Development of Silver Nanodots on Polystyrene Film

Hitesh Agarwal[1], Nirmal Kumar[2], Punit[3]
[1, 2, 3] Dept of Mechanical Engineering
[1, 2, 3] Indian Institute of Technology Delhi

Abstract- *Polystyrene(PS) is a very widely used plastic in industries like food packaging. Polystyrene(PS) is used in the food packaging industry also because it insulates better, keeps food fresher for a longer duration of time and it costs lesser than other alternatives.This paper is focused on building a method to develop well defined silver nanodots of different composition (0.4,0.6,1.2%w/v) on polystyrene film. The antimicrobial activity towards bacteria is checked using experimentation as compared to the plane polystyrene film. It has been found in the literature that such materials(in this case silver nanodots) delay the growth of Pseudomonas fluorescens and Staphylococcus aureus.*

Keywords- Food Preservation, Antimicrobial Packaging, Food Packaging, Polystyrene

I. INTRODUCTION

In recent years, people do not want to waste their time and that's why nowadays those food products are preferred which are ready to eat or use. This leads to increment in demands of packaged food products. To ensure quality and hygiene of food products, packaging should be long lasting and non-toxic. While food processing, the protection of food items from foodborne health issues is one of the major concerns for the whole world. According to the Centre for Disease Control and Prevention (CDC), every year 48 million people get sick, 128,000 are hospitalized and 3000 die due to foodborne diseases in the United States.[1] It was observed that in most of the cases of fresh or processed food products, manly microbial contamination happens on the surface of the food because of the post-process handling, and hence we need an effective way to arrest the microbial growth on the surface of the food items. To prevent foodborne diseases, we need acceleration in the development of antimicrobial food packaging. The modification should be done in such a way that it does not affect the quality of food and keep it fresh for a longer time or delay its spoilage. This can be done by antimicrobial action and it can be obtained through the modification in packaging techniques and packaging materials. The modification can be done with the help of acids, enzymes and polymers (of both types i.e., organic and inorganic). Stability of organic antimicrobial materials is less as compared to inorganic antimicrobial materials at high temperatures.

The use of nanoparticles is increased in the food packaging industry over the last decade and also increased in other fields. Synthesis of nanoparticles follows a top-down approach which includes size reduction of particles using some chemical and physical mechanisms. Food packaging includes nanotechnology can be of two types: (a) Active packaging, there is direct interaction of nanoparticles with the food or the environment and which ensures better protection of the food items, for eg. Silver nanoparticles as potent antimicrobial agents. (b) Improved packaging, it includes the mixing of nanomaterials into the polymer matrix and this is helpful in improving the gas barrier properties. Hence, metal nanoparticles having potent antimicrobial properties can be used as active packaging. Ag, Zn, Ti, Cu and Au are some metal nanoparticles having biocidal properties. Among these elements, silver nanoparticles (AgNPs) have the most effective bactericidal properties because of their large surface area which provides a better contact with the microorganisms and also they show low volatility and stability at high temperatures and it can be useful against a wide variety of pathogenic microorganisms which include fungi, bacteria, viruses and yeasts. The benefit of using AgNPs, it can be hosted in various matrices including stabilizing agents and polymers with the help of different strategies as they can be easily absorbed, coated or incorporated in the synthesis processes. Antimicrobial packaging using AgNPs is an effective way of active food packaging which helps in reducing the risk of foodborne diseases and also extends the shelf life of food items. In this paper, we used a novel methodology to create antimicrobial films using $AgNO_3$ & polystyrene and made multiple samples of these by varying the concentration of solutions. Also, we had tested these samples in order to understand the relation between concentration & the effectiveness of its antimicrobial properties. This method is helpful in generating uniform sizes and shapes of Silver NPs (known as nanodots).

II. MATERIALS USED

1. Poly-styrene
2. $AgNO_3$ (99% min)
3. Anhydrous Ethanol (99%)
4. Acetone (99%)
5. Toluene (99%)

III. PROCEDURE

Below are the steps which are to be followed for the development of silver nanodots pattern over Polystyrene film.

1. Take four Microscope glass slides (of size 2.5 cm × 2.5 cm) as a test substrate.
2. Do ultrasonication (in an ultrasonic bath) for 30 min in ethanol and then acetone before use.
3. Prepare the Polystyrene (PS) solution (1% w/w) in Toluene and stir it for 12 hours in a sealed vessel before use.
4. Do the spin coating of Polystyrene(PS) solutions on the glass slides at 3000 rpm for 30 sec on all of the glass slides(4 glass slides).
5. Do the spin coating of the films of PS obtained from the above procedure (3000rpm for 30sec) with different concentrations(0.4, 0.6 and 1.2% w/v) of the Ag precursor ($AgNO_3$) dissolved in ethanol.
6. Perform the test over all the glass sides for antimicrobial activity.

- Ultrasonication :- It is a process which is used to clean the glass slides from any impurities. The liquid is agitated at an ultrasonicated frequency which produces high forces on contaminants adhering to substrates.

- Stirring:- A magnetic stirrer is a laboratory device which employs a rotating magnetic field to cause a stir bar immersed in a liquid to spin very quickly, thus stirring it.

- Spin-Coating:- It is a process used to deposit uniform thin films over the substrate(here glass slide). This is done in the laboratory device spin coater.

IV. PRECAUTION

1. Prepared $AgNO_3$(here,1 gm) should not be exposed to light in order to avoid photoreaction.
2. The proportion of solution used should be as precise as possible in order to avoid getting varying results.

V. RESULTS & CONCLUSIONS

After completing all the steps, we observed the samples under Standing Electron Microscope (SEM). We also did several antimicrobial and antibacterial testing. It was found that our product indeed have antimicrobial properties. But, the capacity to kill microbes in our product (using Polystyrene) is lesser than that using PS-b-PEO. After completing all the steps, we observe the glass slides on a microscope.

The silver nanodots particles have huge potential to change the food packaging and preservation industry. It will save a huge amount of food from being wasted every year. The original paper (Shafrina et. al.[2]) has presented a successful procedure to do the same using PS-b-PEO block copolymer. But it is extremely costly (500 mg for Rs.33,000)[3]. This makes the entire product too costly and very unlikely for commercial use. Instead, we have used Polystyrene (PS) as the polymer film which is very cheap (Rs. 85/kg). Hence, our product has a much better scope to get commercialize and compete in the market.

REFERENCES

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