MICROBEPROOF™ ANTIVIRAL AND ANTIMICROBIAL PLASTIC FILM
TESTING AND DEVELOPMENT REPORT

DESCRIPTION

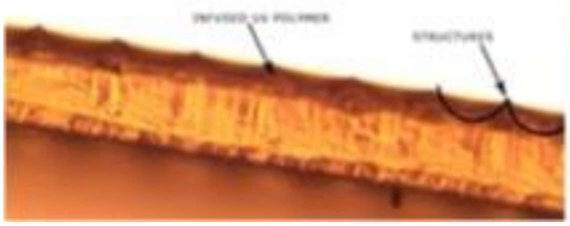
The MicrobeProof novel technological approach is based on the cured surface of the applied UV-Curable coating containing EPA-approved antimicrobial additives, on top of transparent plastic film, which is patterned during the Cast & Cure process in the form of translucent microstructures with a unique geometry that minimizes the adhesion of living bacteria, mold or viruses.

The antimicrobial additives, which are uniformly distributed in the microstructure's matrix, gradually diffuse out of the matrix when the film is contaminated with bacteria or viruses.

This antimicrobial mechanism is based on the electrostatic attraction and charge neutralization between oppositely charged components of pathogen cells and the chemistry of antimicrobial compounds.

The crater-like microstructures of MicrobeProof™ antimicrobial protected films contribute to the high antibacterial activity due to their sharp edges that have different expansion rates in orthogonal axes and induce wall strain during elongation contraction. The crater-like microstructures work by mechanically puncturing a pathogen, and at the same time, applying a positive charge which in turn disrupts its ability to function correctly.

The magnified image of the crater-like microstructured pattern is shown in the images below:



No other commercially available product combines the pathogen unfriendly microstructures, elastomeric topography with asymmetric thermal coefficient properties, and an efficient mixture of ionic antimicrobial chemistries.

MicrobeProof antimicrobial protected conventional and micro structured films have the following properties:

- High efficacy: kills up to 99.99% of majority of common pathogens
- Proven to deactivate the novel Coronavirus
- Lasting protection from mold, fungi, and algae
- Non-leachable
- High accuracy multiple activation modes
- Continuous protection: 24/7, continuously active on the film surface.
- Good chemical, mechanical, and fade resistance properties
- Available in a variety of polymer materials, dimensions, and transparency levels
- Good regulatory status (CFR compliance, etc.)

ANTIMICROBIAL EFFICIENCY OF MICROBEPROOF ANTIMICROBIAL PROTECTED FILMS AGAINST MULTIPLE PATOGENS

To prove the broad antimicrobial efficiency of MicrobeProof antimicrobial protected films, we conducted the ISO 22196: 2011 test against seven common bacteria and one competitive LDPE film Silver Defender™ antimicrobial protected film

MicrobeProof antimicrobial microstructured and Silver Defender™ films have been tested according to the methodology of the ISO 22196 standard within the independent and accredited Industrial Microbiological Services Ltd. The ISO 22196 is an international standard that provides a method to evaluate the ability of treated plastics to kill or prevent the growth of micro-organisms over 24 hours. The following seven essential bacteria were used for this testing: Escherichia coli, MRSA (Methicillin-resistant Staphylococcus aureus), VRE (Vancomycin-resistant enterococci), Salmonella enterica, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Listeria monocytogenes.

The obtained antimicrobial efficiency results are shown in the table below:

Sample Code	Bacterium Type	Film Type	Antimicrobial Efficiency (Escherichia coli)	
			Log Reduction	Percent Reduction
AB-1R	MRSA (Methicillin-resistant Staphylococcus aureus)	Silver Defender™ antimicrobial film	<1.0	23.11%
AB-1	MRSA (Methicillin-resistant Staphylococcus aureus)	CC-1014 antimicrobial film	> 4.0	99.9954
AB-2	E. coli	CC-1014 antimicrobial film	> 4.0	99.9997%
AB-3	VRE (Vancomycin-resistant enterococci)	CC-1014 antimicrobial film	> 4.0	99.9998
AB-4	Salmonella enterica	CC-1014 antimicrobial film	>4.0	99.9988%
AB-5	Pseudomonas aeruginosa	CC-1014 antimicrobial film	>4.0	99.9998%
AB-6	Klebsiella pneumoniae	CC-1014 antimicrobial film	>4.0	99.9986
AB-7	Listeria monocytogenes.	CC-1014 antimicrobial film	>4.0	99.9883

As we can see from the obtained results, the Silver Defender film advertised as the most efficient antimicrobial film in the market today did not pass the ISO 22196 against MRSA, the most common bacterium in hospitals, nursing homes, and health care centers. The ISO 22196 clearly states that any result above 95% is classed as a pass from an antimicrobial standpoint, so 23.11% of Silver Defender antimicrobial efficiency is a complete failure, an indication that their films cannot be used for antimicrobial applications.

On the other hand, the tested MicrobeProof antimicrobial film manufactured almost a year ago exhibits outstanding antimicrobial efficiency against all seven pathogens. We can conclude that Microbeproof's antimicrobial film based on the proprietary micro structured pattern in conjunction with the optimized chemistry has an overall superior antimicrobial efficiency and stability.

