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Biocidal substances in the material of marketed articles – exploring the literature

PM 4/17

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Preface

The Swedish Chemicals Agency was assigned by the Swedish Government to launch an action plan 2011 – 2014 for a Toxic-free Everyday Environment. Reduced chemical risks in the everyday environment would be an important step towards the environmental quality objective A Non-Toxic Environment, established by the Swedish Parliament and operated by The Swedish Chemicals Agency.

Within this framework a project concerning biocide treated articles was led by Lolo Heijkenskjöld, Senior scientific officer at the Agency's Department for Development of Legislation and Other Instruments. For the project, a pilot literature search has been carried out to explore ways to knowledge about the biocide treatment of some material types. The search was performed and reported by Kristin Fransson at Chalmers Tekniska Högskola AB and Jenny Westerdahl at IVL Swedish Environmental Research Institute. Lolo Heijkenskjöld compiled this final report from the study, but the publication was delayed because of a serious accident.

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Summary

New legal requirements apply within EU for the marketing of articles that have been treated with biocides. To comply with these requirements producers, importers and suppliers need access to information about biocidal substances in the material of their articles.

This study was undertaken to explore how knowledge about biocide treatment of some material types can be found in technical and scientific literature. No similar studies aiming for an overview could be found and therefore a pilot search approach had to be developed.

Search approach

The study concerned biocidal substances that may be used in solid materials. Such substances were selected from the ones approved or supported for review under the current EU biocide legislation. The search procedure was aiming for biocidal effects on microorganisms. Textiles, plastics and paper are material types that are often used in consumer articles. They were chosen because of their potential for microbial degradation.

The main sources of information were the two databases SciFinder and Espacenet, each one with its specific potentials and drawbacks. Espacenet covers billions of patents for technical inventions from all over the world. However, patent documents seldom specify individual biocidal substances or describe their use in practice. SciFinder specifies chemical substances but the possibilities to search for chemicals combined with other terms are limited. Also, the possibilities to refine and reduce large amounts of obtained references are limited.

Results

The study showed that biocide treatment of solid materials is not clearly documented in the scientific literature. Further studies would be needed for a more comprehensive understanding of biocide use in the material of finished articles.

The main result of the study was the description of how information about some biocide treated materials could be found through a literature search in SciFinder. When screening the references obtained through this search, it became clear that such information was to be found in patents mainly. Use descriptions in selected patent examples covered methods of biocide application and stated that the treatment would protect the material from microbial damage.

Some treated textiles in the examples were cotton, wool, polypropylene, acrylics, polyamide, polyester and non-woven cellulose materials. Biocidal plastic polymers were polyethylene, polypropylene, ethylene vinylacetate copolymer, PET, polystyrene, ABS, thermoplastics and foamed polymers. Inventions for biocidal paper were building material such as insulating paper and wallboards, other areas were wound dressings, food packaging and wipes.

The example references were mostly published during the past decade. As patent documents normally describe only potential uses for a new invention, the recent publication may indicate an increasing interest in biocide treated materials. Wide spread release of biocidal substances from an increasing use of treated materials may contribute to the microbial development of resistance.

Improved knowledge will be needed so that producers, importers and suppliers can fulfil their legal requirement concerning biocide treated articles.

Sammanfattning

Nya lagkrav gäller inom EU för biocidbehandlade varor på marknaden. För att kunna uppfylla dessa bestämmelser behöver tillverkare, importörer och försäljare tillgång till information om varumaterialens biocidinnehåll.

Denna studie gjordes för att undersöka hur kunskap om några olika biocidbehandlade material kan återfinnas i teknisk och vetenskaplig litteratur. Det fanns inga liknande undersökningar med överblick som mål och därför fick en preliminär sökprocedur utformas.

Sökprocedur

Studien gällde biocidämnen som kan ingå i varumaterial och som godkänts eller är under utvärdering enligt EU-regelverket. Sökproceduren var inriktad mot biocider som har effekt på mikroorganismer. Materialslagen textil, plast och papper valdes eftersom de ofta ingår i konsumentvaror och lätt blir angripna av mikroorganismer.

Huvudsakliga informationskällor var de två databaserna SciFinder och Espacenet, som båda har sina fördelar och nackdelar. Espacenet täcker miljarder patent för tekniska uppfinningar från hela världen men patentdokument specificerar sällan enskilda biocidämnen eller detaljer om deras praktiska användning. SciFinder specificerar kemiska ämnen men har begränsade möjligheter att söka efter kemisk identitet kombinerat med andra söktermer. Möjligheterna att förfina sökresultat med stora referensmängder är också begränsade.

Resultat

Studien visade att biocidbehandlingen av material inte är välbeskriven i vetenskaplig litteratur. Ytterligare studier skulle behövas för en mer fullständig kunskap om användningen av biocider i varumaterial.

Det huvudsakliga resultatet var en beskrivning av hur information om några biocidbehandlade materialslag kan sökas fram med hjälp av SciFinder. Sökresultatets referenser hänvisade oftast till patentdokument. I utvalda referensexempel beskrevs biocidbehandling av materialslaget, dessutom angav man att behandlingen skulle skydda materialet mot mikrobiell nedbrytning.

Några biocidbehandlade textila material i referensexemplen var bomull, ylle, polypropylen, acryl, polyamid, polyester och non-woven cellulosamaterial. Biocida plastpolymerer var polyetylen, polypropylen, etylenvinylacetatcopolymer, PET, polystyren, ABS, termoplaster och skumpolymerer. Biocidbehandlat papper kunde användas till byggisolering, sårvård, livsmedelsförpackningar.

De utvalda dokumenten hade oftast publicerats under det senaste decenniet. Eftersom patent normalt sett endast beskriver de potentiella användningssätten för en ny uppfinning kan den relativt nyliga publiceringen tyda på ett ökande intresse för biocidbehandlade varumaterial. Utspridda utsläpp av biocidämnen från en ökande användning av biocidbehandlade varumaterial kan komma att bidra till utvecklingen av resistens hos mikroorganismer.

Bättre kunskapsunderlag behövs för att tillverkare, importörer och försäljare ska kunna följa EU-reglerna för biocidbehandlade varor.

1 Introduction

Biocides are pesticides used to kill or control harmful organisms, so that their actions do not damage products or create risks to health or the environment. Biocide targets can be microorganisms and insects as well as vertebrates, which means that the control mechanisms need to be very different. Active biocidal substances therefore have widely differentiated properties and should always be handled with caution. As an additional concern it has been raised that excessive use and widespread release of biocides may contribute to harmful microorganisms developing resistance to important active substances.

EU legislation relating to biocides on the market aims to protect human and animal health as well as the environment. This legislation also contains new provisions for the marketing of articles that have treated with biocides.

According to these new provisions, biocide treated articles can only be placed on the market if the active substances have been approved or are included in the EU biocide work programme.[1] When a claim is made about its biocidal properties, the article shall be labelled with information about the incorporated active substances and their biocidal effect. The claimed effects also need to be substantiated in accordance with the directives on misleading advertising.[2]

To comply with the EU provisions, the producers, importers and suppliers need access to information about the biocidal substances in the material of their articles. Finished articles are produced from a broad variety of materials but all treated materials will inevitably give rise to some release of contained biocidal substances during the use, cleaning, wear and tear of the article.

