Research on the TPE Biodegradable Biomedical Polymer Materials

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Abstract: Biomedical polymer materials have been widely applied in biological and medical fields. When the polymer materials were in contact with human body permanently or transiently, they can cause the adverse biological reactions such as inflammation, carcinogenesis, forming thrombus and so on. The adverse biological reactions were caused by the action of materials surface and biological environment. The surface modification of polymer materials can enhance its biocompatibility. This paper is related to the surface modification of PE films by combining plasma pretreatment with UV-induced graft polymerization, in order to improve the antithrombogenicity of polyethylene (PE) films. For improving antithrombogenicity of PE films, the films pretreated by Ar plasma were subjected to UV-induced graft polymerization with acrylamide (AAm) without photo-initiator. It takes further use of plasma technology to do the surface modification for the polylactic acid of biodegradable polymer materials.

Introduction

The biomedical polymer material is the generic terms of polymer materials related to medicine, biology, which is for medical purposes and are applied to be in contact with the biopsy; they are dead polymer materials with the diagnosis, treatment, or the replacement of the body tissues and organs or enhancement of its functionality. But in practice, the drug delivery system, medical cat agent, immobilized bioactive substances, diagnosis and analysis of affinity chromatography separation of the immobilized enzyme, antigens and biosensors, etc. can be also summarized in the medical polymer materials range, in particular, it can show the new composite materials' potential prospects in the future if they are combined with the electronics [1].

In the biomedical polymer field, the major trends and research focuses can be summarized as follows: (a) the biocompatible materials: they include blood compatible materials, organ compatible materials and biodegradable absorbent materials; (b) hard tissue biomedical materials: they include hard tissue materials and biological composite materials, and the curing of biomedical materials; (c) drug delivery polymer materials and delivery systems polymer materials: they include time-controlled release systems, parts-controlled delivery systems and intelligent drugs delivery system; (d) blood purification materials [2].

Polymer drugs have the characteristics of low toxicity, high efficiency, sustained release and long-acting effectiveness. They have good compatibility with blood and body and can stay for a long time in the human body. As the drug carrier, both can contain such kind of small molecule drugs formed by light hydrogen bonding, polymer materials. Although it is still the small molecule drugs contained that has the treatment function, the polymer materials can achieve the purpose of slowing the drug release to slow down the metabolism, keep long-acting drug effectiveness and have small negative effaces . The carrier can deliver the medicine to the confirmed parts of the (target), after the drug released, the polymer carrier will not accumulate in the body and can be ruled out in vitro or absorbed after the hydrolysis. Xing ngsdorfl Chuan proposed the polymer drug carrier model shown in Figure 1. For the high polymer with biological activity, its main chain should be composed by at least three different structural units: the first unit is used to make the whole drug be soluble and non-toxic, which is called as solubilizing portion; the Second unit is a connection area of drug therapy. It is called as the drug moiety; the third unit is corresponding to the transmission system, which is responsible for the role of delivering the drug to the lesion site [3-4].

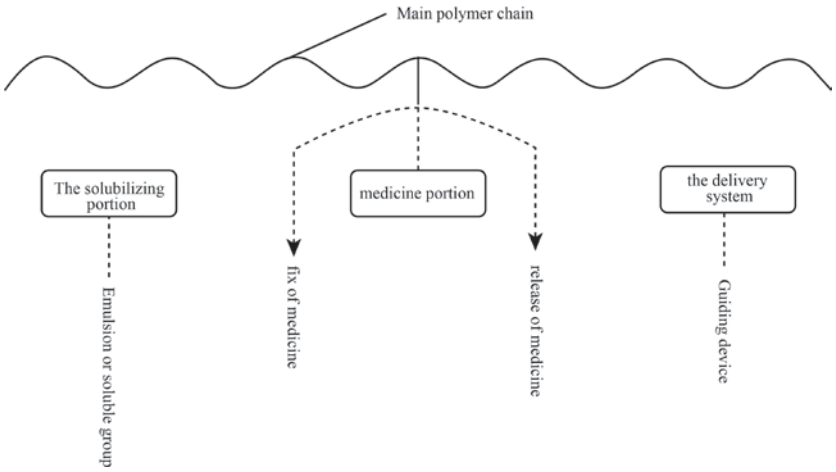

Figure 1 the polymeric carrier drug model

When the biological materials are in contact with the human body permanently or temporarily, there will not have any toxicity, sensitization, inflammation, cancer, thrombosis and other biological reactions happen to the biopsy, which are dependent on the interaction between the materials surface and the biological environment. Therefore, the control and improvement of the surface properties of the biomaterial materials is the key way to improve and promote the advantageous interaction between the surface and the biopsy and inhibited the disadvantageous interaction between them. The surface chemical, the physical and mechanical properties such as the components, structure, surface morphology, the energy state of the surface, the affinities, surface charge, the surface of the conductive characteristics etc. can influence the interaction between materials and biopsy. And this can greatly improve the compatibility between the biological materials and biopsy by improving the material surface properties with various technical means of the physical, chemical and biological etc... [5].

