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Notes

Characterization of an Antibacterial Silver Chloride/Poly(acrylic acid) Deodorant Prepared by a Gamma-ray Irradiation

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Introduction

Silver has been known since ancient times and has long been valued as a precious metal, used to make ornaments, jewellery, high-value tableware and utensils and currency coins. Today, silver metal is used in electrical contacts and conductors, in mirrors and in a catalysis of chemical reactions. Its compounds are used in photographic films and dilute solutions of silver nitrate and other silver compounds are used as disinfectants. Although the antimicrobial uses of silver have largely been supplanted by the use of antibiotics, further research into its clinical potential is in progress.

Because of the excellent antibacterial and bioactive characteristics such as electronics, catalysis, deodorization and antimicrobial properties,[1-6] the silver ion capacity have been received attention for application of the most widely used inorganic/organic research field. To approach the antibacterial deodorant field, it is established that the deodorant biopolymers need to have an outstanding matrix for silver ions. When the silver ions are embedded or encapsulated in a deodorant/bioadhesive polymer solution, the deodorant/bioadhesive polymers act to increase the antibacterial capacity of the silver ions as a surface capping agent.[7-9] In addition to this study, for anti-microbial agents of a subject's ailments like the propagation of a bacterial mold, the control of the morphology and a uniform distribution within the deodorant/bioadhesive polymer solution are the main technology based on the silver ions. Concentration of the ions and the dimensional effect was also observed for the antibacterial properties of the resulting nanocomposite system.[10-12]

For many years, a majority of researchers have introduced a study of anti-microbial agents. A number of processes have been reported for the synthesis of metallic colloids, which can be divided into chemical,[13,14] electrochemical,[15] photochemical,[16] sonochemical reduction,[17] microwave,[18] plasma,[19] ion[12,20] and gamma-ray irradiation process.[21,22] A variety of processes have also been developed to fabricate metal nanoparticles distributed in a solution. Particularly, gamma-ray irradiation involves radiolysis of aqueous solutions that provide an efficient synthesis and distribution to reduce contaminations because of thesis advantages; a gamma-ray irradiation has been extensively used to prepare an ionization process.[23-28]

Moreover, to prepare processed anti-microbial agents of a subject's ailments such as the propagation of a bacterial mold, a process is proposed using deodorant/bioadhesive polymers as a base which can be smoothly processed. Poly(acrylic acid) (PAAc) is the most widely used bioadhesive polymers on tissue as a host for different kinds of medicine in medical materials because of this solubility in water and low cytotoxicity.[29-33] Particularly, a bacterial molds have an offensive odor as ammonia gas. Just use it with PAAc and the patented, sprayed solution goes right to work, reducing ammonia odor, as well as removing most of the terrible smell. Recently, the stench from the sewer/dump is indescribable. Thus a rubbish dump, toilets and the inside of a car are all affected by filamentous fungi if they are exposed to moist air for a long period of time. And should the system overact or go awry, it can cause troublesome allergies and serious disorders called autoimmune disease. Scientists are trying to remove ammonia gas of the filamentous fungi responsible for the disease. It is dangerous to inhale ammonia fumes and spores. To remove the stench of ammonia fumes from filamentous fungi, PAAc solution cleans the gas of ammonia fume-carrying a malodorant effectively and at a low cost.

In this study, the objective is to present experimental results using AgCl in an aqueous solution. To make a type of spraying deodorant/bioadhesive PAAc and a silver ion antibacterial-based capacity of a bacterial mold, a variety of AgCl/PAAc suspensions were fabricated by a gamma-ray irradiation process. The success of this process was confirmed by a characterization of the relationship between the concentration of the agents and the material properties. In addition, this study focused on a point of difference between the silver ion capacity and other anti-microbial agents, as well as the biocompatibility of a type of spraying antibacterial/deodorant AgCl/PAAc suspension depending on the precursor content.

Experimental

Figure 1 shows a schematic diagram of the experimental process for making an antibacterial deodorant. To fabricate

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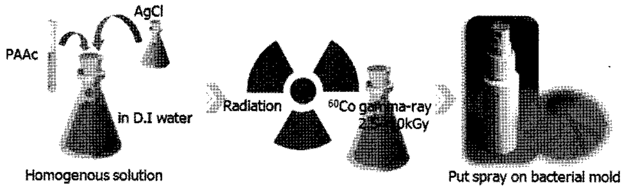

Figure 1. Schematic diagram showing the preparation process of the antibacterial AgCl/PAAc deodorant.

of an antibacterial deodorant, silver chloride (AgCl, 99.5%) was obtained from KOJIMA Chemical Co., Ltd. (Japan). Poly(acrylic acid) (PAAc, MW=5,000) was purchased from Wako Pure Chemical Ind. Ltd. (Japan). Purified and de-ionized water was acquired from AquaMAX system (YOUNGLIN, Korea).