An internet marketing survey showed that vast numbers of consumer articles could be treated with biocides in order to prevent unwanted effects. According to this survey the article suppliers informed about such additional properties, but gave no information on biocidal substances or supporting evidence for the claimed effects.[3]

In view of the known but insufficiently described biocide treatment of consumer articles, Chalmers Tekniska Högskola AB was commissioned to perform a pilot literature search on the use of biocide substances in some solid materials.

Their preparatory searches showed that the amount of scientific references can be very large and increase rapidly for some active substances. But studies aiming for an overview of materials treated with biocidal substances could not be found. Therefore a pilot search approach had to be developed for the study.

[1] Original work programme under Directive 98/8/EC concerning the placing of biocidal products on the market, later replaced by Regulation (EU) No 528/2012 and Commission Delegated Regulation (EU) No 1062/2014 of 4 August 2014 on the work programme for the systematic examination of all existing active substances contained in biocidal products referred to in Regulation (EU) No 528/2012 of the European Parliament and of the Council Text with EEA relevance.

[2] Directive 2006/114/EC concerning misleading and comparative advertising protects professional actors, while Directive 2005/29/EC concerning unfair business-to-consumer commercial practices protects consumers.

[3] KemI PM 2/12 Biocide treated articles – an Internet survey.

2 Description of literature and databases used

Initial searches to identify available literature for this study showed that patents and scientific articles are common sources of information. Patent documents contain technical and legal information about inventions but are seldom referred to in scientific studies, hence there is a need to briefly introduce this source of information.

Patent applications describe inventions that are potentially of technical and economic interest. It is important to bear in mind that patent documents not necessarily report on an invention's use in practice. Instead, the year of publication and frequency of references to the patent may indicate if an invention has been successful on the market. Newer patents may only suggest potential uses for an invention.

It is equally important to see the inventor's interest not to disclose more information than necessary about an invention and its claimed function. At the same time, the description should be as broad as possible. This means that more than one biocidal substance and several materials may be mentioned in one single patent, as shown in the example reference below:

> Patent no WO 2008091794 from Dow Global Technologies Inc., USA
>
> Mold-resistant wallboard that provides increased mold resistance at lower biocide loadings
>
> Wallboard and facing paper that provides increased mold resistance at lower biocide loadings are described. The biocide is: (a) an n-alkyl isothiazolinone such as octylisothiazolinone (OIT), a monohalo and dihalo substituted n-alkyl-isothiazolinone such as chloromethyl-isothiazolinone (CMIT) or dichlorooctylisothiazolinone (DCOIT), 3-iodo-2-propynyl-butylcarbamate (IPBC), chlorothalonil, methylene-bis-thiocyanate or mixts. of two or more thereof; or (b) carbendazim and a second biocide selected from 3-iodo-2-propynyl-butylcarbamate (IPBC), diiodomethyltolylsulfone (DIMTS), sodium pyrithione, octylisothiazolinone (OIT), dichlorooctylisothiazolinone (DCOIT), and chlorothalonil.

2.1 Espacenet database on patents

The database Espacenet[4] gives access to publically available information from more than 80 million patent documents, European and global. It contains data originating from year 1836 up to the present time. The database is compiled by the European Patent Office.[5]

The patent documents are reviewed and classified by experts according to one or more coding systems, for example the International Patent Classification (IPC) or the European Classification (ECLA), which is based on the IPC. The patents can be coded into several classes, such as A "Human Necessities" or C "Chemistry; Metallurgy", and into related sub-classes, for example type of product, material or production process.

[4] http://www.epo.org/searching/free/espacenet.html
[5] http://www.epo.org/index.html

An example shows the hierarchy of codes and sub-classes:

G	Physics
G02	Optics
G02C	Spectacles, sunglasses or goggles
G02C5	Construction of non-optical parts

Some 70.000 different codes are used in the IPC system; ECLA has a much larger number of sub-classes and hence a higher resolution.

The Espacenet database can be searched for patent title, inventor, company, application number, year of publication, classes and sub-classes. It is also possible to search for combinations of sub-classes to obtain patents within their intersect.

2.2 SciFinder database on chemicals

The database SciFinder is focused on chemical substances and contains information from scientific reports, articles and books as well as from patents and commercial data sources. More than 10.000 scientific journals and 63 patent authorities around the world (including Europe, America, China and Japan) are covered. The database is compiled by the American Chemical Society.[6]

References for some 70 million organic and inorganic substances can be explored, using their CAS number as search entry, i.e. their unique registry number with the Chemical Abstracts Service (a division of the American Chemical Society). Chemical structures, trade names and text-phrases can also be used, but searches for combinations of text phrases and/or CAS numbers are not possible. Instead, single text phrases or pre-defined SciFinder index terms have to be used.

Sets of references retrieved from a search can be sorted and further refined in several ways. For instance, pre-defined category headings and categories like “Technology” and “Metallurgy” can be used with the “categorize” function to limit the number of references. The number can be further reduced by the “refine” function, where text-based searches among the references are performed. Sets of references can be saved and combined to make intersects of the saved references.

However, some limitations of importance for this study need to be noted. If a search generates more than 20.000 references, the dataset cannot be saved. When the number of references is higher than 15.000, it is not possible to use the function “categorize” and in sets of more than 10.000 references, duplicate references are not removed.

[6] http://www.acs.org/content/acs/en/about.html

3 Description of performed searches

3.1 Combined searches in Espacenet

In Espacenet inventions with a biocidal function belong to the sub-class “Preservation of bodies of humans or animals or plants or parts thereof; biocides e.g. as disinfectants, as pesticides, as herbicides” (A01N), where more than 50.000 items can be found.

The database was searched for references in the intersects of the biocide sub-class above and the sub-classes for some material types often damaged by harmful organisms: textiles, plastic polymers, paper, leather and hides.

The search gave the number of references to biocide use in these materials as shown in Table 1 below. The largest amount of references were obtained for textiles and polymeric materials (more than 6.000 patents each). Again, it needs to be underlined that patents do not reflect a factual use and that a high number of patents only indicates that biocidal use is possible and maybe of technical and economic interest.

For textiles, the Espacenet sub-classes are divided according to production processes, such as fibre processing, weaving or surface treatment. However, the search results in Table 1 showed that patents for biocidal function in textiles were mainly registered for treatment of fibers, yarns or finished textiles.

For polymeric materials, the sub-classes describe different types of polymers and their chemical composition as well as polymer production processes, such as compounding. The search results showed that the patents mainly referred to chemical composition of the polymer.

The sub-classes for paper are based on production processes, including the production of pulp and cellulose. The number of patents concerning paper was smaller and the patents mostly involved biocide use for the preservation of pulp; less than half appeared to deal with surface treatment of finished paper.

Only very few patents concerned biocidal effects in leather and hides.

Table 1. Number of patents obtained in an Espacenet search for sub-class A01N "Preservation of bodies of humans or animals or parts thereof; biocides e.g. as disinfectants, as pesticides, as herbicides" in combination with sub-classes for certain material types.