When the biological materials are in contact with the human body permanently or temporarily, there will not have any toxicity, sensitization, inflammation, cancer, thrombosis and other biological reactions happen to the biopsy, which are dependent on the interaction between the materials surface and the biological environment. Therefore, the control and improvement of the surface properties of the biomaterial materials is the key way to improve and promote the advantageous interaction between the surface and the biopsy and inhibited the disadvantageous interaction between them. The surface chemical, the physical and mechanical properties such as the components, structure, surface morphology, the energy state of the surface, the affinities, surface charge, the surface of the conductive characteristics etc. can influence the interaction between materials and biopsy. And this can greatly improve the compatibility between the biological materials and biopsy by improving the material surface properties with various technical means of the physical, chemical and biological etc.

Experimental Part

As TPE has the excellent physical and chemical properties, it has been widely used in the field of medical polymer. It is mainly used to make artificial lung, artificial kidney, artificial urethra, artificial trachea, syringe, blood collection bags, various catheters and artificial joints etc... It is like the other polymer materials, the compatibility of the TPE materials surface and the blood is to be solved. The improvement of surface modification of polymer materials can improve the blood compatibility of the material surface. When the material is in contact with the blood, it firstly adsorbs the plasma protein s on the material surface. The composition and conformation of proteins adsorption layer determines the compatible behavior of the material and blood. When the surface adsorption layer is mainly the fibrinogen or globulin and the conformation of proteins change, it will activate the coagulation factors and platelets, which will cause the coagulation cascade and forms the thrombosis. However, when the material surface adsorption layer is mainly albumin, it can prevent the occurrence of coagulation [7-8].

Therefore, the albumin coating or the improvement of the structure of material surface can be used to make the material selectively adsorb albumin to improve its blood compatibility. The binding status of albumin on the material surface is the key of whether the albumin can work or not. The albumin coating binding force gained by physical adsorption is worse. It is prone to exchange with other proteins when it is in contact with blood, so that the anticoagulant properties decline gradually. The covalent grafting method can get a high binding ability between the albumin layer and the substrate formed on the material surface. Introducing hydrophilic side chains from the material surface, such as polyoxyethylene and polyacrylamide chains etc…to improve the hydrophilicity of the material surface, this can reduce or inhibit the adsorption of plasma proteins on the material surface. Also, using the free fatty acids to adsorb albumin selectively as the base and immobilizing sixteen or eighteen carbon alkyl group on the surface can improve the blood compatibility of the material.

In this paper, it combines the plasma pretreatment and UV-grafting together, introduces the polyacrylamide as "spacer arm", uses octodelyl as the “terminal group" and makes use of the synergistic effects from the nonspecific adsorption of polyacrylamide hinder proteins and octadecyl selective adsorption of albumin to improve the blood compatibility of PE film.

Materials: The thickness of high-density polyethylene (HDPE) film is 006unn; propylene Thalidomide (AAm), AR; eighteen drunk, C.P; human anticoagulated whole blood is provided by Blood Center of Shanxi Province; the rest amentias are all AR.

Experimental Methods: Put the TPE film in a plasma processing apparatus (homemade, outer electrode, the electrode space is 7 cm, with a type SY 300W crystal-controlled RF power source, Beijing Microelectronics Center), the bottom vacuum shall be pumped to 1 Pa, control the hydrogen flow rate with mass flowmeter, high-frequency discharge can be operated until the pressure is stable, after the plasma treatment processed for some time, remove the TPE film out and expose it to the atmosphere with10 min to form the peroxy group.

