

Application of inorganic antimicrobial “Bactekiller” in polymer materials

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Appearance of inorganic antimicrobial “Bactekiller”



Antimicrobial agent “Bactekiller” (Powder)



Master batches (MB)



Master paste (MP)



Antimicrobial “Bactekiller” offers customers satisfactory performance

[Products lineup provided from customer’s perspective]

- Different types of antimicrobial such as powder, master batch (MB) and master paste (MP)
- Antimicrobial grades complying with US and EU regulations such as EPA, FDA and BPD

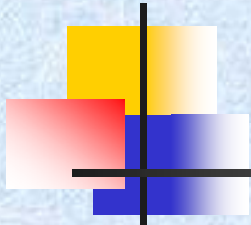
[Technical services from customer’s perspective]

- Selection and determination of antimicrobial types and concentrations depending on the type of intended resin to be used
- Evaluation (by contracted public testing institutes) of antimicrobial efficacy and testing of discoloration resistance of antimicrobial-treated products

[Backup of differentiation of customer’s products]

- Advices and recommendations of labeling regarding efficacy and properties on customer’s products

**Bactekiller boasts the largest share (35%) in the markets of Japan and Asia.
(Market share of competitors: 20% by S company, 20% by I company, 20% by T company)**



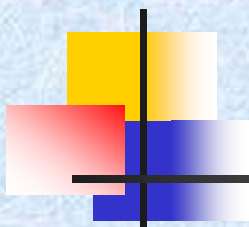
Features of three antimicrobial carriers

Carrier	Phosphate	Zeolite	Glass
Quantity of metal released (Antimicrobial efficacy)	Small	Medium	Medium-Large
Discoloration	⊙	△ - ○	○ - ⊙
Remarks	Fine particle (0.5µm)	Possibility of discoloration	Versatility

Mechanism of discoloration of silver antimicrobials

Reactants	Potential source of reactants	Mechanism of reaction	Countermeasures
Phenol	Resin additives	Phenol compounds → Quinone	- Prohibition of contact for long time
Sulfur	Resin additives SO _x	Ag ⁺ + S ⁻ → AgS	- Use of non-sulfur resin additives
Chlorine	Resin additives Residual catalyst	Ag ⁺ + Cl ⁻ → AgCl AgCl → AgO, Ag ₂ O	- Neutralization by MgO and hydrotalcite - Use of resin additives without chlorine
Amine	Resin additives Antistatic agent	Ag ⁺ + NH ₂ ⁻ → AgNH ₂	- Use of resin additives without amine - Preferable to use monoglyceride type antistatic agents
Functional groups - COOH, - OH	Resin additives	Ag ⁺ + COO ⁻ → COOAg Ag ⁺ + OH ⁻ → AgO	- Removal of moisture in case of discoloration by - OH group
Halogen Cl, F, Br, I	Resin additives (Flame retardants)	Ag ⁺ +F ⁻ → AgF Ag ⁺ +Br ⁻ → AgBr Ag ⁺ +I ⁻ → AgI	- Use of neutralizers for halogens

(Note: Refer to the attached technical document "Application of antimicrobial," pages 7-8, for taking countermeasures against color change.)



Evaluation of discoloration resistance of antimicrobial-treated products

<p>Light</p>	<p>Outdoor exposure in the sunlight is the best weathering test for polymer products containing silver antimicrobials. However, accelerated tests are usually carried out instead, due to time limitations.</p> <p>Accelerated weathering machine:</p> <ul style="list-style-type: none"> - Xenon lamp WOM - Sunshine WOM <p>When testing using weatherometer, a sample with silver antimicrobial shall be compared with a sample without silver antimicrobial.</p>
<p>Heat</p>	<p>Polymers generally degrade under exposure to oxygen and moisture at high temperature. Especially, in case of formulations containing silver antimicrobial, interactions between antimicrobial and resin additives are also accelerated by heat. Therefore, it is necessary to test color stability under heating condition.</p>
<p>Gas (SoX)</p>	<p>Polyolefin containing general phenolic stabilizer may react with air contaminant NOx gas and has a phenomenon of discoloration. Content of silver antimicrobials may accelerate such reaction. Concerning products with silver antimicrobial, note especially the possibility of interaction between silver antimicrobial and sulfur gas derived from cardboard cartons used for storage.</p>

(Note: Fuji Chemical offers charge-free testing of the above, or discoloration resistance as technical services, as well as testing of antimicrobial efficacy at contracted public test institutes.)