Our next milestone was to find a way to determine whether Microbeproof products are also efficient against Clostridium difficile, which is one of the most common pathogens in nursing homes, and which is resistant even to very aggressive surface cleaners. Our success criteria were that any results above 95% would be considered good for this problematic bacterium. Clostridium difficile (C.dif) is a spore-forming bacteria. When in an inhospitable environment (i.e., outside the body), it forms a spore around its vital components as a means of protection. Once it returns to a suitable environment, such as when it is ingested, it will return to a vegetative state. In theory, there is a 'window of opportunity before sporification, during which an antimicrobial system will potentially have an effect. The magnitude of the effect is therefore determined by the duration of that window of opportunity.

Initially, we struggled to find a lab that routinely carries out the ISO 22196/JIS Z 2801 test and offers C.dif as a test organism. Some labs suggested to MicrobeProof that since it wasn't a test they used with any regularity they felt that the results could therefore be unreliable. The labs indicated that our antimicrobial compounds could reduce the population of spore-forming bacteria, but they would not be comfortable making any claims to that effect. There is a reason that most antimicrobial film suppliers don't make claims in the absence of any substantiating test results for the spore forming bacteria or have had tests carried out against C.dif in the vegetative state, which is misleading.

Only Microchem had a procedure for testing against C.dif. They developed their own non-GLP modified ISO 22196 method for this bacterium. The reason is that C.dif is an anaerobic microorganism, and to accommodate this, the inoculated samples are placed in a special anaerobic chamber to prevent them from dying off due to O2 presence.

The obtained results show the antimicrobial efficiency of CC-1014 film against C.dif of 95.96% that, according to the ISO22196 standard, is above the classified pass value of 95% and suitable for antimicrobial protection. Although the test was performed in a controlled environment, the results indicate that the MicrobeProof antimicrobial film would be efficient against C.dif at ambient conditions, and therefore can be recommended as antimicrobial and anti-C.dif protection for nursing homes and hospitals.

ANTIMICROBIAL TEST CERTIFICATE

protected by SteriTouch®

CUSTOMER: LUMENCO/MICROBEPROOF **CERTIFICATE REF:** RADICAL-LUMENCO/MICROBEPROOF-20-09-2021

DATE OF TEST: 20/09/2021

TEST LABORATORY: IMSL LTD, Unit 4-5 Pale Lane Farm, Pale Lane, Hartley Wintney, Hook RG27 8DH, UNITED KINGDOM

This certificate is a summary of the testing conducted on behalf of LUMENCO/MICROBEPROOF by IMSL on materials submitted to Radical Materials. Further information on the test results, protocols employed and IMSL certificates are available on request.

MATERIAL REF.	DESCRIPTION	METHOD	DURATION	TEMPERATURE	SALMONELLA	PSEUDOMONA AERUGINOSA	KLEBSEILLA PNEUMONIAIE	LISTERIA MONOCYTOGENES
54280	PLASTIC FILM	ISO 22196	24 HR	35°C	99.9988% REDUCTION			
54281	PLASTIC FILM	ISO 22196	24 HR	35°C		99.9998% REDUCTION		
54282	PLASTIC FILM	ISO 22196	24 HR	35°C			99.9986% REDUCTION	
54283	PLASTIC FILM	ISO 22196	24 HR	35°C				99.9883% REDUCTION

ANTIMICROBIAL TEST CERTIFICATE

CUSTOMER: LUMENCO/MICROBEPROOF **CERTIFICATE REF:** RADICAL-LUMENCO-44274

DATE OF TEST: 19/03/2021

TEST LABORATORY: IMSL LTD, Unit 4-5 Pale Lane Farm, Pale Lane, Hartley Wintney, Hook RG27 8DH, UNITED KINGDOM

This certificate is a summary of the testing conducted on behalf of LUMENCO by IMSL on materials submitted to Radical Materials. Further information on the test results, protocols employed and IMSL certificates are available on request.

MATERIAL REF.	DESCRIPTION	METHOD	DURATION	TEMPERATURE	E.COLI	STAPHYLOCOCCUS AUREUS
54041	COATING/LACQUER + % ST1312	ISO 22196	24 HR	35°C	99.9997% REDUCTION	
54042	COATING/LACQUER + % ST1312	ISO 22196	24 HR	35°C		99.9954% REDUCTION
54043	AFTER IPA CLEANING + % ST1312	ISO 22196	24 HR	35°C	99.9998% REDUCTION	

ANTIMICROBIAL TEST CERTIFICATE

CUSTOMER: LUMENCO/MICROBEPROOF **CERTIFICATE REF:** RADICAL-LUMENCO-44295

DATE OF TEST: 09/04/2021

TEST LABORATORY: IMSL LTD, Unit 4-5 Pale Lane Farm, Pale Lane, Hartley Wintney, Hook RG27 8DH, UNITED KINGDOM

This certificate is a summary of the testing conducted on behalf of LUMENCO by IMSL on materials submitted to Radical Materials. Further information on the test results, protocols employed and IMSL certificates are available on request.

MATERIAL REF.	DESCRIPTION	METHOD	DURATION	TEMPERATURE	STAPHYLOCOCCUS AUREUS
54081	MICROSTRUCTURED AM FILM (without AM additives)	ISO 22196	24 HR	35°C	99.9866% REDUCTION
54082	MICROSTRUCTURED AM FILM (with AM additives) Design One	ISO 22196	24 HR	35°C	99.9966% REDUCTION
54083	MICROSTRUCTURED AM FILM (with AM additives) Design Two	ISO 22196	24 HR	35°C	99.9877% REDUCTION
54088	SILVER DEFENDER FILM – COMPETITOR	ISO 22196	24 HR	35°C	23.11% REDUCTION

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