New Antimicrobial Treatment for Carpet Applications

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Consumers frequently demand the right to control and select their environment with respect to colors, texture, temperature, humidity, odors, light, and sound. Carpeting constitutes a major environmental surface for both residential and commercial establishments. One implication is that the dyeing and finishing industries are constantly challenged to provide carpeting with desired and needed functional and aesthetic features.

A desirable feature, as shown in market studies, concerns freedom from foul odors. Carpeting by its construction and use provides a habitat for a large variety of microorganisms, some of which not only produce putrid and mildew odors, but also contribute to unsightly defacement and deterioration of carpet components. These microbes may also produce infectious and/or allergenic conditions in humans.[1-5]

Dow Corning Corporation has long been recognized as a world leader in the preparation and uses of polymers made from silicon, including fluids, resins, rubbers, and their manufacturing precursors. One subset of these materials is that of the organo-functional silanes; they are chemically tailored to bond a variety of similar and dissimilar surfaces to each other. Many variations in substituents on silicon are presently available, chosen for the specific surfaces to be modified.

As an extension of this technology, scientists at Dow Corning have learned to bond biologically and/or chemically active molecules to surfaces, thus permanently imparting properties of those molecules to otherwise inert surfaces.[6]

The Dow Corning® antimicrobial agent is the first such material which modifies surfaces by rendering them permanently bactericidal, fungicidal, and algicidal.[7]

Screening Project Success

The antimicrobial activity of certain silane-modified surfaces was discovered during a screening project in which the minimum inhibitory concentrations (MIC) for bacteria were being determined for various Dow Corning products. Repeat testing in the same glassware revealed the glassware itself had become antimicrobial. Continued investigation led to a series of U.S. patents and publications covering this class of materials as broad spectrum algicides, bactericides, and fungicides when applied to solid substrates.

The first commercial application, on men's socks, helped prevent microbially-caused deterioration and defacement, and reduced sock odor associated with the proliferation of microorganisms. An article by Gettings and Triplett presented conclusive evidence that the antimicrobial feature provided a significant reduction in sock odor and that the protection afforded by the treatment was not significantly diminished even after repeated launderings.[8] Mechanisms of

attachment to surfaces, general treatment phenomena, and performance profiles have also been previously presented by Malek and Speier and will not be detailed in this paper.[9]

Specific application of this technology to carpeting and/or carpet fibers has been accomplished and will be described. The technology is being commercialized as the Sylgard™ antimicrobial treatment.

Carpet Applications

In September 1981, the EPA granted Dow Corning an amendment for the use of Dow Corning7 5700 antimicrobial agent on carpeting, giving rise to a new generation of carpet and carpet fiber features. The market for controlling mildew and putrefaction odors on carpet has been filled with powders, liquids, and aerosols designed to mask, modify, or absorb microbially-generated odors.

Today, the approach to serving this market segment is to prevent these odors by dealing with the cause via the Sylgard antimicrobial treatment, rather than periodically attempting to deal with the symptoms.

Of course, cooking, smoking, and other nonmicrobially-generated odors must still be dealt with by appropriate ventilation and housekeeping techniques.

Need For Treatment

The increased use of carpets in hospitals, schools, and other institutions demonstrates the need for an additional property in carpeting: the prevention of bacterial and fungal growth. The need is obvious in hospitals, where the greatest concern about carpeting is apprehension about possible infectious hazards.[2,4,5,10,11] However, the need for a safe antimicrobial treatment is not limited to hospitals. Inhibiting bacteria and fungi is equally important in carpeted areas of play rooms, convalescent bedrooms, sanitariums, and hotel/motel rooms. All of these areas may serve as a reservoir for potentially harmful bacteria and fungi. In addition, there is the problem of odor and deterioration caused by the presence of microorganisms and their breakdown products. Extension of this need to the home is obvious as we consider the use of carpeting in bathrooms, kitchens, below-grade areas, recreation and family rooms, as well as other areas where our pets and babies roam. The need for hygienic freshness is a reality in the consumer's mind.

In institutions, all flooring coverings, textile as well as hard surfaces, need to undergo periodic housekeeping to maintain hygiene aesthetics.