Bactekiller grades recommended by resin type

(Antimicrobial activity: More than 2.0 against *Escherichia coli* and *Staphylococcus aureus* specified in JIS Z2801/ISO22196)

Application	Resin	Antimicrobial grade	Concentration (%)	Remarks
Home electronics parts Electronic parts Household equipment	PC	BM-102SD BM-102TG	0.3-0.5 0.4-0.6	Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	PC/ABS	BM-502CD BM-102SD BM-102TG	0.3-0.5 0.3-0.5 0.4-0.6	Approved by EPA and FDA Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	PC/ABS (Flame proof grade)	BM-502CD BM-102SD BM-102VT	0.3-0.5 0.3-0.5 0.4-0.6	Approved by EPA and FDA Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	ABS	BM-102SD BM-102TG	0.3-0.5 0.4-0.6	Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	ABS (Flame proof grade)	BM-102SD BM-102TG BM-102VT	0.3-0.5 0.4-0.6 0.4-0.6	Approved by EPA and FDA General-purpose grade General-purpose grade

Bactekiller grades recommended by resin type

(Antimicrobial activity: More than 2.0 against *Escherichia coli* and *Staphylococcus aureus* specified in JIS Z2801/ISO22196)

Application	Resin	Antimicrobial grade	Concentration (%)	Remarks
Home electronics parts Electronic parts Household equipment	HI-PS	BM-102SD BM-102TG	0.2-0.3 0.3-0.5	Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	GP-PS	BM-102SD BM-102TG	0.2-0.3 0.3-0.5	Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Industrial components	PMMA	BM-502CE BM-102SD	0.2-0.4 0.2-0.4	Approved by EPA and FDA Approved by EPA and FDA
Home electronics parts Electronic parts Industrial components	SAN, ASA	BM-503CE BM-102SD BM-102TG	0.2-0.4 0.2-0.4 0.3-0.5	Approved by EPA and FDA Approved by EPA and FDA General-purpose grade
Home electronics parts Electronic parts Household equipment	PP	BM-102SD BM-102TG	0.2-0.4 0.3-0.5	Approved by EPA and FDA General-purpose grade

