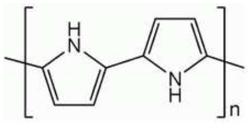


• **Polypyrrol**

Most of the study is conducted on the Polypyrrol polymers among the conductive polymers because of the ease of synthesis, good redox properties, remain stable in the oxidized form, capable of high electrical conductivity, water solubility, availability of commercial and useful electrical and optical properties.

Polypyrrols have numerous applications due to the good intrinsic properties in the batteries, electrochemical biosensors, conductive textiles and fabrics, anti-static coatings and drug delivery systems. Polypyrrol intrinsic properties depends on its intrinsic electro polymerization conditions [6].

Figure 5: Polypyrrol structure



- Applications of the Conductor Polymers

The applications of the conductor polymers are as follows:

• Nanoelectronic Devices: transistors and light distribution diodes

• Sensors: Gas and chemical sensors, optical sensors and biosensors

• Catalyst: Optical and chemical catalyst and electro catalyst

• Save energy: solar cells, fuel cells and lithium-ion batteries

• Microwave absorbing and electromagnetic frequency interference preserver

• Electro-rheological fluids

• Biomedical applications: drug delivery and purification of proteins, tissue engineering, neural interfaces and actuators

4. Methods of Conducting Polymers

There are three methods for conducting polymers:

- The development of the polymer with semiconductor main chain that has alternate dual-band and its conductivity increases with an operation called doping.

In this way, the polymers are became electricity conductive without adding conductor materials. Common form of all polymers that have electrical conductivity capability is that simple and dual bonds are placed alternately in their molecule structure.

Some of the dual bonds are released in the case of dopingand clouds of electrons moving along the chain. In this case, the electricity conductivity reaches up to 400 thousand Siemens per centimeter for some polymers [3].

The main problem with this type of conductivity is the low stability of the electrical conductivity state. For some polymers after a few weeks, the conductivity is decreased to powers of ten. Another problem of this conducting is that the doped polymers are infusible and insoluble and therefore their process is almost impossible in the industry. This procedure requires the design and construction of reactors and acquires technical knowledge to produce these materials that is prevented the wide use of this method.

- Put the electrical conductive coating on the polymer

In this method, the polymer setting claddings is done with metals, metal oxides or semiconductor. The important problem in this conducting is that the coatings are often drawn on the polymer surface using (steam leak in a vacuum) process and they are often unstable in terms of chemical- by oxidation in air- or mechanical – wear and adhesion resistance. Also, the high cost of some physical processes which are used for this purpose and inefficiency in some applications are among the usage problems in this method.

- Addition of the electricity conductor material to the polymer compound

Today, there are a variety of additives to create the electrical conductivity of polymers such as nickel, silver, stainless steel and carbon in various shapes and sizes, such as powders, flakes and long and short fibers.The use of fibrils are common in the various applications such as electrostatic painting and wasters of static electricity load. Most of the fibrils are used in the plastic molded of the interior and exterior of the cars. The other applications include shields against electromagnetic waves or radio waves (EMI / RFI), ESD and sensitively-temperature or sensitively-pressure conductive polymers [5].

Among the various additives to provide electrical conductivity, carbon black is the most common and effective material to create electrical conductivity because it is cheaper and lighter thanthe other materials. With the addition of carbon black to the polymer, conductivity increases but mixing process and production become difficult and mechanical properties are decreased. Also, because the conductor fumes are more expensive than polymers so a lot amount of them increases the final expense of the production.

5. Review three important use of conductor polymers

- Cathode Anti-corrosion coatings and electrolyte dams

This invention investigates the way to increase the corrosion resistance to the metals. There are many benefits against the existing methods. This system has a cathode coating with polymeric compounds and sacrificial metal particles. One of the corrosion-resistant coatings are barrier coatings such as chrome- nickel coatings which are separated metal from the surrounding environment. These coatings have corrosion inherent potential due to the electro-chemical activity and they cause problems by forming galvanic cell. The other coatings are sacrificial coatings that react with corrosive environment and they are consumed but they become the protective substrate.

This type of coating is divided into subsets such as chemical reactants, chromate coatingand electrochemically active coatings (including materials such as aluminum, cadmium, magnesium and zinc)and it is known as cathode protection. Old methods are problematic because of environmental problems and vaporize of coatings.