This is particularly true of carpeted patient-care areas. For this reason, hospitals regularly use antimicrobial additives as part of their cleaning procedures. These additives are based on halogenated phenol derivatives, halogenated salicylic acid anilides, organotin compounds, quanternary ammonium compounds, and quaternary ammonium sulfonamide derivatives.

All of these compounds base their activity on leaching or diffusion into their surroundings. Such compounds must be reapplied often because they lack durability against washing, cleaning, and shampooing. Many also have limited effectiveness against specific pest microorganisms and thus have to be applied with other compounds to increase their spectrum of activity.

Table 1
Antimicrobial Activity of Nylon Carpet with the Sylgard Treatment in a 36-Month Study at Duke Hospital

Sample Nylon carpet	Percent Bacterial Insult[1] Reduction[2]			
	Before Installation	12 Months wear,1.5m traffics	22 Months wear,3 M traffics	36 Months wear, 4.5M traffics
Untreated Control	0	0	2.3	3.8
Sylgard Antimicrobial	85	91	78	87

1. Bacterial inoculum was Klebsiella pneumoniae.
2. Average of triplicate tests.

Table II

Antifungal Activity of Nylon Carpet with the Sylgard Treatment

Twelve-Week Tropical Chamber Exposure

Percent covered by fungi
No. of weeks exposure[1]

Sample:	1 Weeks	6 weeks	12 weeks
High Density Nylon Control:			
Unwashed, no shampooing	100	100	100
7 shampoo cycles[2]	100	100	100
14 shampoo cycles	100	100	100
21 shampoo cycles	100	100	100
High Density Nylon with Sylgard Treatment:			
Unwashed, no shampooing	0	0	0
7 shampoo cycles[2]	0	0	0
14 shampoo cycles	0	0	0
21 shampoo cycles	0	0	0

1. Samples were rechallenged with a spore suspension of Aspergillus niger and
2. Penicillum variable at 3, 6, and 9 weeks of the study.
3. Cleaning agents used included Fiber Fresh®, Blue Luster®, HR3® and Woolite® . Data are representative of all test conditions

Laboratory data were presented at the 1982 fall scientific meeting of the Carpet and Rug Institute to show that both gram negative and gram positive bacteria readily adapted to the presence of these toxicants. Projection of this to the "real world" is possible, but has not yet been demonstrated. All of these traits are highly undesirable and have contributed to the lack of confidence expressed by some hospital personnel in the safety and efficacy of these materials on carpets.

Sylgard Treatment

The active ingredient (3-trimethoxy-silylpropyldimethyloctadecyl ammonium chloride) of the Sylgard antimicrobial treatment offers safety and efficacy advantages not found with other hygienic finishes. This compound combines two technologies: the binding mechanisms of alkoxysilanes, with the microorganism-killing ability of conventional antimicrobials. This results in a carpet with these benefits:

1. The treatment is durable and resistant to repeated washing, cleaning, and shampoo-ing of the carpet. (Tables 1 and II)
2. It has a broad spectrum of biological activity, i.e. bacteria, fungi, and yeasts are killed or suppressed from their development and rendered incapable f increasing in numbers when they contact the treated surface. (Tables III and IV)
3. The Sylgard Antimicrobial Treatment is compatible with other finishes and is generally applicable using the usual finishing methods of the carpet manufacturer. (Table V)
4. When used as directed, it is safe to man and the environment. Over 30 intensive toxicological and environmental tests have been performed and reviewed by the EPA for the active ingredient of the Sylgard Treatment.
5. Clinical evaluations demonstrate that textiles with the Sylgard Antimicrobial Treatment effectively reduce and inhibit the growth of odor-causing bacteria.
6. Lack of adaptation of bacter4ia to the presence of the Sylgard Antimicrobial Treatment on the untreated surfaces has been demonstrated using traditional techniques (Table VI)
7. Extension of the finishing technology has also been demonstrated for nylon carpet fibers. (Table VII)

Table III

Efficacy of Dow Corning 5700 Antimicrobial Agent Against Microorganisms of Medical and Economic Importance

(This table indicates the broad spectrum of activity exhibited by Dow Corning 5700 and represents only a small number of the total microorganisms which could be controlled. Dow Corning 5700 is the antimicrobial component of the Sylgard Antimicrobial Treatment)