Material type sub-class code	Material type sub-class code name	Number of patents
Textiles:		
D01	Natural or artificial threads or fibres; Spinning	288
D01F	Chemical features in the manufacture of artificial filaments, threads, fibres, bristles or ribbons; Apparatus specially adapted for the manufacture of carbon filaments	252
D02	Yarns; Mechanical finishing of yarns or ropes; Warping or beaming	10
D03	Weaving	8
D04	Brading; Lace-making; Knitting; Trimmings; Non-woven fabrics	130
D06	Treatment of textiles or the like; Laundering; Flexible materials not otherwise provided for	2.714
D06L	Bleaching, e.g. optical bleaching, dry-cleaning, or washing fibres, yarns, fabrics, feathers or made-up fibrous goods; Bleaching leather or furs	103
D06M	Treatment, not provided for elsewhere in D06, of fibres, yarns, fabrics, feathers, or fibrous goods made from such materials	2.358
D06N	Wall, floor or like covering materials	108
D06P	Dying or printing textiles; Dying leather, furs, or solid macromolecular substances in any forms	279
Polymeric materials:		
C08F	Macromolecular compounds obtained by reactions only involving unsaturated carbon-to-carbon bonds	1.641
C08G	Macromolecular compounds obtained otherwise than by reactions only involving unsaturated carbon-to-carbon bonds	2.003
C08J	Working-up; General processes of compounding; After-treatment not covered by C08B, C08C, C08F and C08G May overlap with C08F and C08G	1.010
C08J3	Processes of treating or compounding macromolecular substances May overlap with C08F and C08G	553
C08J9	Working-up of macromolecular substances to porous or cellular articles or materials; After-treatment thereof May overlap with C08F and C08G	280
C08L	Compositions of macromolecular compounds May overlap with C08F and C08G	1.279

Paper:		
D21	Paper-making; Production of cellulose	1.036
D21C	Production of cellulose by removing non.cellulose substances from cellulose-containing materials; Regeneration of pulping liquors	211
D21H	Pulp compositions; Preparation thereof not covered by classes D21C or D21D; Impregnating or coating of paper; Treatment of finished paper not covered by class B31 or subclass D21G; Paper not otherwise provided for	857
C08L1	Compositions of cellulose, modified cellulose or cellulose derivatives	46
Leather and hides:		
C14	Skins; Hides; Pelts; Leather	150

3.2 Searches in SciFinder

3.2.1 Bibliographic searches

A bibliographical search was performed in SciFinder in order to arrive at biocidal effect terms that are more specific than the Espacenet sub-class. For this, a list of biocide terms was provided by the Swedish Chemicals Agency. The terms and the number of references for each one are shown in Appendix A. By far, the most frequently documented phrase was "antibacterial agents" with more than 700.000 references.

Arranging the results from this search according to type of target organism, e.g. bacteria or fungi, it could be seen that the number of references declined considerably if target terms were specified by the addition of "products" or "materials" or "treatment". This is shown in Table 2 below. Detailing the search terms more could thus be one way to further refine search results.

Table 2.Number of references obtained in a bibliographic SciFinder search for biocide target organisms and specified use terms.

	Target term	**Target term + "products"**	**Target term + "materials"**	**Target term + "treatment of products"**	**Target term + "treatment of materials"**
Antibacterial	416.652	14.387	9.057	4.639	2.702
Antimicrobial	227.838	17.809	6.650	4.212	2.009
Antifungal	224.758	13.241	4.361	-	1.605
Disinfectant	88.075	17.014	8.550	-	-

A second bibliographic search was performed to study citation frequencies for biocidal substances that may be used in materials. This search concerned substances included in the EU biocide legislation[7] work programme 2012 for the following product types (PT):

- PT1 - Human hygiene biocidal products
- PT2 - Private area and public health area disinfectants and other biocidal products
- PT7 - Film preservatives
- PT9 - Fibre, leather, rubber and polymerised materials preservatives.

Volatile and dissociating substances, e.g. alcohols and acids, were excluded as unlikely to integrate into solid materials. A list of potentially relevant active substances, prepared by the Swedish Chemicals Agency, is shown in Appendix B, together with the number of references obtained for each substance in this search.

The number of references varied largely, from zero up to more than 10.000 references for some substances. For silver and silver compounds extreme amounts of references were found, something that might reflect a high technical and economic interest in their use.

[7] Original work programme under Directive 98/8/EC concerning the placing of biocidal products on the market.

3.2.2 Literature searches

Relevant active substances

The references found in the second bibliographic search described above were further studied in a literature search. This was done to explore the SciFinder possibilities to find references that report on the use of active substances for biocidal material properties. Textiles, plastic polymers and paper were identified as important material types in the Espacenet searches.

The following procedure was used for this SciFinder literature search:

1. For substances with more than 40.000 references, an initial text-based search was made for ”Biocide” to reduce the number of references.
2. For all substances, references connected to the pre-defined terms “Uses” and “Preparation” were found.
3. The “categorize” function was applied, using the category “Materials & products” under the heading “Technology”.
4. The retrieved references were further refined using pre-defined terms relating to the three material types.

The resulting references were screened manually. Relevant information on active substances and their biocidal function when used in a solid material was compiled from selected examples as shown in Appendix C.

The selected examples covered several active substances. The documents described the biocidal effects and in some cases claimed that the substances would protect the material against microbial deterioration and improve its durability. The biocide concentration in plastic materials was sometimes suggested, but generally given in very broad ranges, e.g. 0.001-10 percent.

Treated textile materials were for instance pure or blended cotton, wool, polypropylene, acrylics, polyamide and polyester. Non-woven cellulosic materials were mentioned for wipes and other cleaning devices, towels and bandages. Other textile products mentioned in the example references were clothes, bed linen, carpets, filters and textiles for use in surgery and hospitals.

Some biocidal plastic polymer examples were polyethylene, polypropylene, ethylene vinylacetate copolymer, PET, polystyrene, ABS, thermoplastics and foamed polymers in general. Specific product types such as storage bags, protective covers, insoles, coating on bank notes, electric power cords, wiring and cables were also mentioned.

Biocidal paper inventions concerned building material such as insulating paper, antifungal paper, wallboard and facing paper. Other areas for treated paper were wound dressings, food packaging and wipes.

One single active substance

To further explore the possibilities to reduce the number of references to a workable and yet meaningful size, a second literature search was performed for the well-known antimicrobial substance triclosan. The results of this search would help illustrating the strengths and weaknesses of SciFinder as search engine.

The following procedure was used:[8]

1. Initial search for triclosan, CAS number 3380-34-5
2. The “categorize” function was applied to the references found, using the category “Materials & products” under the heading “Technology”.
3. The “refine” function was applied to the retrieved references, i.e. text-based searches for the frequently reported biocidal effect terms: ”antibacterial”, ”antimicrobial”, ”antifungal” and “disinfectant”.
4. The sets of obtained references were combined and saved.
5. The “categorize” function was applied once more, this time using “Technology” and either category “Materials & products - textiles”, - plastics” or - paper”.

The initial search gave 5.131 references for triclosan. Table 3 below shows how the number of references declined for each step of the search procedure. The first step resulted in some reduction, whereas the following one achieved practically no reduction at all. The last step, however, seemed to bring substantial reduction.

Table 3. Number of triclosan references obtained in a SciFinder literature search and rate of reduction in each procedural step.