The new coating system is presented in this invention in order to solve the corrosion problems of different areas effectively, economically and proportional to environment. The developed coating is useable for ferrous and non-ferrous areas and cathodic corrosion control is done with the help of coating by conductor polymers and sacrificial anode metal components.

The coating is done with pre-mixing of the conductor polymers with anode metal compounds and there is a conductive composite of metal polymer to create two kinds of coatings to prevent corrosion. In this method, the diffused metal galvanic anode particles are combined in a conductive polymeric area and create a conductive composite. This coating is applied to the surface of the area metal and provides cathodic protection, which increases corrosion resistance.

A proper coating is created by mixing a resin binder selected from the waterproof and anti-soluble resins group and a modifying agent with the mixture. The act of mixing metal particles is done with conductive polymeric area at a temperature of 100 to 220 ° F for sufficient time in order to remove the hydrogen gas from the mixture.

In the mixture, first the desired compound is mixed with the resin binder and the next phase involves mixing with modifying factors. Also, this method includes the step of combining certain amounts of polymer clay by mixture before synthesize the composite mixture with the resin binder and modifying factors. The volume percentage of conductor polymer is 1 to 35% of coating and the metallic volume percentage is 5 to 20% of the total coating. The combination of the conductive polymer involves one of the poly aniline, lingo sulfuric, Polypyrrol, Polythiophene, poly acetylene and poly phenylene polymers.

Metal particles are made of aluminum, magnesium, cadmium, zinc and alloys of these metals. The resin binder is also from the epoxy graves, natural resins, acidic resins and polyester. The combination of modifier can be one of the sulfonamide, indrid compounds, free radicals and amino types. The coating is done with powder method and electrostatically.

- Separation of chromium from the plating industries wastewater using polymeric coatings and compositions and comparing them

This study examined the possibility of using conductive polymers in the separation of chromium from the plating industries wastewater and the results are compared with the different surface absorbents. The results showed that the poly aniline has optimal performance in the removal of chromium ion with the 59.6 percent among the conductor polymers. However, the Polypyrrol has no optimal performance in the removal of chromium ion from the plating industries wastewater with 8.2 percent.

This study also examines the effect of conductor polymers composite on the chromium removal.

The results show that the removal percentage of chromium from the sewage is decreased in the polyvinyl and quartz and conductor polymers composite compared to the normal state. However, the removal percentage of chromium from the sewage is increased in the quartz and Polypyrrol composite compared to the normal state [7].

- The effect of different surface absorbentsand cationic exchangers

According to the results of the effect of different surface absorbents and cationic exchangers, maximum removal of chrome is related to the cationic exchanger of pyrolite type 302 with 85.7 percent and the minimum removal is related to the quartz with 14.3 percent. The priority of chrome removal in the sewage used for consumer absorbents is for cation exchanger of 302 pyrolite, cation exchanger of AMBERJET, bentonite, anthracite and quartz.

Table 1: The effect of different surface absorbents in the chrome separation

Chrome concentration	Cation exchanger of 302 pyrolite	cation exchanger of AMBERJET	anthracite	Bentonite	quartz
Initial concentration (ppm)	28	28	28	28	28
Final concentration (ppm)	4	5.7	23	19	24
Removal percentage (%)	85.7	79.6	17.9	23.1	14.3

Table 2: The effect of conductive polymers on the separation of chrome

Chrome concentration	Polyanilin absorbent	Polypyrrol	The mixture of poly aniline and Polypyrrol with 1-2 ratio	The mixture of poly aniline and Polypyrrol with 1-3 ratio
Initial concentration (ppm)	28	28	28	28
Final concentration (ppm)	11.3	25.7	19	24.4
Removal percentage (%)	59.3	8.2	32.1	12.8

The removal priority for different absorbents and conductor polymers is obtained by comparing tables 1 and 2.

Quartz <anthracite <bentonite <poly aniline < AMBERJET exchanger < pyrolite cation exchanger <Polypyrrol

- The effect of conductive polymers composite

According to the results of the effect of the conductive polymers composite in table 3 for alcohol vinyl composite and conductive polymers, the amount of the chrome removal is increased up to the acceptable limit. The rate of removal for poly aniline and Polypyrrol are 73.9 and 32.2 percent, respectively. The reason for this is that polyvinyl alcohol is a stabilizer material and affects the size, shape and equitability of the polymer, because the additives can be physically absorbed to the growing polymer or it can be chemically bond to the growing polymer particle.