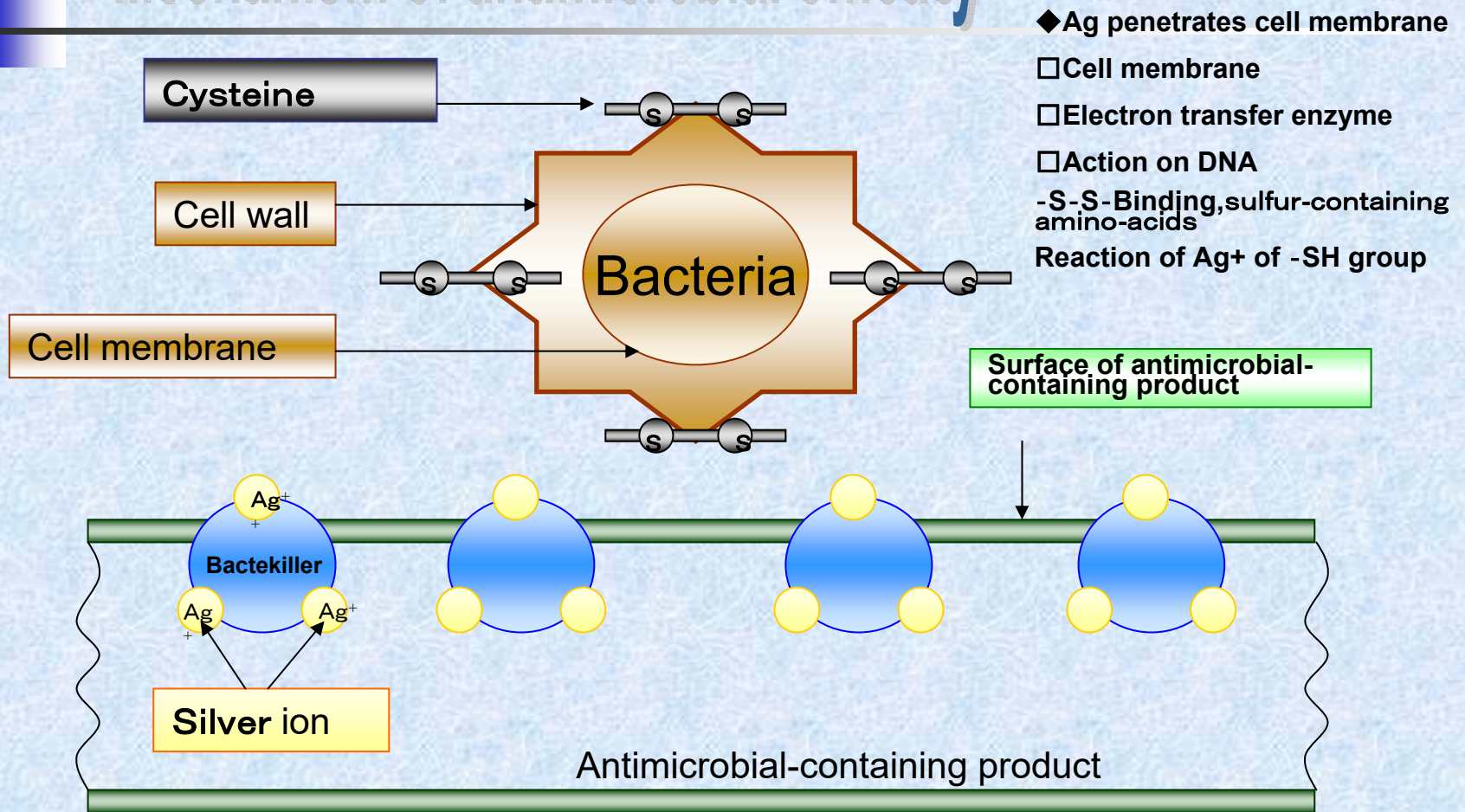


Bactekiller approval status under overseas government regulations

Grade	Type	EPA	EPA Food	FDA	BPD	EFSA
BM-502CD	Ag-Zn-Glass	Approved	–	Approved	Approved	–
BM-503CE	Ag-Glass	Approved	Approved	Approved	Approved	Approved
BM-103NA	Ag-Glass	Approved	Approved	Approved	Approved	Approved
BM-102SD	Ag-Glass	Approved	Approved	Approved	Approved	Approved
BM-102VT	Zn-Glass	–	–	–	Approved	–

- EPA: U.S. Environmental Protection Agency
- EPA Food: U.S. EPA Food Contact
- FDA: U.S. Food and Drug Administration
- BPD: Biocidal Products Directive
- EFSA: European Food Safety Approval

Mechanism of antimicrobial efficacy



Properties of antimicrobials

	Inorganic antimicrobials	Organic antimicrobials
Heat resistance	600°C <	c.a. 200°C
Solubility	Difficult solubility due to being inorganic substance	Selective solubility
Safety	Safer than organic antimicrobials	Some antimicrobials cause a serious skin irritancy due to containing halogens such as chlorine and bromine.
Properties	Effective on bacteria rather than fungi	Effective on fungi rather than bacteria
	<ul style="list-style-type: none"> - Antimicrobial exposure on the surface of resin is important. - Uniform dispersion on the surface of product is important. 	

(Note: Regarding uniform dispersion of antimicrobial: refer to the attached technical document "Application of antimicrobial" on pages 4-6.)

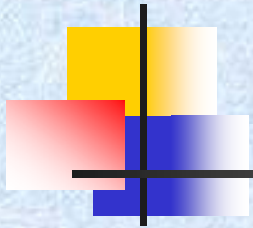
Antimicrobial efficacy of Bactekiller

MIC: minimal inhibitory concentration

	Bacteria (generic term)	Aspect	MIC
Gram positive bacteria	Bacillus subtilis	Saprogenic. Grass decomposing fungi. Spore forming bacteria. Bacillus natto.	250
	Staphylococcus aureus	Food poisoning and microbism bacteria. (Disease causing bacteria)	250
	MRSA	Food poisoning and microbism bacteria. In-hospital infection bacteria. (Disease causing bacteria)	500
Gram negative bacteria	Escherichia coli	Contaminative bacteria in food. Also exists in the intestines.	125
	Pseudomonas aeruginosa	Growing on wounds and burns, and irritating the skin. (Disease causing bacteria)	125
	Klebsiella pneumoniae	Indigenous bacterial flora in fecal matter.	125
Fungus and yeast	Aspergillus niger	Growing in and contaminating bread and fruit.	500
	Penicillium citrinum	Growing in and contaminating bread, fruit and glutinous rice.	250
	Saccharomyces cerevisiae	Used for bread making. Saccharomyces is also used for making miso, soy source and sake.	250