Initial search	**Categorize: Technology; Materials & Products**	**Refine: antibacterial, antimicrobial, disinfectant or antifungal**	**Categorize: Technology; Materials & Products**		
			- Textiles	**- Plastics**	**- Paper**
5.131	3.847 (25 %)	3.798 (1 %)	157 (96 %)	82 (98 %)	86 (98 %)

[8] This was done at a later point in time than the first literature search.

4 Discussion

Search approach

Preliminary test searches showed that biocide use mostly is reported in relation to the preservation of wood and chemical mixtures. As these uses are relatively well documented already, they were excluded from the study. Instead, work was focused on the search for scientific literature on some biocide treated materials often used in consumer articles: *textiles*, *plastic polymers* and *paper*.

By the legal definition biocides are aimed to control all kinds of harmful organisms, such as microorganisms, insects or vertebrates. For this study, however, the search concerned biocidal effects on microorganisms only, as the chosen material types often are damaged by microorganisms. The terms *Antibacterial*, *Antimicrobial*, *Antifungal* and *Disinfectant* were selected as they appeared often in the first bibliographical search.

The citation frequency for a substance can be seen as an indication of interest in its technical use. Another bibliographic search was performed to see the amount of references to biocides that may be used in materials, i.e. *biocidal substances in the work programme for four product types according to the EU biocide legislation*. These four product types cover biocide treatment of materials better than the other eighteen types. Several substances were deselected from the list because of their unsuitable dissociating and volatile properties. Nevertheless, the number of potentially relevant substances reached almost one hundred. This amount of substances contributed to making the literature search quite time consuming.

The number of references found in the second bibliographic search varied largely but mostly more than thousand references per substance were found. The total amount of citations for all substances therefore became very large. Later search results did, however, indicate some ways to reduce the number of retrieved references for a future study (detail the biocidal effect terms more, deselect more product types, disregard substances with lower amounts of references).

Sources of information

The two databases SciFinder and Espacenet both cover large amounts of references. Espacenet provides references to patents concerning technical inventions from all over the world. Patent documents may often be both broad and vague, in order to indicate as many applications as possible for a new invention but not disclose too much information about it. The documents in Espacenet get reviewed and classified according to a system where classes and sub-classes may follow several separate structures, for instance production process as well as chemical composition for polymers. The classification of patent documents was therefore less useful in this search for references to individual substances and their use in specified material types.

References to individual chemicals can on the other hand be retrieved in SciFinder. Ambiguities relating to chemical nomenclature or trade names are avoided through the use of unique CAS registry numbers. However, Boolean logic cannot be applied in SciFinder searches; this means that searching for combined text phrases and/or CAS numbers is not possible. Instead, single text phrases or pre-defined SciFinder terms have to be used.

The first literature search for references to a hundred substances, using pre-defined terms that cover broad areas, gave results that needed refinement in several steps. This required quite some time and the example references were finally selected after manual screening of the retrieved references.

As a way forward, the search procedure was modified in a second literature search concerning the well-known antimicrobial substance triclosan. The results here showed that further detailing the terms for biocidal effects did not help reducing the number of retrieved references. That should, however, be reasonable for a substance so widely used for its antimicrobial properties. When more detail was added to the search terms for its use in materials, the amount of retrieved references was significantly reduced.

Materials and articles in selected references

The selected example references from the general literature search showed that a considerable variety of textile and plastic materials was proposed to be treated with biocides. For instance, the examples could deal with pure and blended cotton, wool, nonwoven cellulosic fabrics, acrylics, polyester or polyamide textile fibres. Biocide use in plastics was suggested for polymers like polyethylene, polypropylene, ethylene vinylacetate copolymer, PVC, PET, polystyrene, ABS, thermoplastics and foamed plastics in general.

Also the finished articles proposed to be made from biocide treated materials varied greatly. Some treated textile products were cleaning devices, clothes, bed linen, carpets, filters and wound dressings. Biocidal plastic articles were food containers, storage bags, protective covers, insoles, bank note coatings, electric power cords, wiring and cables. Furthermore, biocidal paper applications could be insulating paper and wallboards in buildings, food packaging, wound dressings or wipes.

Conclusions

The study showed that in general, documents describing the biocide treatment of solid materials are not easily found in the scientific literature. Frequent citation could be found for certain biocidal substances but, for an overview and a more general understanding of the use of biocides in finished articles, further studies would be needed.

The main result of the study was the description of how knowledge on some biocide treated materials can be found through a literature search in SciFinder. The large amount of references obtained in this explorative search did, however, require quite cumbersome refinement steps. After a manual screening of the documents, a number of examples were selected to show relevant information concerning the use and function of several active substances in materials. Some of the substances seemed to be easily integrated into different material types and were proposed to be used in a wide variety of consumer articles.

Most of the examples were patent documents and mainly published during the past decade. As patents normally describe the potential uses for a new invention rather than an ongoing use, the observed recent publication could indicate an increased future interest in biocide treated materials.

An increasing use would further stress the need for improved knowledge. Otherwise, article producers, importers and suppliers will have difficulties fulfilling their legal requirement and consumers will not be able to make informed choices. An increasing wide spread release of biocidal substances from treated articles may thereby contribute to the development of microbial resistance to important biocides.

Appendix A

Bibliographic SciFinder search for references to biocidal effects

Number of references	Search phrase
742.290	Antibacterial agents
416.652	Antibacterial
227.838	Antimicrobial
224.758	Antifungal
88.075	Disinfectant
65.453	Anti-infective agents
61.182	Antifungal agents
53.616	Preservatives in products
30.023	Preservatives in materials
20.986	Antifungal treatment
17.809	Anti-microbial products
17.014	Disinfectants in products
14.747	Antibacterial properties
14.387	Antibacterial products
13.241	Antifungal products
9.057	Antibacterial materials
8.550	Disinfectants in materials
6.650	Anti-microbial materials
4.868	Antibacterial surface
4.639	Antibacterial treatment of products
4.361	Antifungal materials
4.212	Antimicrobial treatment of products

1.605	Antifungal treatment of materials
2.702	Antibacterial treatment of materials
2.009	Antimicrobial treatment of materials
1.971	Biocidal/biocide products
1.223	Bio-resistancy
670	Biocide treatment of products
465	Biocide treatment of materials
255	Treated articles
178	Preservatives in consumer goods
60	Germ free material
55	Self-decontaminating materials
48	Self-decontaminating surface
9	Biointeractive fibers
6	Antibacterial treatment of consumer goods
3	Antifungal treatment of consumer goods

Appendix B

Bibliographic SciFinder search for references to active substances

Number of references	Substance	CAS number
253.798	Silver	7440-22-4
44.055	Chitosan	9012-76-4
25.218	Silver nitrate	7761-88-8
12.859	Glycollic acid	79-14-1
12.509	Cinnamic aldehyde	104-55-2
12.191	Silver chloride	7783-90-6
12.037	Pentachlorophenol	87-86-5
9.294	Glyoxal	107-22-2
9.204	Thiram	137-26-8
7.887	Dichlorvos	62-73-7
7.163	Diuron	330-54-1
6.871	Carbendazim	10605-21-7
6.840	Cetylpyridinium chloride	123-03-5
6.673	Deltamethrin	52918-63-5
6.241	Nonanoic acid	112-05-0
5.078	Thiabendazole	148-79-8
4.905	Imidacloprid	138261-41-3
4.631	Triclosan	3380-34-5
4.621	2-Phenoxyethanol	122-99-6
4.255	Biphenyl-2-ol	90-43-7
2.932	Propiconazole	60207-90-1
2.884	Tosylchloramide sodium - Chloramin T	127-65-1