According to this table, the amount of chrome removal is decreased for quartz and poly aniline composite and it reached to 29.6 percent. However, the amount of chrome removal is increased for Polypyrrol and quartz and it reached to 32.1 percent.

Table 3: The effect of the conductive polymers composite in the separation of chrome

Chrome concentration	Poly aniline and polyvinyl alcohol	Poly aniline and quartz	Polypyrrol and polyvinyl alcohol	Polypyrrol and quartz
Initial concentration (PPm)	28	28	28	28
Final concentration (PPm)	7.3	19.7	19	23.2
Removal percentage (%)	73.9	29.6	32.1	17.1

The results show that poly aniline has optimum performance with 59.6 percent of chrome removal from wastewater plating industry among the conductive polymers.

The percentage of chrome removal is increased in the conductive polymers composite with polyvinyl alcohol and it was reached to 73.9 and 31.2 percent for poly aniline and Polypyrrol. The removal percentage is decreased in the poly aniline and quartz composite and it is reached to 29.6 percent. However, the removal percentage is increased for Polypyrrol and quartz composite and it is reached to 17.1 percent. The removal priority for conductive polymers composites is as follows.

Quartz and Polyaniline composite <polyaniline < poly (vinyl alcohol) and Poly aniline composite

Polypyrrol< quartz and Polypyrrol composite < poly (vinyl alcohol) and Polypyrrol composite

6. The study of Polypyrrol and poly aniline anti-corrosion properties (as conductive polymer)

The protective effect of conductive polymers against corrosion is proposed in 1985 by Mac Diarmid for the first time. Many researches are conducted in the field of conductive polymers application as corrosion protective coatings. The studies have shown that these types of coatings have very good protective capability. Conductive polymers are prepared by both of the chemical and electro-chemical methods. Most of the conductive polymers are prepared by the electrochemical method with anode oxidation [5]. Researches are conducted in the field of poly aniline protective role against corrosion. These results showed that poly aniline protect the metal against corrosion in the corrosive media like strong acids. Parts of the bare metal that are exposed to corrosive media showed that the reason of increased protection against corrosion is forming a zincoid layer of iron oxide.

Several hypotheses are suggested about protective mechanism of conductor polymers against corrosion that are as follows.

1. Conductor polymers play role in the formation of electrical field in the metal surfaces and prevent the flow of electrons from metal to the oxidizing agent.
2. Conductor polymers form a dense film with low permeability and strong adhesion on the metal surface.
3. Conductor polymers cause the formation of protective layers from metal oxide on the metal surface.

The advantage of polymeric coatings application for protective is that these coatings have defects that remove the tiny holes through the zincoid.

In addition, studies have shown that conductive polymers lose water when they are outside of the soluble and then return to their original state by contacting with the solution without lose their electrical and mechanical specifications.

Research has shown that conductive polymers stabilize the metal potential in the metal zincoid region and create protective oxide layer on the metal. The oxygen reduction reaction occurs on the coating because of conductive nature of coating while the oxidation of iron ions and their transformation to the iron oxide on the ironic surface that is exposed to the corrosive environment occurs in the very tiny holes areas.

In one study, Polypyrrol/ poly aniline composite is stabilized by potentiostatic method on the carbon steel bridge and then its anti-corrosion properties are investigated using electrochemical methods. So that, the electrochemical studies are conducted in a normal electro-chemical cell and the carbon steel metal bridges of treated sand are used as the working electrode. Carbon steel is chosen because it is commonly used in the structures and it is necessary to be protected in the corrosion environments. For this purpose, a composite of aniline Polypyrrol films (as double layer) are prepared on the carbon steel using potentiostatic method.

The formation potential of these films is 900 nv. This potential cause the partial zincoid of metal and reduce its dissolution rate without preventing the monomer electro polymerization. The Polypyrrol film is placed on the Polypyrrol in the solution involves Pyrrol monomer (0.1 molar) and potassium sulfate (0.5 molar). The films are washed completely with potassium sulfate solution without monomer and distilled water and then they are exposed to the solution of 3.5 percent of chloride sodium after drying and their anti-corrosion properties are investigated.