Antimicrobial efficacy by resin type containing Bactekiller

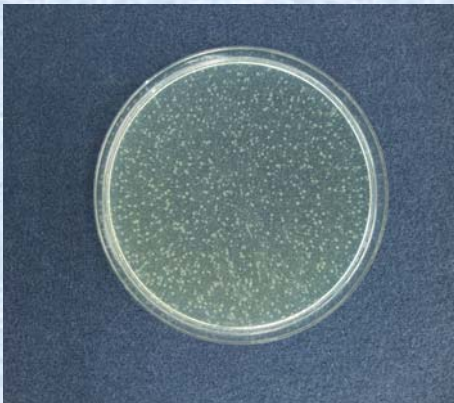
Sample	Test condition	<i>Escherichia coli</i>		<i>Staphylococcus aureus</i>	
		Zero hours	After 24 hrs	Zero hours	After 24 hrs
PE resin (0.5% Bactekiller)		5.1×10^5	Under 10	6.5×10^5	Under 10
PE resin (untreated)			3.3×10^6		4.1×10^5
PP resin (0.3% Bactekiller)			Under 10		Under 10
PP resin (untreated plate)			6.1×10^6		4.9×10^5
PS resin (0.3% Bactekiller)			Under 10		Under 10
PS resin (untreated)			5.2×10^6		3.7×10^5
ABS resin (0.5% Bactekiller)			Under 10		Under 10
ABS resin (untreated)			6.3×10^6		3.1×10^5
Control			7.8×10^6		4.1×10^5



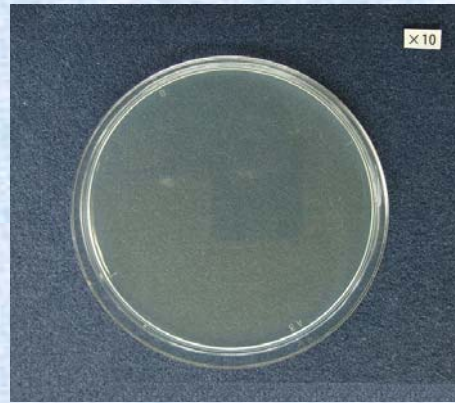
Photos of bacteria incubation in antimicrobial efficacy test

Incubation state on PE resin with 0.3% BM-102TG, tested by JIS Z 2801 (ISO22196)

Zero hours

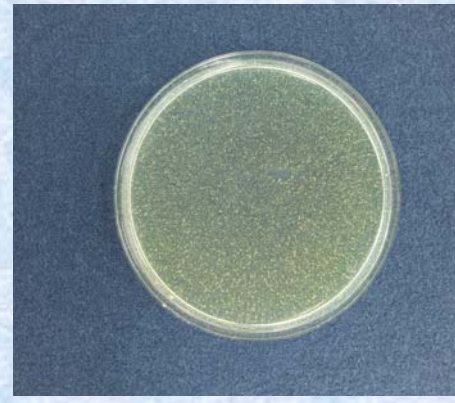


After 24 hrs

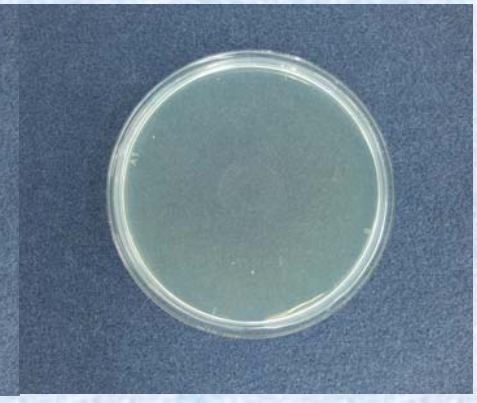


Escherichia coli

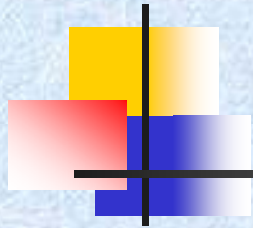
Zero hours



24 hours



Staphylococcus aureus



Definition of antimicrobial efficacy

Inhibition of the growth of bacteria on the surface of targets

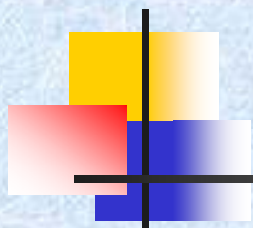
Antimicrobial test piece is to be judged to have efficacy with the result that reduction ratio of bacteria on treated test piece after 24-hour incubation is more than 99% to that immediately after inoculation on untreated test piece