Number of references	Substance	CAS number
2.840	Dimethylfumarate	624-49-7
2.839	Methynonylketone	112-12-9
2.699	Tebuconazole	107534-96-3
2.682	3-(4-isopropylphenyl)-1,1-dimethylurea / Isoproturon	34123-59-6
2.582	Lambda cyhalothrin	91465-08-6
2.561	CHDG	18472-51-0
2.338	Chlorocresol	59-50-7
2.288	Bis(tributyltin)oxide	56-35-9
2.267	Abamectin	71751-41-2
2.253	Fipronil	120068-37-3
2.094	2-Butanone, peroxide	1338-23-4
1.947	Terbutryn	886-50-0
1.889	Zinc pyrithione	13463-41-7
1.808	Folpet	133-07-3
1.803	PVP-iodine (see iodine) Polymer	25655-41-8
1.801	Symclosene	87-90-1
1.651	Dichlofluanid	1085-98-9
1.539	BIT	2634-33-5
1.504	Troclosene sodium	2893-78-9
1.461	Sodium dimethyldithiocarbamate	128-04-1
1.433	Bronopol	52-51-7
1.369	DDAC	7173-51-5
1.282	Naled	300-76-5
1.201	Bendiocarb	22781-23-3
1.157	Monolinuron	1746-81-2

Number of references	Substance	CAS number
1.083	Metam-sodium	137-42-8
1.003	IPBC	55406-53-6
.967	OIT	26530-20-1
862	Sulphuryl difluoride	2699-79-8
811	Dimethyloctadecyl[3-(trimethoxysilyl)propyl]ammonium chloride	27668-52-6
799	PQ Polymer	25988-97-0
770	Triklokarban	101-20-2
760	Flufenoxuron	101463-69-8
711	Poly(hexamethylenebiguanide) Polymer	91403-50-8
696	Tolylfluanid	731-27-1
671	DCOIT	64359-81-5
639	Sodium 2-biphenylate	132-27-4
609	TCMTB	21564-17-0
528	Chlorophene	120-32-1
513	Sodium pyrithione	3811-73-2
453	DBNPA	10222-01-2
334	THPS	55566-30-8
328	p-[(diiodomethyl)sulphonyl]toluene	20018-09-1
235	PAP	128275-31-0
213	TMAD	5395-50-6
148	Peroxyoctanoic acid	33734-57-5
147	Diamine	2372-82-9
126	Potassium dimethyldithiocarbamate	128-03-0
118	BBIT	4299-07-4
106	Octenidine dihydrochloride	70775-75-6

Number of references	Substance	CAS number
94	DCPP	3380-30-1
91	Sodium dichloroisocyanurate dihydrate	51580-86-0
87	TCDO	92047-76-2
70	Dimethyltetradecyl[3-(trimethoxysilyl)propyl]ammonium chloride	41591-87-1
49	Oxazolidin / MBO	66204-44-2
39	Sodium p-chloro-m-cresolate	15733-22-9
37	Cu-HDO	312600-89-8
33	Bardap 26 Polymer	94667-33-1
28	Potassium 2-biphenylate	13707-65-8
26	MMPP	84665-66-7
23	HPT	25254-50-6
14	PHMB Polymer	27083-27-8
1	Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides (see ADBAC)	68391-01-5
1	ADBAC	68424-85-1
1	Quaternary ammonium compounds, benzyl-C12-14-alkyldimethyl, chlorides (see ADBAC)	85409-22-9
1	Silver zeolite A	130328-18-6
0	Quaternary ammonium compounds, di-C8-10-alkyldimethyl, chlorides (see DDAC) (New CAS-number 32289-58-0)	68424-95-3
0	Amines, C10-16-alkyldimethyl, N-oxides	70592-80-2
0	Quaternary ammonium compounds, C12-14-alkyl [(ethylphenyl)methyl]dimethyl, chlorides (see ADBAC)	85409-23-0
0	Glucoprotamin	164907-72-6
0	Silver-Zinc-Zeolite	130328-20-0
0	Silver phosphate glass (New CAS-number 15627-09-5)	398477-47-9

Appendix C

Information on biocide treated materials and active substances in selected documents

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
133-07-3 Folpet	Antimicrobial/antifungal properties are derived from natural compds. that are extd. from plants and incorporated into resins in a suitable concn. and extruded on a blown or cast film extruder. Storage items and protective covers are formed from the blown or cast film. An anti fungal and anti-microbial compound which is included in storage items and protective covers. The storage items comprise storage bags. The protective covers to comprise covers for mattresses, furniture and rugs. The storage items and covers comprise poly-olefins, such as polyethylene and polypropylene. The anti-microbial/anti-fungal properties are derived from natural compounds that are extracted from plants. In an embodiment, the plants are lusianthrin and chrysin. In an embodiment, the compounds are chemical in nature. The treated bags and covers protect contents from molds and fungi that ordinarily form over time in a closed storage environment.	Polyolefins such as polyethylene and polypropylene Storage items, protective covers	Suitable	BLOK, J. 2010. Anti fungal and anti-microbial protection for storage items and protective covers. US patent application US20100657012 20100112
148-79-8 Thiabendazole	Synthetic thermoplastic polymer articles are effectively protected from infestation by mites, such as house dust mites or bed mites, by incorporation of an agent selected from propiconazole, cyproconazole, difenoconazole, fludioxonil, thiabendazole, tebuconazole, zinc pyrithione, 2-n-octyl-4-isothiazolin-3-one, 4,5-dichloro-N-n-octylisothiazolin-3-one, certain 2,4-bis(alkylamino)pyrimidines or silver compds., carbendazim, 10,10'-oxy-bis-phenoxyarsene, and/or n-butyl-1,2-benzisothiazolin-3-one and optionally an antimicrobial agent into the bulk of the resin. The final articles may be filters, bed clothes and fillings, mattresses, covers, pillowcases, upholstery fabrics and foams, textiles, and floor coverings including carpets, backing material like backing for flooring, and underlays. Thus, 0.2% triclosan and 0.2% thiabendazole were mixed with polypropylene pellets (Moplen HP 451N) at room temp. and extruded via a twin-screw extruder at 230°, cooled, solidified, and used to produce polypropylene multifilament fibers with a fiber spinning line. The fibers were knitted into socks that, when soiled with natural dust, acclimated, and inoculated with mites (Dermatophagoides pteronyssinus) had no living dust mites after 6 wk of incubation under optimal conditions.	Textiles from thermoplastic polymer (polypropylene)	0.2 %	SCHNEIDER, A., HERBST, H., RIEFFEL, T. T. & KOLB, M. 2008. Acaricide synthetic materials and articles made therefrom. Switzerland patent application WO2007EP60576 20071005