The thickness of Polypyrrol and poly aniline layer in the composite are 1 and 9.2 m, respectively. The platinum plate auxiliary electrode and reference electrode (SCE) are selected. The electrochemical deposition of Polypyrrol on oxide metals such as iron is not easy. Because before reaching the metal to the monomer electro polymerization potential (Pyrrol), it has tendency to dissolution. The metal oxidation potential is more negative than Pyrrol oxidation potential. So, metal dissolution occurs and stabilizes the electrode potential in a negative amount and prevents the monomer oxidation. Therefore, it is necessary to determine appropriate electrochemical conditions to Polypyrrol deposition on the iron that leads to the partial zincoid of metal and reduction of the dissolution speed.

The auxiliary electrolyte of oxalic acid and sulfate potassium are considered for Polypyrrol and poly aniline in order to prevent the dissolution of the metal substrate.

At first, the effect of the optimum thickness of each of the homogeneous polymers (Polypyrrol and poly aniline) was alone investigated. Polypyrrol film is synthesized during different times (50-800s) at constant potential (+900 m.v) in a solution containing oxalic acid and Pyrrol monomer on the carbon steel.

While the potential applied, a layer of iron oxalate crystals are placed on the electrode surface of carbon steel and the polymerization electrode is begin after zincoid of surface with this layer. Then, the changes process of corrosion and circuit potential are investigated in the different thicknesses of 3.5% NaCl solution.

As you can see, the corrosion process is decreased with increasing the duration of Polypyrrol synthesis and it reached a constant value after a lapse of 600 seconds. In the other hand, the potential value is displaced towards more positive values by increasing the synthesis time. This observation shows that synthesized Polypyrrol in 600s has better protective and stability behavior compared to the lower thicknesses. Displacement towards more positive potentials is due to the storage of more load amount in the thicker films that stabilize the carbon steel potential in the more positive span.

Part of the Polypyrrol performance is related to the presence of conjugated dual bonds and the other part is due to the presence of the N-I polar group in the Pyrrol chain. These two factors act as corrosion inhibitors. In addition, load lead in the Pyrrol facilitates the non-settlement of the load. This is postponed the anode or cathode areas formation. It has been proven about the systems consisting of different layers of conductor polymers that the electrochemical reactions occurs in the verge of separation of soluble and polymer instead of the verge of separation of metal substrate and polymer.

It is clear that part of the anti-corrosion properties of conductor polymers is due to that such substances may be able to move verge of separation of the electro active from its usual place i.e., the verge separation of solution and metal in their conductive state.

Three distinct parts are seen in the potential graph. In the first section, there is a first bottom potential that the potential value gradually increased up to 21 days followed by it and there is a final degradation in the potential in the third section. The time the potential takes to reach to its maximum value is called half-life time (21 days). The potential reductionafter 28 days takes place with the advent of rust on the surface of the film [7].

7. Investigating a few new innovations on conductive polymers

1. Strength of conductive polymers

Canadian chemists at the University of Manitoba have managed a new method to enhance the strength of the polymer materials used in electronic industries. According to IRNA, polymer-based electronics field where the polymeric filaments are used to conduct electricity instead of using metals has not been developed because the polymeric materials do not have enough strength and they are heated by passing electronic current and lose their initial hardness and strength. One of the reasons for the low resistance of polymer filaments against heat is the material that will be added as impurities to them in order to increase their ability to conduct electricity. We can increase the stiffness and strength rate of these materials with binding polymer molecules strings to each other. However, the drawback of this method is that it turns the polymer to the electrical insulation and prevents its use in the electronics industry [7].

According to the Journal of Materials Chemical, chemists of Manitoba University are produced a new polymer to use a chemical substance called aniline boronic acid that is heavily fortified and it is able to add impurities to its internal structure to raise ability to conduct electricity.

The aniline boronic acid is heated in order to produce this type of polymer and this would change the chemical structure of the molecule and makes boron atoms to be connected within the new molecule structure as chain strings. This increases the polymer strength and raises its electrical conductive ability.

2. Production of Electric wire using protein

Iranian researcher named Mahyar Hamedi from Linkoping University in collaboration with Anaherland and his colleagues in the field of bio molecular and organic electronics are succeed to develop this technique. He said that: we first made proteins that conduct the electric current very well and can be used as a semiconductor in transistors and other electrical equipment.