Value of antibacterial activity: $R \geq 2.0$ (defined by JIS Z 2801)

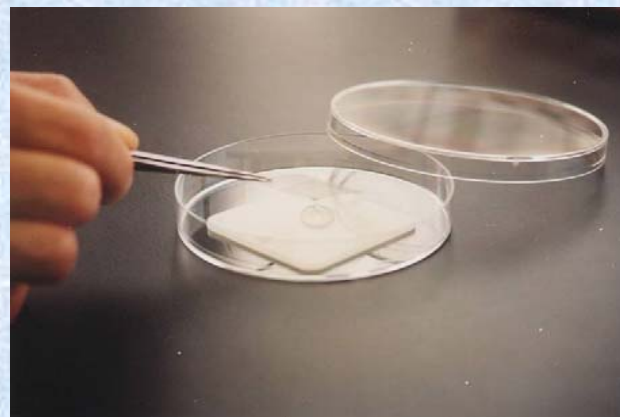
$$R = A - B$$

A: log (number of viable cells of bacteria on untreated test piece after 24 hrs)

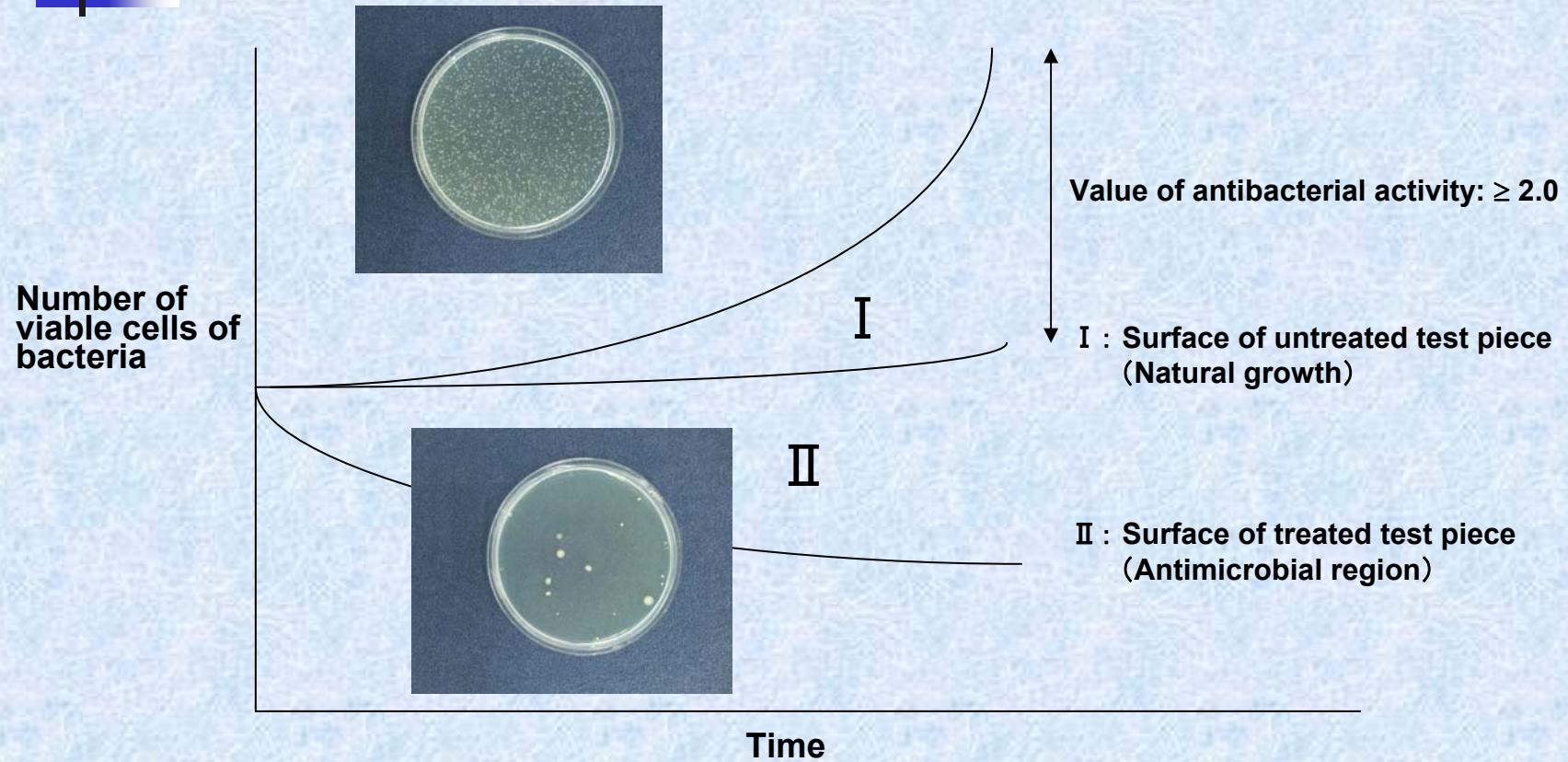
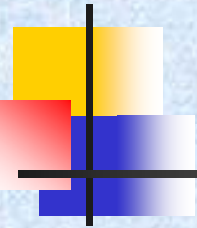
B: log (number of viable cells of bacteria on treated test piece after 24 hrs)