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
148-79-8 Thiabendazole	The paper product contains substituted 1,2-dihydroquinoline antimicrobial agent to inhibit microbial growth or replication in paper products. The paper product is manuf. by contacting the substituted 1,2-dihydroquinoline with a compn. contg. a pulp; forming a paper web from the pulp and drying the paper web.	Paper		ABOU-NEMEH, I. 2007. Anti-microbial paper products having a substituted 1,2-dihydroquinoline. US patent application WO2006US38783 20061004
148-79-8 Thiabendazole	The invention relates to a process for preparing a biocidal composition for plastics which comprises a graft copolymer and a biocidally active polymer additive and the biocidal polymer composition which comprises a graft copolymer and thiabendazol. It is known that formed polymer articles deteriorate and degrade by action of microorganisms, such as bacteria, algae and fungi, which can be prevented by adding biocides into the plastic materials, cf. Plastics Additives Handbook, Ed. Hans Zweifel, 2001, Antimicrobials, D. Ochs, pp. 647-680 and Directory of Microbicides for the Protection of Materials, A Handbook, Ed. Wilfried Paulus, 2005, Microbial degradation of plastics, P.J. Dylingowski, R. G. Hamel, pp. 325 - 345. In order to obtain the desired activity, the concentration of the biocidal compound must be higher at surface of the polymer article, where micro-organisms are attached to the plastic article. In addition, biocides should not be easily extractable from the plastic material to sustain long-term activity and reduce undesired exudation and leaching into the environment. The objective of this invention is to improve the biocidal activity of biocidallly active polymer additives in polymer compositions. According to a more specific embodiment, the invention relates to better compatibilization and dispersability of organic biocides like triclosan and thiabendazol in plastic materials.	Plastics	0.001 – 10 % (w/w)	SIMON, D., HERBST, H. & RIEFFEL, T. T. 2009. Biocidal composition for plastics. Germany patent application WO2009EP50978 20090129
3380-34-5 Triclosan	The disposable hand-sterilizing towel comprises a towel main body composed of layered cotton-based nonwoven, and a towel extn. ring. Individual disposable hand-sterilizing towels are packed in plastic bags. The disposable hand-sterilizing towel has the advantages of simple structure, easy operation, and convenient usage.	Cotton-based non-woven Towels		HU, W. & LIU, W. 2011. Disposable hand-sterilizing towel for preventing hospital infection. China patent application CN 2011-20060583.

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
3380-34-5 Triclosan	Certain non-woven materials such as wiping cloths ("wipes"), packaging materials, non-woven bandages etc. function often as short lived disposable articles because after some use they are prone to rapid biodeterioration. Moreover prolonged use of e.g. wiping cloths may lead to bad sanitary conditions e.g. due to undesired spread of bacteria and moulds. That is why such articles are usually discarded after having been used only once. Washing may help to extend the lifespan of these articles somewhat but is often found too cumbersome. The present invention aims at providing certain non-woven articles such as wiping cloths etc. having a longer resistance to biodeterioration and a longer lifespan than is normally available, and the usage of such non-woven articles may help to improve sanitary conditions in hospitals, laboratories, catering establishments and households in general. Consequently "wipes" for industrial and domestic use are provided.	Polymer in non-woven material	0.1 - 5 % (w/w)	MCLENNAN, A. J. & KAPADIA, S. N. 1996. Sanitiser in polymer and its use in non-wovens. Great Britain patent application EP19940309133 19941207
3380-34-5 Triclosan	An antimicrobial plastic compn. Suitable for any non-foamed application includes an antimicrobial compd. uniformly dispersed in a plastic. The antimicrobial compd. is selected from the group consisting of silanol quaternary ammonium compds. and salts thereof (SQACs) having a hydroxyl or hydrolyzable silane group capable of undergoing a condensation polymn. reaction to form a homo or copolymer, and/or forming a covalent bond with the plastic and/or other components in the plastic compn. Also described are methods for prepg. an antimicrobial plastic compn. including: (i) uniformly dispersing an antimicrobial compd. in a plastic; (ii) forming a shaped article; and (iii) optionally exposing the shaped article obtained in (ii) to moisture or steam. The antimicrobial plastic compn. can provide an article which is non-leaching, environmentally safe, non-toxic, with surface renewability, durable antimicrobial properties and also has improved phys. and chem. properties such as tensile strength, static dissipation and chem. resistance.	Non-foamed plastic	0.1 - 30 % (w/w)	NEIGEL, D., LODER, E. & DVORAK, M. 2011. Antimicrobial plastic compositions and methods for preparing same. US patent application WO2011US00554 20110325
3380-34-5 Triclosan	Polymeric material such as polypropylene, which can be used in the manuf. of banknotes having security features therein. The material can be a sheet or substrate and/or an acrylate polymer coat applied to at least one surface of a banknote.	Polymeric		OLSSON, A. 2008. Antimicrobial currency, material and method. WO2008097314A1.
7173-51-5 DDAC	Devices are provided which are functionalized to include surface regions having anti-infective agents. Methods are provided for functionalizing various material surfaces to include active surface regions for binding anti-infective agents. Methods are provided by which anti-infective moieties or agents are bonded to functional zirconia thin film in formed on a polymer substrate. Also a zirconium oxide/alkoxide adhesion layer was deposited onto Nylon 6/6 and then reacted with a soln. of 11-hydroxyundecylphosphonic acid.	Metals, alloys, polymers, plastics, glass, textiles		Clevenger, Randell; Schwartz, Jeffrey (2010). ANTI-INFECTIVE FUNCTIONALIZED SURFACES AND METHODS OF MAKING SAME. Patent no. US2010215643. Orthobond Corp., USA.