The findings showed that fully functional Nano patterns with high density can be created in the organic electronic materials.

Production of flexible organic electronics requires processing and patterning of electro-active materials from solvents. Although, printing and Inkjet are the most common methods of this function but micro-scale structures are created using these methods. So, the manufacture of the nano-devices with these techniques is not possible.

Now, Mahyar Hamedi and his colleagues overcome these problems using a new method that is based on the large Nano elastomeric matrix. These researchers put the elastomer in contact with a filled matrix with a soluble of conductive polymer (PEDOT-S) and remove the elastomer solution after drying. Finally, this method leads to the production of structures smaller than 100 nanometers on a regular basis and a large scale.

Hamedi said, "It is interesting that the polymer (PEDOT-S) maintains its electrical conductivity even when the produced patterns are smaller than the micron scale. This had never seen before about the other conductive polymers."

The team also has shown that it can be produce connected structures such as lines micro-nano and nano-transistors using this method.

Hamedi said that the possibility of creating cross bars with high density with conductive polymers should be raised and they had to be used in the applications such as memories and bio sensors. These scientists are planning to produce smaller structures and checking the formation of cross bars.

3. New Epilepsy and Parkinson's Treatment

The Iranian scientist and biochemical post-doctoral succeeds to improve neurons signals reception rate with the invention of microelectrodes impregnated to the conductive polymers in order to provide a new treatment for improvement of patients with spinal cord injuries.

Mohammad Reza Abidian has stained the small microelectrodes to the polymer called PEDOT that is a resistant and conductive biopolymer consisting of nanotubes which showed a greater ability in the absorption of neuronal signals to the normal metal chips. In fact, Abidian's innovation is in the production of these polymers because this increases the resistance coverage and lifetime of electrodes and improve the absorption of their signals. Conductive polymers that are formed from organic molecules and can conduct the electricity are appropriate choices for biomedical applications. For example, these polymers are used as neurons partition, biosensors and transmission systems. According to the Abidian, at first an electro-neuron is implanted to the brain of three mice in order to experiment and research team controlled the electrical resistance and quality of signals record for seven weeks in the regions that the electrodes are placed in them.

The results of this test showed that the existing Nanotubes in the covering polymer of electrodes could improve the quality of neurons signals record up to 30 percent that is significantly progressed compared to the normal metal electrodes [8].

According to the publication report of Advanced Material, Mohammad Reza Abidian the researcher of Michigan University in the biomedical engineering department believes that these microelectrodes can increase the hope to improvement in the people who have suffered spinal cord injuries and degenerative diseases of neuronal.

8. Conductive Polymers as Intelligent Materials

The applications of the conductive electro-active system have been raised followed by the development of the many intelligent materials. The intelligent materials are substances that are able to identify appropriate environmental stimulus, information processing resulting from stimulus and response to it in a timely and appropriate manner so that to increase the performance or structure of material. The other important properties are energy storage and energy conversion.

The fundamental difference of intelligent materials from conventional materials is in their dynamic factor that should be controlled and response appropriately. If it is very slow then it may have no practical application and if it is very fast then it may be useless and dangerous.A quick look at the components used in the nature to the development of intelligent materials systems shows a vital role of conductive polymer.

Another application of them is to use the semiconductor nature of conductive polymers as anti-static. Electrostatic discharge (ESD) cause the device components to be removed in the high voltage wave. Thus, it will be desirable to usethe transparent packaging materials for covering and packaging of these equipment that its contents are visible. A combination of metals and polymers that has the conductivity and transparency as well as adhesion and initial resistance.

A number of companies use conductive polymers to protect against ESD to cope with this material limitation. Recently, conductive polymers are used in the microelectronic. These materials are used as a plastic chips where the poly aniline and polythiophene were used in the polyamid. The poly aniline absorb the UV light and cause the photochemical reaction that leads to the increased conductivity.

Other applications of it is intelligent label instead of barcode. The intelligent mechanism in this material is reaction to the external electrical stimulation. This reaction involves the change of material dimension and geometry. Also, it is used in scanning the electronic microscope in the connectors and diodes and transistors.