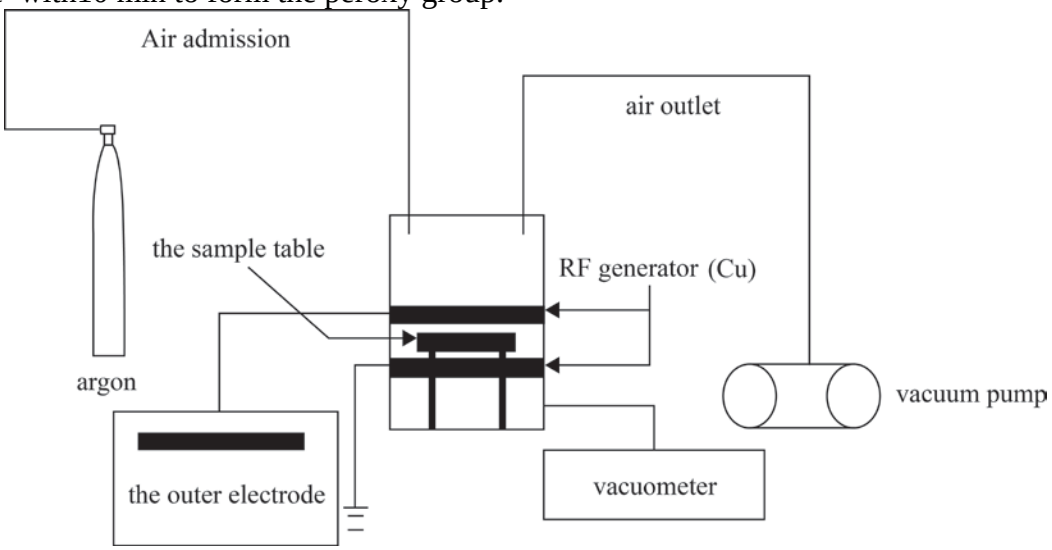

Figure 2 diagram of homemade plasma processing device

Put the pretreated PE film in a plasma with certain concentration of the AAm aqueous solution, place it in the ultraviolet generator (with a 500 W medium pressure mercury lamp, the characteristic wavelength is 280 ^ 385 nm, Netherlands PHILIFS Corporation), in the ice-water bath, it will react under the nitrogen oxygen discharge conditions, the grafted TPE film ((PE-g-PAAm) should be washed through the flow of distilled water 24 h to remove the unreacted AAm and the produced copolymer.

Surface characteristics: PE, PE-g-PAAm and water contact angle measurement PE-g-SPAAm use the JY-82-type contact angle measurement apparatus (Hebei Chengde Testing Machine Co., Ltd.) to measure in a room temperature of atmosphere, at least five samples should be tested in each condition, and each sample should measure 10 contact angles of the 5 water, and get the averaged data.

PE, PE-g-PAAm and PE-g-SPAAm attenuated total reflectance infrared spectroscopy (ATR-FTIR) measurement was determined by FT IR EQUI NOXSS type FT IR infrared spectrometer (Germany Broke: Company), the infrared spectrum of each sample was 480-4000 cm ', scan 64 times in the range and cumulate them.

Results and analysis

It is well known that phthalic amino can react with many different perrsad. When AAm grafted onto PE film surface, it will form an activated polymer surface contains phthalic amino. For the activated surface, it can induce the other materials into it with the reaction of phthalic amino on the surface to improve the surface properties. PE film only contains the C elements, but AAm comprises three elements C, N and O, so the changes of the N elements percentage composition (%) of PE film surface will be selected to indicate the AAm grafting rate.

The plasma parameters can be represented as wiFM, w is the e plasma processing power and the units is w; F is the flow rate of Ar and the units is SCCM; M is the 39.948 g / mol relative molecular weight of Ar. Under the conditions of the Ar plasma treatment time are 2 mins, AAm monomer concentration is 20 wt. %, and UV radiation is30 mins, it discusses the effects of different WlFM to grafting reaction of PE film. As figure 3 shows, WlFM is between 0.080.10 GJ / kg, the contact angle of the PE film surface of is smaller, the percentage composition of N elements is higher, the AAm grafting effect is good. When WlFM is too low, as the air flow rate is relatively higher, the plasma is in the zone lacks of energy and the energy utilization rate is low, it can not be effectively activated the ionization and will generates the low concentration of active particles, the activation of the polymer surface is low and produces a small number of free radicals Therefore when the percentage composition of N elements is relatively small and WlFM is too high, the power is high but the air flow is small, the plasma is in the zone lacks of energy. The active particles generated in this zone will decrease with the reduction of air flow, and therefore the quantity of free radicals produced on the polymer surface becomes smaller, the contact angle is large but percentage composition of N the element is relatively small.