Bacteria	Yeast	Fungi
S. aureus	S. cerevisae	A. niger
S faecalis	C. albicans	A. flavus
E. coli		A. terreus
S. typhosa		C. globosum
S. choleraesuis		A. verrucaria
P. aeruginosa		P. funiculosum
M. smegmatis		T. interdigitale
M. tuberculosis		P. pullulans
S. mutans		T. maidson
K. pneumoniae		C. fragens
E. agglomerans		
A. calcoaceticus		
S. epidermidis		

Table IV

Control of Bacterial Clinical Isolates on Rugs with the Sylgard Antimicrobial Treatment

Sample	Organism	% Reduction
Control		0
Treated	Steptococcus Fecalis wound isolates	100
Inoculum		0
Control		0
Treated	Staohylococcus aureus wound isolate	100
Inoculum		0
Control		20
Treated	Escherichia coli urine isolate	99+
Inoculum		1
Control		47
Treated	Klebsiella oxytoca urine isolate	100
Inoculum		1

Table V

The Sylgard Antimicrobial Treatment Compatibility with Carpet Processing

Available Carpet Process	Potential Application Process	Anticipated Antimicrobial Activity
		Percent Reduction[1]
Kuster	Pad/spray/foam	>99.9
Beck	Pad/exhaust/spray/foam	>99.9
Sock or Yard	Pad/exhaust/spray/foam	>99.9

1. Percent reduction – CTM-0923 test organisms K. pneumoniae ATCC 4352

Table VI

Bacterial Adaptation Studies on Nylon Carpet Processed with Sylgard Antimicrobial Treatment

Percent Reduction[1]

	Klebsiella pneumoniae					Staphylococcus aurus				
Exposure	1	2	3	4	5	1	2	3	4	5
Nylon Control	0	0	0	0	0	10	5	9	13	26
Nylon with Sylgard Treatment	99.8	99.6	98.8	97.5	99.9	98.6	97.5	96.3	99.4	98.8

1. CTM 0923 shake flask test
2. Shake flask survivors were used for subsequent exposures

Table VII

The Sylgard Antimicrobial Treatment
Compatibility with Carpet Fiber Processing

Nylon Carpet Fiber Stage	Percent Reduction[1]	
	Klebsiella pneumoniae	Staphylococcus aureus
Extrusion	Not tested	Not tested
Finish Application	99.99	100
Drawing approx. 3X	99.99	99.99
Texturing (steam jet)	99.99	99.99
Crimp set-continuous	99.99	99.99
Crimp set-autoclave	99.99	98.6
In carpet mill		
Carding (staple fiber)	Not tested	Not tested
Spinning (staple fiber)	Not tested	Not tested
Autoclave set	98.7	99.99
Superba set	97.6	98.4
Suessen set	99.99	99.99

1. CTM 0923 shake flask technique

Positive Direction

In the quest for better control of our environment, antimicrobial carpeting and carpet fibers with the Sylgard treatment off a clear and safe alternative to the negative effects f microorganisms. In bathrooms, kitchens, basements, children and pet areas, as well as hospitals, nursing homes, hotels, and restaurants, microbial odors and defacement were presumed to come with the territory. Both scientists at Dow Corning and those in the carpet area offer a new option to the consumer-mediation of microorganisms and a more hygienic environment by the use of the new antimicrobial treatment

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Editor's Note: This article was originally published in the June 1983 issue of American Dyestuff Reporter. Since that time, McGee and Malek have retired from Dow Corning Corporation and Mr. White is CEO and Director of Research & Development of ÆGIS Environmental Management, Inc. of Midland, Michigan. ÆGIS was founded in 1990 to commercialize one market segment for the antimicrobial technology described in this article. In 1996, ÆGIS purchased all remaining portions of Dow Cornings' Antimicrobial business and is now engaged in all facets of the global commercialization and technical development of this unique technology. The products referred to in this article as DOW CORNING 5700® Antimicrobial Agent and SYLGARD® Treatment are now known respectively as AEM 5700 Antimicrobial and ÆGIS™ Antimicrobial.