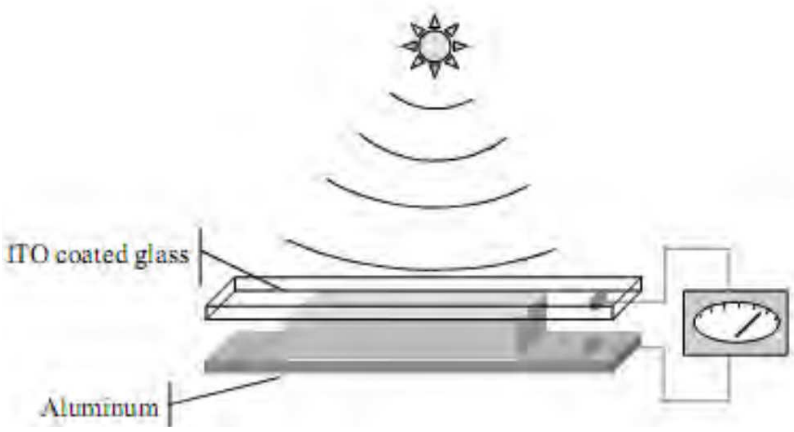
The redox properties of conductor polymers such as Polypyrrol are used in the manufacture of solid batteries. The conductive polymers in combination with the other electrode such as lithium in one cell and applying usable voltage cause the energy dense and charge of commercial solid batteries.

Due to low sales of these batteries, the batteries are designed in which the cathode-anode polymer and electrolyte are used instead of the previous design that the polymer is just used as an electrode (cathode). The good performance of this battery and high flexibility and their light weight makes their development.

- Photovoltaic Polymers (light-induced charge separation)

Light-sensitive polymers such as polyvinyl and its derivatives (figure 6) is one of the covered glass transparent materials such as indium tin oxide (ITO) and the other electrode is a metal such as aluminum or calcium that create the light absorbed by the polymer.

Figure 6: Photovoltaic



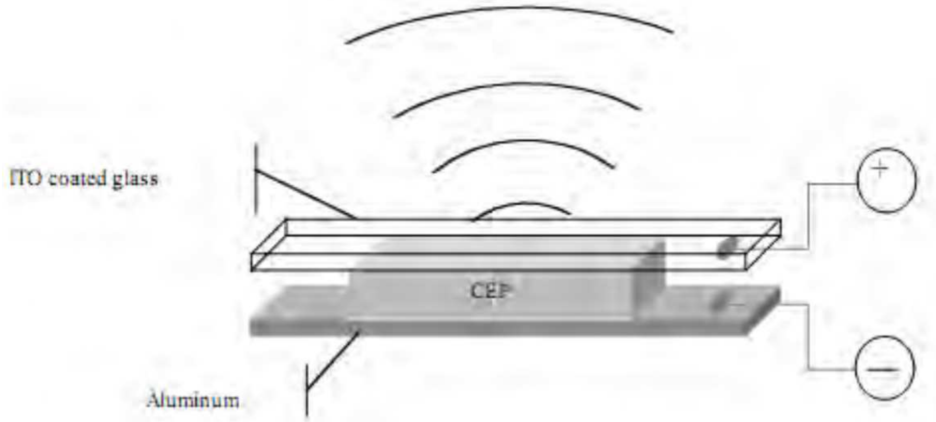
Production of photovoltaic polymers are inexpensive and it is used for roofs and exterior walls of buildings.

- Screen: electrically stimulated emission of light

The process used for photovoltaic devices can be reversed to product a light emitting diode (LED).

An electric field with two electrodes (Figure).

Figure 7: Screen: electrically stimulated emission of light



Free electrons of holes are moving in the opposite directions and a light photon is releases under the effect of electrical field. The color of emitted light depends on the capacity of the band and conduction of the polymer.

The appropriate combination of polymers PLEDs and PPv releases three colors of red, blue and green.In the Cambridge University, Ella and Richard (1990) express that the productivity of devices was 0.01 percent but it is reached to 4 percent, now. It is used in the mobile phone and car devices panel.

- **Electro-chromic**

It is another software that changes the color using dynamic properties of conductor polymers such as poly aniline and polythiophene under the electrical potential. For example, the thin film of poly thiophene changes from the red color (oxidized state) to the blue color (restoration state). Its application includes display advertisements and intelligent window and device memory of information storage. In all of these cases, the solid conductor polymers are used in the environment where its dynamic nature is controllable (Figure 7).