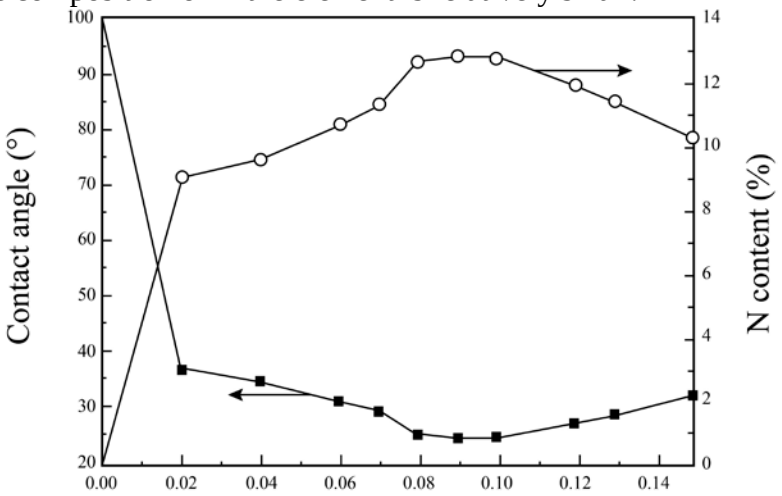

Figure 3 the influence of plasma composite parameters to the graft reaction

In order to further confirm the occurrence of grafting reaction, it does an ATR-FTIR spectrum analysis on the PE film before and after grafting. From the comparison of ATR-FTIR spectra of PE PE-g-PAAm and the PE spectrogram, it can be seen that it appears a stronger absorption peak at around 1667cm's which is corresponding to the stretching vibration absorption on AAm; while there is new absorption peak at the 3348 cm "and 3201 cm ' which is corresponding to the asymmetric stretching vibration and symmetric stretching vibration absorption peak of N-H key on AAm. It can be better seen from Figure 4, compared the 20 wt. %} carbonyl and absorption peak N-H key of AAm monomer concentration with the 5 wt. % AAm monomer concentration, the former is increasing obviously, so the grafting effects of 20 wt. % AAm monomer concentration is better than that of 5 wt. %, which is consistent with the influence of the AAm monomer concentration affects

the contact angle and the composition percentage N elements as discussed previously. The analysis results show that, AAm monomer has been grafted onto the TPE base material.

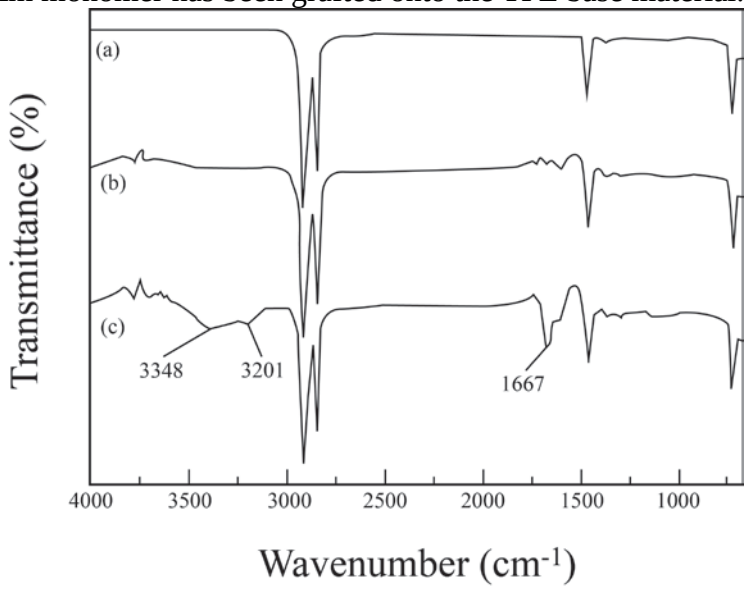

Figure 4 the ATR-FTIR spectrum before and after TPE films surface grafting AAm

Conclusion

Pretreat the PE films with the Ar plasma, performing the UV-induced grafting AAm and the compatibility of membrane of blood can be significantly improved under the conditions of photoinitiator. It has been speculated the reaction mechanism and speculates that it forms the structure on the PE films surface with polyacrylamide being as the"spacer arm" and for the octadecyl being as the "tailshape" in the terminal group. The improvement of TPE films anticoagulant effects may be the synergistic effects from the non-specific adsorption of proteins of polyacrylamide hinder and the selective adsorption of albumin of octadecyls.

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