To prepare an offensive odor treatment with and antimicrobial agents, commercial-grade PAAc (0.02 wt%) powders were dissolved in de-ionized water with sliver chloride (2, 5, 10, 20 and 30 ppm). The solutions were mixed homogeneously by a stirring for 1 h in air. Subsequently, the suspensions without a chemical contamination were kept in a field of a Co^{60} gamma-ray source in the Advanced Radiation Technology Institute (ARTI). The suspensions were irradiated using a gamma-ray irradiation (radiation dose: 2.5~10 kGy/h, MDS Nordion, CA, IR221n wet storage type C-188, KAERI, Korea) for a bridged bonding and sterilization.

To evaluate the growth inhibition plate assay of the antibiotic substance, the growth behavior of *Alternaria alternate (KACC 40020), Fusarium oxysporum f. sp. Lycopersici (KACC 40239), Colletorichum higginsianum (KACC 40807)* and *Colletorichum gloeosporioides (KACC 40690)* like molds on the plate with antibiotic substances were investigated for 10 days as shown in Figure 5, respectively.

Results and Discussion

The SEM images of the prepared antibacterial 0.02% poly(acrylic acid) deodorant in the presence of 10 ppm AgCl, irradiated with 10 kGy, is shown in Figure 2.

After spraying the solution, it is confirmed that the nano-silver particles are uniformly dispersed in the poly(acrylic acid) in Figure 2(a). In an enlarged image of the antibacterial deodorant in Figure 2(b), many fine nano particles of silver of about 5~70 nm in diameter were observed. The absorbent PAAc grabbed hold of the nano-silver particles.

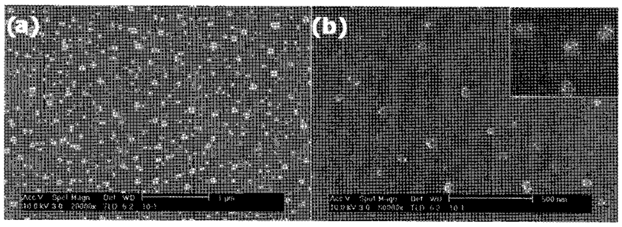

Figure 2. SEM micrographs of nano-silver particles in PAAc in the presence of 10 ppm AgCl, irradiated with 10 kGy.

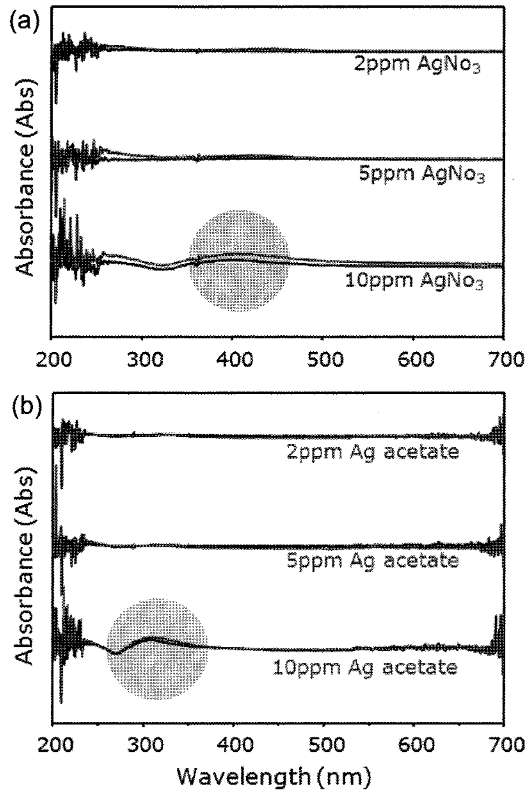

Figure 3. The UV-vis absorption spectra of synthesized various suspensions depending on the starting materials; (a) silver nitrate ($AgNO_3$) and (b) silver acetate ($AgC_2H_3O_2$).

Except AgCl as starting materials for the synthesis of nano-silver particles, however, there are many reports on starting materials such as silver nitrate ($AgNO_3$) and silver acetate ($AgC_2H_3O_2$). Additionally in this study we should conduct an experiment to make sure the note brings out everything necessary for a better option about starting materials. Accordingly with a dynamic similarity, the UV-vis absorption spectra of synthesized various suspensions are shown depending on the concentration of the starting materials in Figure 3. The absorption spectrum of silver has not showed up at for the 2~5 ppm silver nitrate or silver acetate solutions. With a increasing Ag+ precursor, the intensity for the absorption profiles of silver increase up to 10 ppm in Figure 3(a-b) gradually. It was confirmed that the silver particles by the silver nitrate and silver acetate were detected at the 300 to 450 nm region corresponding to the surface plasmon resonance (SPR) band for the planar surfaces of the particles.

