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Research Article

Development of Antimicrobial Plastic Material for Automotive Applications

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Abstract – This article discusses the development of antibacterial plastic materials that can inhibit the growth and spread of harmful microorganisms on plastic surfaces. The incorporation of antibacterial additives into plastic formulations has been explored to address the issue of bacterial contamination in various sectors, including healthcare, food packaging, and consumer goods. The article presents the results of trials conducted on three different antibacterial plastic materials: 20% talc-filled polypropylene, unfilled polyamide 6, and 35% glassfiber-reinforced polyamide 6, enhanced with silver and zinc pyrithione additives. These materials are tried in recliner lever of car seats which is handled by driver and passangers.

The antibacterial activity of these materials was tested using standardized methods to evaluate their effectiveness in reducing microbial contamination. The results showed that the incorporation of silver and zinc pyrithione significantly reduced bacterial growth on the plastic surfaces, making these materials suitable for applications where hygiene is crucial in nowadays.

The article also discusses the benefits of these antibacterial plastic materials, including their versatility, durability, and public health benefits. As research in this field continues, more advanced antibacterial plastic materials are expected to emerge, providing additional protection against microbial threats in our everyday lives. The development of these materials represents a significant step forward in improving the hygiene and safety of various products and applications.

Keywords – Antimicrobial, Automotive, Polymer, Silver, Zinc Pyrithione

I. Introduction

Plastics have become an integral part of our daily lives, finding applications in countless industries due to their versatility, durability, and lightweight nature. However, the presence of bacteria on plastic surfaces poses a significant concern in various sectors, including healthcare, food packaging, and everyday consumer goods. Specially, in auto interior materials are usually suffered from the attack of bacteria and therefore affect people. To address this issue, researchers have been working on developing antibacterial plastic materials that can inhibit the growth and spread of harmful microorganisms [1]. It is known that microorganisms such as bacteria in the polymer can be removed by coating the plastic film surface with antibacterial substances or incorporating them into the plastic [2]. The development of antibacterial composite materials is basically achieved by incorporating two types of antibacterial materials into the polymer matrix: organic and inorganic. Although organic substances have a wide range of effects, inorganic substances show good stability against harsh conditions such as high pressure and temperature. The most well-known substances among inorganic antibacterial materials are silver (Ag) and copper (Cu) [3]. The effect order of metal ions showing good antibacterial properties is Ag > Hg > Cu > Cd > Cr > Pb > Co > Au > Zn > Fe > Mn > Mo > Sn [4]. Since metal or metal oxide particles have a higher surface area than larger particles, their metal ion release and antibacterial effect are higher. As another advantage, it is known that the particles are easier to incorporate into the polymeric matrix than larger particles. [5]. This article explores the results of trials conducted on three different antibacterial plastic materials, including 20% talc-filled polypropylene, unfilled polyamide 6, and 35% glassfiber-reinforced polyamide 6, which have been enhanced with special additives such as silver and zinc pyrithione.

II. Materials and Method

Composites prepared with two different base polymers, zinc pyrithione and silver additives, were used in the production of antimicrobial plastic materials. The polypropylene used in the study was supplied by LyondellBasel, the polyamide was supplied by Epsan, and the zinc pyriyhione and silver used were supplied by Microban company. Product compositions are created by adding additives as shown in the table 1 to polymer resin at different rates in the injection process shown in figure 1. Injection parameters for each sample are given in the table 2.

Table 1. Product compositions

Sample no	**base polymer compound**	**additive**	**addition range (%)**
D1	%20 talc filled polypropylene	zinc pyrithione	1.0
D2	%20 talc filled polypropylene	silver	2.5
D3	Polyamide 6	silver	3.5
D4	%35 glass fiber reinforced Polyamide 6	silver	3.5