Figure 8: Electro-chromic

- Electromechanical Actuator

Electromechanical actuator is made of materials that their physical dimensions can change in the stimulation time of the electrical signal. One of the disadvantages of the CEPs is their slow response time and life limitation.The actuator movement operation consists of three layers of gold and CEP, formed membrane that CEP acts in that membrane and porous membrane processes and electrolyte that includes ion resource.

- Its other applications are in rehabilitation gloves- electronic Braille page (Figure 9).

- Implant of snails to help hearing of deaf people

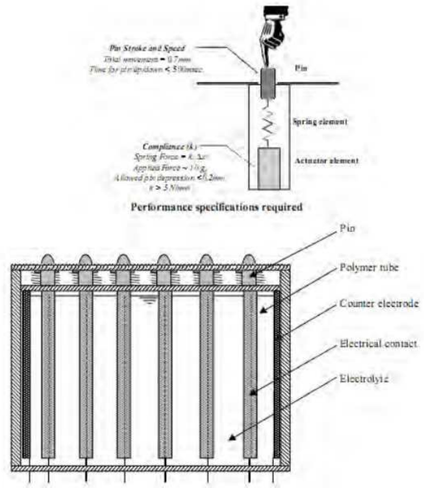
- Wide application of intelligent polymers in medical, dentistry and pharmaceutical

- Atubak-Haskr Company of composite materials, Armku Company to produce artificial organs such as artificial leg (blade) for athletes around the world.

- Researchers at the University of Illinois were able to build a grain finger using nanotechnology that enhances surgeon's sense of touch. The electric seed finger inform the surgeon with symptoms such as tingling and burning after hitting with the surfaces.

- Georgia Institute of Technology in America were able to build anintelligent polymer that is deformed because of the heat and it is used in the closed artery within the brain, heart and damaged vertebrae of the spine.

Figure 9: electronic Braille page based on the conductor polymer



9. Conclusion

Several intelligent polymers with a variety capabilities of specialized and commercial fields need assessment. These polymers can restore a specific response to the environment by creating a change in their structure due to an actuator. Actuators can also be physical, chemical and biological. Intelligent polymer give a rapid and reversible response to the actuator during a predicted path. This response can be rapid macroscopic changes of structural, physical and dimensions that is often reversible in color, permeability, form and so on.

Conductive polymers are a class of exciting electronic materials which have wide applications due to the combination of electrical or optical properties of metals or semiconductors and mechanical properties of polymers. So that, a connection line to the molecular and bio molecular world is obtained with the understanding and use of their chemical and dynamic properties that is a basis for development of dependent intelligent systems through the development of inter-system communications.

Conductive polymers such as polyaniline has interesting properties of electrical, optical and electro activity conductivity. Among the many applications of this nano-polymers and its composites are electronic industries, sensors, electrode protection, absorption and transport of heavy metals and absorption of organic dyes from the solutions. The intelligent polymers are not commercialized yet. However, they will have a good market in the future. They will have various applications in the different areas such as medical, computer, automobiles, televisions, electronic money, health controllers, air and space, biotechnology and … according to the resistance properties against corrosion, high biocompatibility, and production capability in the very small sizes, high flexibility properties and power production.

References

1-Hu J., Meng H., Guoqiang L., and Ibekwe S., A Review of ,Stimuli-responsive Polymers for Smart Textile Applications .Smart Mater. Struct., 21, 2012

2-Shirakawa, H., Louis, E. J., Mac Diarmid, A. G., Chiand, C. K., Heeger, A., j., Chem. 16(1977)578 .

3-Mahajan A. and Aggarwal G., Smart Polymers: Innovations in .Novel Drug Delivery, Inter. J. Drug Dev. Res., 3, 16-30, 2011

4-J. Wu, W.M. Mullet, J. Pawliszyn, Anal. Chem. 74 (2012) 4855 .

5-C.O. Too, G.G. Wallace, J. Intell. Mater. Syst. Struct. 9 (1997) 723 .

6-Staasen, T. Sloboda, G. Hambitzer, Synth. Met.71 (1995) 219 .

7-B. Scrosati, in "Handbook of Solid State Batteries & Capacitors" M.A. Munshi, Ed., 1995, Chap. 1, WorldScientific, Singapore .

8-D. Tallman, G. Spinks, A. Dominis, G. Wallace, J. Solid State Electr. 6 (2002) 73