The compatibility of the solutions about their discoloration and deposition is also a major requirement, so experiments were carried out for a clothing and skin. After being sprayed, for the clothing in Figure 4, about the discoloration

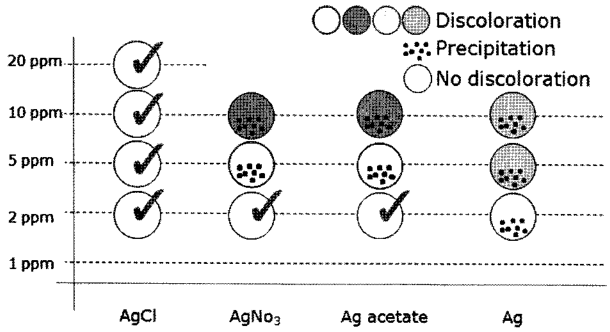

Figure 4. The compatibility (check-mark) profiles about the reaction of various solutions depending on the concentration.

and deposition it shows the reaction of various solutions depending, on the concentration. After the chemical reaction has finished the unwanted by-products have to be removed. But the silver nitrate, silver acetate and commercial silver particles caused a discoloration or deposition except for silver chloride. Such a reaction is considered a serious health problem such as a discoloration and deposition for an antibacterial deodorant. The silver nitrate, silver acetate and commercial silver particles are an incongruent starting material because of troublesome allergies and serious disorders called autoimmune disease.

Concentration quotas for starting materials such as silver nitrate, silver acetate and commercial silver particles will be raised to meet the requirements of the antibiotic substance, but in this study the use of harmful chemicals and the consequent damage to the discoloration and deposition were a very serious matter.

On the other hand, the silver chloride can serve as an antibacterial deodorant's needs no matter what the discoloration and precipitation conditions. The chips in Figure 5(a-c) were covered with molds over time. Starting materials of a low level like the silver acetate, silver nitrate and commercial silver particles were very poorly antibacterial, almost by definition. It has not affected all of the molds in an identical way. Nevertheless in the case of antibacterial silver chloride/poly(acrylic acid) deodorant (d) secretes antibiotic substances into the mold to inhibit the growth of and competition from other species.

Conclusions

In the present work, antibacterial silver chloride/poly (acrylic acid) deodorant was fabricated by using a gamma-ray irradiation. The main particles size in the deodorant can be controlled in a range from 10 to 50 nm in diameter. Silver nitrate, silver acetate and commercial silver particles as starting materials caused a discoloration or deposition, except for silver chloride. From the growth inhibition plate assay using *Alternaria alternate, Fusarium oxysporum f. sp. Lycopersici, Colletorichum higginsianum* and *Colletorichum gloeosporioides* like molds, it was confirmed that silver nitrate, silver acetate and commercial silver particles

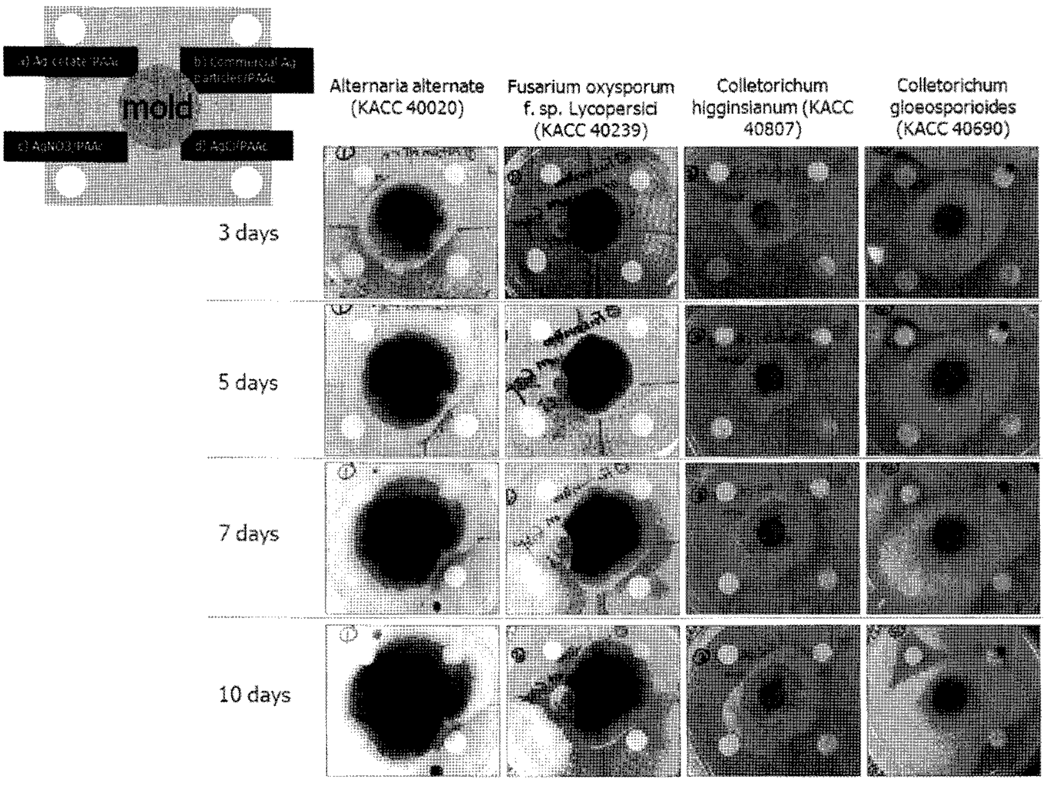

Figure 5. The growth inhibition plate assay of the antibiotic substances for 10 days.

had not affected the growth inhibition of the molds while antibacterial silver chloride had blocked the bacterial growth behavior on the plates after 10 days.

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