

Diffusible antibacterial material

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1. Introduction

The need for antibacterial measures is surfacing as the result of the growing trend toward cleanliness among people and public concerns over the coliform bacilli (O-157) and hospital infection of MRSA.

Most of the existing antibacterial products are made by incorporating or coating antibacterial material in or over resin products. In other words, the antibacterial material is added directly to resins in the form of resin molding and paints. We focused our study on glass and stainless steel products that were left out from antibacterial treatment. This led to the development of new antibacterial materials and their application methods (antibacterial material diffusion) that give an antibacterial effect to the glass or stainless steel products, without using antibacterial paint or affecting the product substrate itself.

Among the new materials, diffusible antibacterial materials called AGL and DAH are introduced below along with their application methods.

2. Conventional Antibacterial Processes for Glass and their Drawbacks

1) Silver addition method

- * Not economical as a large portion of silver remains embedded without contributing to the antibacterial effect.
- * Large loss during hot melting because of thermal resistance of silver.
- * Possible lack of uniformity of silver in glass.
- * Failure of antibacterial effect in non-soluble glass because silver elution is nearly zero.

2) Coating method

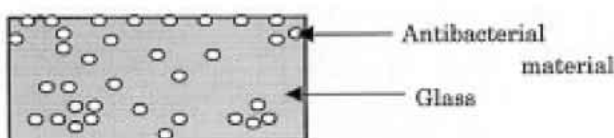


Fig. 1 Silver addition method

- * Loss of antibacterial effect after peeling, wear, or deterioration of the coating or binder.
- * Serious damage to product appearance due to interference fringes.

3. Principle and Main Features of

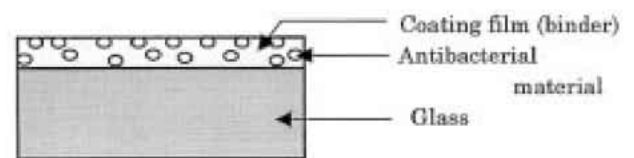


Fig. 2 Coating method

Antibacterial Material Diffusion Process

The antibacterial material diffusion process is our company's proprietary technology. Inorganic silver diffusible antibacterial material is applied over the substrate and subjected to energy (heat, pressure, etc.) so that it is diffused from the substrate surface to the depth. As the result, a diffused antibacterial layer is formed near the surface (several μm).

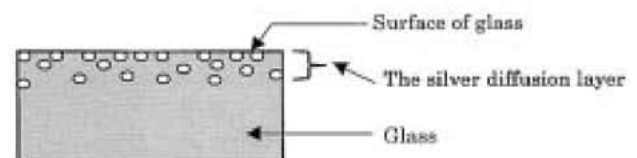


Fig. 3 Silver diffusion method

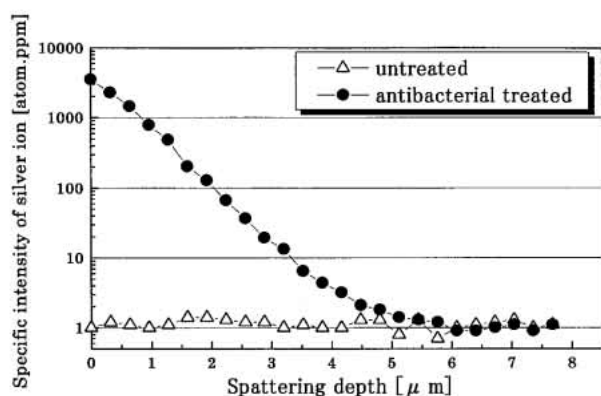


Fig. 4 Silver depth analysis by glow discharge mass spectroscopy (GDMS)

The antibacterial material diffusion process has the following features:

- * Highly economical because the antibacterial diffusion layer is formed near the substrate surface and contributes almost entirely to the antibacterial effect.
- * Original impression of the substrate is retained and antibacterial effect lasts because the effect is built into the substrate itself.
- * Color tone of the product is not affected because antibacterial material becomes colorless and transparent (ionized) by diffusion.

4. Antibacterial Material Diffusion Process

Two types of antibacterial materials, AGL and DAH, are available for glass application. AGL is primarily for offline use (secondary process) while DAH is for online use (substrate production). Their treating processes are introduced below.

- 1) AGL antibacterial material process (offline)
Substrate surface washed → AGL applied (sprayed, dipped) → Heated (400-450°C for 30 minutes)
- 2) DAH antibacterial material process (online)
DAH applied (sprayed) at substrate surface temperature 100~450°C during substrate production and slow cooling.

The following cautions must be kept in mind:

- * Diffusion progresses more under higher diffusion temperature (heating temperature or substrate surface temperature). This leads to longer durability of the antibacterial performance due to increased surface concentration and diffusion depth.
- * In an online process, a high substrate surface tem-

perature or a large spraying rate may damage the substrate due to a larger thermal impact.

- * The treating temperature and time must be adjusted according to the substrate composition and the structural condition of the crystalline glass.

5. Evaluation of Antibacterial Performance

Antibacterial performance of AGL-010 (450°C x 30 minutes) and DAH-010 (250°C), as applied on soda-lime glass, was evaluated by "Film adhesion method" (revised in 1998) established by the Antibacterial Product Technical Council.

Table 1 Results of antibacterial performance test

Test organism	Inoculation level t=0hrs. N _i [cfu.]	sample	Viable count per test piece t=24hrs.		Increase/decrease value logN _c -logN _p
			N _c [cfu.]	N _p [cfu.]	
<i>Escherichia coli</i> (IFO3972)	5.5 × 10 ⁵	Blank	4.1 × 10 ⁶	—	—
		AGL	—	10 >	5.6 <
		DAH	—	10 >	5.6 <
<i>Staphylococcus aureus</i> (IFO12732)	3.4 × 10 ⁵	Blank	5.0 × 10 ⁵	—	—
		AGL	—	10 >	4.7 <
		DAH	—	10 >	4.7 <

6. Safety

Table 2 Results of antibacterial material safety test on AGL-010 and DAH-010

safety test	AGL-010	DAH-010 heated at 105°C.
LD 50 (Acute oral toxicity)	20ml/kg <	2000mg/kg <
Primary skin irritation	weak	weak
Mutagenicity	negative	negative
Skin sensitization	negative	negative

7. Concluding Remark

Antibacterial glass is used in household, kitchen, medical, and food processing appliances (glassware, showcases, windows, mirrors, etc.) Our diffusible antibacterial materials include AGL and DAH for glass, and AST for stainless steel application. They are being supplied to meet various substrates and manufacturing and treating processes. Antibacterial glass using our antibacterial material was introduced in the market in January, 1999. Continued studies are under way to develop new applications for the diffusible antibacterial material.