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
7173-51-5 DDAC	The present invention provides an antimicrobial wipe comprising a substrate comprising from 1 to 100% by wt. of a cellulosic material and incorporating a compn. comprising: (i) an antimicrobial component comprising at least one quaternary ammonium compd. of a specified formula, (ii) a nonionic surfactant, and (iii) a polar solvent, wherein the compn. is substantially free of anionic surfactant. Optionally the compn. may contain a further antimicrobial agent and a hydrophobic material. An exemplified compn. contains benzalkonium chloride, polyhexamethylene biguanidine, ethoxylated alcs. and water.	Cellulosic material Wipe		Falder, Stephen Brian; Francis, Thomas Trevor (2011). Anti-microbial wipe. Patent no. GB2475790. Byotrol PLC, UK.
7173-51-5 DDAC	The present disclosure provides a method for killing arthropods. According to one embodiment of the present disclosure, the method preferably includes providing a pesticide compn. which includes from about 0.01 to about 0.8 %, by wt., of a surfactant and from about 0.2 to about 15 %, by wt., of a boron-contg. component. The pesticide compn. is applied to a absorbent material which is infested with arthropods, so that the pesticide compn. is adsorbed by the absorbent material in an amt. sufficient to kill arthropods. The arthropods contact the absorbent material and are killed by the adsorbed pesticide compn.	Textiles (bed sheets)	0.2 - 15 % (w/w)	Lloyd, Jeffrey D.; Kirkland, Kevin; Malone, Tracy D. (2011). Insecticide for Bed Bugs. Patent no. US2011256196. Nisus Corporation, USA.
7173-51-5 DDAC	The invention discloses a composite antibacterial textile finishing agent, which consists of the following components of: an organic antibacterial active ingredient, an inorganic antibacterial active ingredient, a penetrating agent, an adhesive, a softening agent, a suspending aid and water. A preparation method comprises the following steps of: dissolving the penetrating agent, the adhesive, the softening agent and the suspending aid into the water to prepare solution at normal temperature under normal pressure; adding the organic antibacterial active ingredient and the inorganic antibacterial active ingredient into the solution, and quickly stirring the solution; and treating the solution by using a Nanomizer high-pressure homogenizer to obtain the finishing agent. An application method comprises the following steps of: selecting pure cotton or blended fabric, soaking the pure cotton or the blended fabric into the composite antibacterial finishing agent, and soaking and rolling with an open width padder; and conveying the pure cotton or the blended fabric into a drying oven of 100 DEG C, pre-drying for 180 to 300 seconds, and conveying the pure cotton or the blended fabric to a drying oven of 120 DEG C for setting so as to obtain an antibacterial textile. The finishing agent plays a role in killing bacteria such as escherichia coli, staphylococcus aureus, candida albicans and the like; and the prepared textile has good antibacterial performance and durable antibacterial effect, the original wearing property of the textile is not changed, and the textile has good handfeel.	Textiles pure or blended cotton fabric		Wu, Qingduan; Lv, Youjun; Wang, Zhongying; Liu, Mei; Zang, Na; Wu, Lei; Liu, Wei (2011). Composite antibacterial textile finishing agent and application thereof. Patent no. CN102094323. China National Academy of Nanotechnology & Engineering, Peop. Rep. China.
7440-22-4 Silver	A wiper having a controlled release antimicrobial agent for providing antimicrobial cleansing of surfaces is provided. The wiper is formed from an absorbent base web to which an	Textile		ANDERSON, R. L., RADWANSKI, F. R. & CLARK,

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
	antimicrobial formulation is adhered. The formulation includes an antimicrobial agent that is capable of being controllably released from the wiper. In some embodiments, a polymer mixt. may be employed to control the rate of release of the antimicrobial agent. Various antimicrobial agents, such as metal ions and org. compds. may be employed. For example, an antimicrobial wiper was formed from a base web and AgION silver-zeolite antimicrobial particles. The polymer mixt. included Hycar RLP resin, XAMA-7 (a curing agent) CMC (as a viscosity modifier), and water. The polymer mixt. and antimicrobial agent were incorporated into the formulation such that the antimicrobial agent constituted 1% add-on of the wiper wt. After mixing, the formulation was then printed onto the web in accordance with the present invention. Once applied with the formulation, the wiper was then tested to det. the amt. of silver present in soln. after 1, 5, 10, 15, and 20 rinses. Using at. spectrometer measurements, it was detd. that silver remained present at 140 ppb (ppb), 100 ppb, 90 ppb, 70 ppb, and 17 ppb, for each resp. rinse.	Wiper		J. W. 2001. A wiper containing a controlled-release anti-microbial agent. US patent application WO2000US34931 20001222
7440-22-4 Silver	Bandage from textile material is disclosed, with integrated silver layer, comprising plant active substances in the form of plant exts., with biocide effect. Detailed scheme of the bandage design is provided; no compn. example is presented.	Textiles Bandage		BUDDE, F.-J. 2011. Biocidal bandage comprising plant extracts, with integrated silver layer. German patent application DE 2011-202011001797.
7440-22-4 Silver	A review. Nanotechnol. defined as the contour and manuf. of materials, devices and systems with control at nanometer dimensions is considered as a concept in which everything in the world is considered from the viewpoint of at. or mol. building blocks, and is already influencing a very broad range of human technol. activity. When a bulk material is reduced to small-size particles with one or more dimension within the nanometer range, the material will show properties that are drastically different from those of the bulk material. Recently, nanosized org. and inorg. particles have drawn increased attention in medical textile applications due to their amenability to biol. functionalization. The nano-science and nanotechnol. make excellent developments in textile science as well as others sciences. The development of new clothing products based on the immobilization of nanoparticles on textile fibers has recently received a growing interest both from academic and industrial sectors. These products impart unrivalled properties, esp. antibacterial activity, to the treated fabrics. In the last few decades there has been growing interest in reducing the availability of com. textile contg. chem. antibacterial agents due to the environmental pollution, poisonous nature, and irritant property; so the new types of safe and commodious biocidal materials need to be replaced with these chem. agents. A wide range of nano-structures such as nanosilvers can be immobilized on fibers, which brings antibacterial properties to the final	Textile		DADVAR, S., OROUMEI, A. & HAGHI, A. K. 2011. Synthesising methods and application of nanosilvers in antibacterial coating of textiles. Journal of the Balkan Tribological Association, 17, 95-121.

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
	clothing product. This review introduces the application of nanosilvers in antibacterial coating of textiles in details up to 2008.			
7440-22-4 Silver	The inserted unloading insole with biocidal effect contains contact and inter-insole layer. Inter-insole layer, in heel part and on section of external and transverse arches has relief corresponding to relief of healthy foot in position of even rest with both feet on soft base, and on the section of internal arch, to position with full loading of all body wt. with rest of one foot on soft base. Inter-insole layer is made forming-on in process of wearing foamed thermoplastic material, copolymer of ethelyne with vinylacetate, with d. 0.17-0.20 g/cm3. Contact layer is made from natural leather, modified by nano-dimensional prepns. of silver with content of electrochem. active silver 7 × 10-5 to 6.4 × 10-3% of leather wt. The invention ensures even distribution of pressure on sole surface of foot, which allows to unload painful zones, reduces foot fatigability, arising during the day, and also ensures prevention of arising static foot deformations, relieves pain in case of calcaneal spurs, and prevention of ulcers, fungal diseases, etc, in particular in case of diabetic foot.	Ethylene vinylacetat copolymer Inserted insole	7E-5 to 6.4E-3 % (w/w of leather)	KISELEV, S. Y., KISELEVA, M. V., BARANOV, V. D. & BELGORODSKIJ, V. S. 2010. Inserted unloading insole with biocidal effect. Russia patent application RU 2008-147072.
7440-22-4 Silver	A method of prodn. of fire-resistant polyethylene terephthalate materials with biocidal properties comprises spinning or extruding poly(ethylene terephthalate) in a liq. medium contg. modifying additives which may adsorb on the PET surface, and drying the article in air until complete removal of the solvent. The additives are selected from biocides (e.g., ammonium salts, polyalkyleneguanidine salts, aldehydes, silver salts, silver nanoparticles) and fireproofing agents (e.g., phosphates, polyphosphates, phosphonates, and phosphinates). The method can be used to produce fibers, films, tapes, tubes and other shapes.	Polyethylene terephthalate (PET)		KRUTYAKOV, Y. A., KUDRINSKIJ, A. A., ARTEMOV, A. V., ZHIL'TSOV, V. A. & KULYGIN, V. M. 2011. Production of fire-resistant polyethylene terephtalate materials with biocidal properties. Russia patent application RU 2009-147383.
9012-76-4 Chitosan	The nonwoven fabrics are prepd. by the steps of (a) selecting wood pulp as raw material, and preferably pulp cellulose of staple or filament with cellulose content >85% and d.p. 500-1200, (b) putting N-methylmorpholine-N-oxide (I) as dissolving solvent and 1,3-phenylenebis(2-oxazoline) as stabilizer into the prepd. pulp to form a mixed mucilage, (c) blending modified and nanominiaturized chitosan into the mucilage of pulp and I, to form a dope by rapidly blending and grinding the cellulose mucilage at 60-80°, dehydrating the dope for 5 min under vacuo to form a homogenized dope with water content 5-13%, (d) extruding the dope through a spinneret by the meltblowing method to form filament bundle, and (e) coagulating the filament bundle by means of mist of aerosol of water, and water rising the web, hydroentangled needle punching the web, drying the web, and winding the web. A dope contg. cellulose pulp with d.p. 650, and contg. 0.5% chitosan with deacetylation degree 87%, was spun through a spinneret by the meltblowing method to form a nonwoven web.,	Non-woven fabrics made from cellulose	0.5 % (w/w)	Chou, Wen-Tung; Lai, Ming-Yi; Huang, Kun-Shan (2011). MELTBLOWN WETLAID METHOD FOR PRODUCING NON-WOVEN FABRICS WITH ANTI-MILDEW, ANTI-BACTERIA AND DEODORIZING CAPABILITIES FROM NATURAL CELLULOSE. Patent no. US2011156299.