Procedure of JIS Z 2801



Schematic diagram of antimicrobial efficacy



Application of Bactekiller in kitchenware

(Antimicrobial activity: More than 2.0 against *E. coli* and *S. aureus* specified in JIS Z 2801)

Application	Resin	Antimicrobial agent	Concentration (%)	Remarks
Cutting boards	LD-PE LLD-PE PP	BM-102TG BM-503CE BM-103NA	0.2-0.4 0.2-0.4 0.2-0.4	80% share of antimicrobial agent for cutting board products for Japanese market
Transparent sealed containers	PP PE (lids)	BM-102TG BM-503CE	0.2-0.3	Excellent transparency
Dish drainers, dishpans	PP	BM-102TG BM-503CE	0.2-0.3	60% share of antimicrobial agent
Handles of kitchen knives	Melamine POM	BM-102TG BM-103NA	0.2-0.4	
Sponges	PU	BM-102TG BM-103NA	0.3-0.4	

Application of Bactekiller in refrigerator-related articles

(Antimicrobial activity: More than 2.0 against *E. coli* and *S. aureus* specified in JIS Z 2801)

Application	Resin	Antimicrobial agent	Concentration (%)	Customers
Vegetable compartments, shelves	GP-PS	BM-503CE BM-102TG	0.2-0.3 0.2-0.3	Hitachi Toshiba Sanyo Electric Sharp Corp.
Parts for freezers	PP	BM-503CE BM-102TG	0.2-0.3	Same as above
Parts for freezers	PE	BM-503CE BM-102TG	0.2-0.3	Same as above
Door handles	ABS	BM-503CE BM-102TG	0.3-0.5	Same as above
Inside walls	ABS	BM-503CE BM-102TG	0.3-0.5	Same as above

Application of Bactekiller in household equipment

(Antimicrobial activity: More than 2.0 against *E. coli* and *S. aureus* specified in JIS Z 2801)

Application	Resin	Antimicrobial agent	Concentration (%)	Remarks
Toilet seats	PP PP (flame-retardant grade)	BM-102TG BM-102VT	0.3-0.5 0.4-0.6	60% share of antimicrobial agent in toilet seats in Japan
Kitchen counters	Unsaturated PET	BM-103NA BM-102SVP02	0.3-0.7	Application in SMC and BMC
Bathtubs	PMMA	BM-503CE BM-102S5	0.3-0.5	
Door handles	ABS	BM-503CE BM-102TG	0.3-0.5	
Water tanks	PE	BM-102TG BM-503CE	0.3-0.5	

Application of Bactekiller in building materials

(Antimicrobial activity: More than 2.0 against *E. coli* and *S. aureus* specified in JIS Z 2801)

Application	Resin	Antimicrobial agent	Concentration (%)	Remarks
PVC floor materials	PVC	BM-102P BM-102M MP-102P	0.3-0.5 0.2-0.4 0.5-1.0	PVC calendering (BM type) PVC sol processing (MP type)
PVC wallpapers	PVC	BM-102P BM-102M MP-102P	0.3-0.5 0.2-0.4 0.5-1.0	Same as above
Wooden floor materials	UV hardened acrylic	MP-102SVC715	0.5-1.0	Phosphate type antimicrobial agent
Artificial marble	Unsaturated PET (SMC, BMC)	BM-102SVP011 BM-102SVP02	0.3-0.7	Same as above
Artificial marble	MMA	BM-102SVP011	0.3-0.7	Same as above