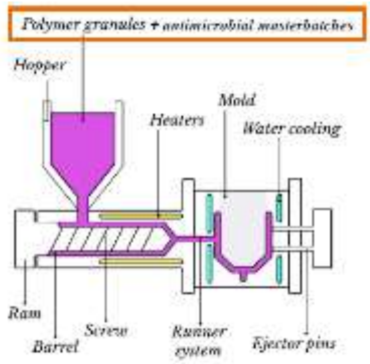

Figure 1. produciton of antibacterial plastics

Table 2. injection molding parameters

Material		**D1**	**D2**	**D3**	**D4**
Screw tempera ture(C)± 6%	**1st**	230	230	280	280
	Nozzle	250	250	300	300
Back pressure (bar) ±0.5%		5	5	7	7
Cooling time (s)±0.5%		30	30	30	30
Injection speed (mm/s)±1%		20	20	20	20
Injection pressure (bar)±1%		140	140	150	150
Injection time (s)±2%		2.8	2.9	3.0	0.9
Holding time (s)±3%		5	5	5	5

III. EXPERIMENTAL

The prepared mixtures were tested for the seat adjustment part, which is one of the surfaces that are contacted by hand in vehicles. Measurement of anti-bacterial activity on plastic surfaces (ISO 22196:2011) test was performed on the seat adjustment part samples.

The effect of antibacterial additives used in prepared seat adjustment parts on the weight of the part is given in the table below. As can be seen, the silver additive did not have any negative effect on the weight of the piece. Zinc pyrithione supplementation increased weight by only 1 gram. It is important that antimicrobial additives do not cause an increase in weight, especially for their use in the automotive industry. The reason for this is that part weights are desired to decrease in an industry where carbon footprint reduction efforts are carried out.

In the bacterial activity tests performed with Escherichia coli bacteria and Staphylococcus aureus bacteria, when looking at the part surfaces in the table 3, it was seen that both additives were very effective in reducing bacterial activity. In bacterial activity tests, it was observed that the surface activity of Escherichia coli bacteria on the surface of the part produced with PA6 reinforced with only 35% glass fiber was 96.19%, which, although it was the lowest bacterial activity inhibition value, was still a very effective value in preventing bacterial activity. The bacterial activity inhibition ability of other samples was over 99%.

IV. RESULT AND DISCUSSION

In the study, it was proven by tests that two different additive types could reduce bacterial activity on the surface of plastic products. The fact that these additives have the same effect even on different polymer types shows that they can be used in many areas.

Table 3. bacterial activity test results

Material	**Escherichia coli bacterium**			**Staphylococcus aureus bacterium**		
D1	**Contact time**		**% Reduction**	**Contact time**		**% Reduction**
	0h	24h		0h	24h	
	9.0 x 10^3 cell/cm^2	<1.00 cell/cm^2	≤99.99	1.1 x 10^4 cell/cm^2	<1.00 cell/cm^2	≤99.99
D2	**Contact time**		**% Reduction**	**Contact time**		**% Reduction**
	0h	24h		0h	24h	
	9.0 x 10^3 cell/cm^2	<1.00 cell/cm^2	≤99.99	1.1 x 10^4 cell/cm^2	<1.00 cell/cm^2	≤99.99
D3	**Contact time**		**% Reduction**	**Contact time**		**% Reduction**
	0h	24h		0h	24h	
	9.0 x 10^3 cell/cm^2	<1.00 cell/cm^2	≤99.99	1.1 x 10^4 cell/cm^2	<1.00 cell/cm^2	≤99.99
D4	**Contact time**		**% Reduction**	**Contact time**		**% Reduction**
	0h	24h		0h	24h	
	9.0 x 10^3 cell/cm^2	<1.9 x 10^2 cell/cm^2	96.19	1.1 x 10^4 cell/cm^2	<1.00 cell/cm^2	≤99.79

These materials offer versatile solutions for industries where cleanliness and hygiene are of most importance. As research in this field continues, we can expect even more advanced antibacterial plastic materials to emerge, providing additional protection against microbial threats in our everyday lives.

In the further stages of the study, in addition to the antibacterial activity test, scanning electron microscopy and energy dispersive X-ray spectroscopy tests will be performed to examine how the additives are distributed in the polymer matrix, and at the same time, aging tests under heat and humidity will be performed to test whether the antibacterial plastic parts have undergone any migration. In this way, the suitability of using antibacterial plastics in the automotive industry can be proven.

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