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
	coagulated and regenerated with mist of aerosol of water, rinsed, hydroentangled needle punched, dried, and wound to give a nonwoven fabric with antibacterial, deodorizing, and fungicidal properties.			Acelon Chemical and Fiber Corporation, Taiwan.
9012-76-4 Chitosan	In this paper, it uses chitosan and baicalin that is the effective components extd. from a Chinese herbal Scutellaria to finish wool fabric with the rolling method and the single-factor anal. for different concns. of antimicrobial agents, curing temp. and curing time. It then tests and analyzes the antibacterial properties of the finished fabric. The results show that the antibacterial effect of the finished fabric is good to Escherichia coli, Staphylococcus aureus and Bacillus subtilis, inhibition rate is more than 92%. After washing for 20 times, the inhibition of staphylococcus rate is still more than 80%, and basically keep the original style and taking the performance of the fabrics. The whiteness and permeability are little affected by antibacterial finishing. Through the expt. detd. the best concn. of antibacterial agent is 20 ~ 25 g/L, the best curing temp. is 110 °C.	Textile (wool)		Gao, Dong-mei; Xue, Shuang; Zhao, Wei (????). Antibacterial finishing with baicalin and chitosan on wool fabrics. Chinese scientific publication, not available.
9012-76-4 Chitosan	A novel antibacterial and mildew resistant agent (ABMR) was prepd. through compounding nano TiO2 and chitosan and then was applied on the surface of the cotton fabric. The fungus resistance of the treated fabric was investigated under daylight. The exptl. results revealed that the agent compounded from chitosan and nano-TiO2 had synergistic effect, greatly enhancing its inactivity ratio against fungus. The cotton fabric with a loading amt. of 1.5% of ABMR displayed excellent anti-fungus activities. Its inactivity ratio against Aspergillus niger reached 99.99% after 12 h. In the case of repeated use, its inactivity ratio kept over 99.5% after 24 h. Inactivity ratio against fungus of the treated fabric still reached 99.99% after 15 laundry cycles when tested after 24 h. In addn., the agent had little effect on the strength of the treated cotton fabrics and their wearing characteristics such as color and pH were conformed to the national anti-fungus textile std.	Textiles (cotton)	1.5 %	Qian, Tingting; Su, Haijia; Tan, Tianwei Fungus resistance of textiles treated by a novel antibacterial and mildew resistant agent. Fangzhi Xuebao (2011), 32(3), 95-99. In Chinese.
13463-41-7 Zinc pyrithione	The invention provides a biocidal concentrate including zinc pyridinethione; and a second biocide selected to be biocidally effective in a pH range complementary to zinc pyridinethione. The second biocide may be an aromatic halogenated phenol such as triclosan, dichlorophen and trichlorcarban. The invention also provides biocidal cleaning devices and plastic materials and methods of manufacture thereof. one or more selected biocides. For example triclosan, dichlorophen (sometimes known as dichlorophene or DCP) or other chlorinated phenolic biocides, phenolic biocides. or trichlorocarban. in combination with an organometallic biocide. for example a metallic pyridinethione. exhibit a synergy which enables the combination to be effective against a wide range of bacteria under a wide range of pH conditions.	Textiles used for cleaning, also applicable to other materials such as sponges, paper, plastics, concrete etc.		KWON, H. S. & KRITZLER, S. 1999. Improved biocide and biocidal cloth. Australia patent application WO1998AU00984 19981126

CAS number Substance	Function (quoted)	Material / Product	Conc.	Reference
64359-81-5 DCOIT	The present invention relates to textile fibers. A viscous fiber having antimicrobial activity and a method of making thereof is disclosed. Micro-reservoirs are forced in the fibers in which the antimicrobial constitutes are embedded	Textile fibers		Preeti, Lodha; Bir, Kapoor (2009). Antimicrobial textile fiber. Patent no IN 2007MU01262. Aditya Birla Science & Technology Co. Ltd., India
64359-81-5 DCOIT	Wallboard and facing paper that provides increased mold resistance at lower biocide loadings are described. The biocide is: (a) an n-alkyl isothiazolinone such as octylisothiazolinone (OIT), a monohalo and dihalo substituted n-alkylisothiazolinone such as chloromethylisothiazolinone (CMIT) or dichlorooctylisothiazolinone (DCOIT), 3-iodo-2-propynyl-butylcarbamate (IPBC), chlorothalonil, methylene-bis-thiocyanate, or mixts. of two or more thereof; or (b) carbendazim and a second biocide selected from 3-iodo-2-propynyl-butylcarbamate (IPBC), diiodomethyltolylsulfone (DIMTS), sodium pyrithione, octylisothiazolinone (OIT), dichlorooctylisothiazolinone (DCOIT), and chlorothalonil.	Paper Wallboard and facing paper		Tinetti, Sheila M.; Foley, Paul; Wang, Li; Enzien, Michael V. (2008). Mold-resistant wallboard that provides increased mold resistance at lower biocide loadings. Patent no WO 2008091794. Dow Global Technologies Inc., USA
64359-81-5 DCOIT	Multiple conductor elec. power cords, signal transmitting wiring and cable is insulated with one or more layers or sheathing of a thermoplastic polymer compn. with at least the outer layer of the compn. contg. contaminant resistant or combating agents that inhibit growth of biol. contamination. The microbial resistant cord or wiring has particularly advantageous utility of power cords for use with appliances or elec. products in facilities that affect health, such as medical and food related facilities that require safeguarding against contaminating microorganism attack formation, or growth.	Thermo-plastics		Parsons, Walter Brian; Hunter, Jimmy Dale (2009). Anti-microbial/anti-fungal plastic jacketed/insulated electric power cords. Patent no US 20090101387. Cable Tech Global Limited Partnership, USA

KEMI
Kemikalieinspektionen

Box 2, 172 13 Sundbyberg
08-519 41 100

Besöks- och leveransadress
Esplanaden 3A, 172 67 Sundbyberg

kemi@kemi.se
www.kemikalieinspektionen.se