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Technical Information

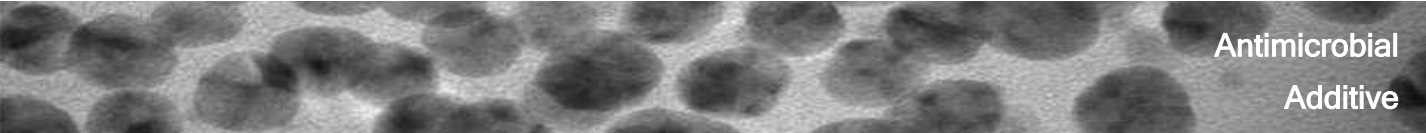
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Revision 7.0

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July 2020

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Antimicrobial  
Additive



agpure®

# 1 Description

## 1.1. Introduction

agpure® is designed for the antimicrobial functionalization of surfaces and bulk materials. Due to the high activity of nanoparticles only low levels of silver are necessary for the best antimicrobial performance. Consequently, the release of silver ions can be fixed at an accurate level ensuring the best antimicrobial efficacy and thus also avoiding cytotoxicity.

Potential applications of agpure® products range from paints, varnishes and coatings over thermoplastic, duroplastic and elastomeric polymers to textile fibers. agpure® is also utilized as an antimicrobial additive for many chemical formulations like detergents, cleaners, cosmetics and especially certain resins based on organic substances.

Low levels of agpure® nanosilver provide long-term preservation against microbial attack. Treated material is protected against staining, embrittlement and the growth of microorganisms. Adverse odors and the spread of diseases, even nosocomial infections caused by MRSA or 3,4 MRGN are avoided.

This Technical Information is intended to give our customers technical background information on our agpure® materials and to help them select the right agpure® grade for their specific application. Additional information for use and application of agpure® can be requested at our laboratory. Material Safety Data Sheets and Technical Product Data Sheets can be downloaded from our website or obtained from our office.

Name	Ag content	Water content	Appearance	Color	Application / Area
agpure® W10	10,0 ± 0,50 %	75 %	Dispersion	Orange	Additive for aqueous and non-aqueous products and formulations
agpure® W50	45,0 ± 1,50 %	< 5 %	Dispersion	Brown	Additive for the production of polymers and coatings
agpure® W3	3,0 ± 0,1 %	< 0,5 %	Dispersion	Brown	Additive for organic solvents and formulations, like resins, varnishes, etc.
agpure® I	3,0 ± 0,1 %	< 0,5 %	Dispersion	Gray	Additive for color sensitive aqueous and non-aqueous products and formulations
agpure® ST	15,0 ± 1,0 %	< 0,5 %	Powder	White	Powder additive, colour sensitive applications
agpure® W2	2,0 ± 0,1 %	< 1 %	Powder	Gray-white	Powder additive, colour sensitive applications
agpure® PBT6500	0,65 ± 0,05 %	< 0,004 %	Chips	Brown	PBT-Masterbatch for production of polymers
SANPURE® K130	200 ppm	< 5 %	Dispersion	Yellow	Invisible coating on metal, glass, ceramic, polymers

Table 1: agpure® grades and properties

## 1.2. Chemical character

agpure® W10 is a nanosilver colloidal dispersion with a nominal silver content of 10 w/w%. agpure® W10 dispersion is dark orange; it is an aqueous dispersion of nanosilver with stabilizing agents, consisting of < 10 % emulsifying agent.

agpure® contains silver particles of about 15 nm size with a narrow size distribution of 99 % of the particle number concentration exhibiting a diameter of below 20 nm. A second, much smaller abundance of particles was identified by TEM to have narrow diameter distribution of around 5 nm. The silver content and particle number was shown to be stable up to 12 months.

Use biocides safely. Always read the label and product information before use!

agpure® W50 is based on W10. They differ in the absolute content of the ingredients (Table 1). As absolute concentrate of our technology it is the basis for applications with special demands and for the most of our special agpure® grades.

agpure® W3 is based on W50. The addition of special dispersants makes the formulation of solvent based products easier. Especially varnishes and sol/gel coatings are easier to formulate for our customers.

agpure® I is a liquid additive for color sensitive applications. It is designed for organic varnishes and duroplastic resins.

agpure® ST is silverchlorid adsorpt on silica. This stable aggregate shows reduced colour effects compared to W10 or W50 additives.

agpure® W2 contains silver nanoparticles adsorbed on larger titanium dioxide particles. This powder shows drastically reduced colour effects compared to W10 or W50 additives.

agpure® PBT6500 is composed of the crude PBT polymer and agpure® W50.

SANPURE® K130 is a siloxane based sol containing agpure® silver nanoparticles for sol/gel coatings. It allows the invisible and costly equipment of hard surfaces with antimicrobial properties.

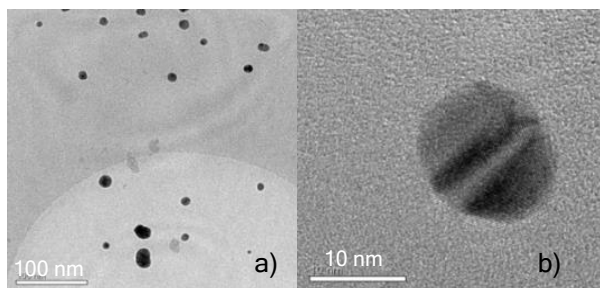


Figure 1: a) and b) Electron microscope images of agpure® silver nanoparticles.

## 2 Key advantages

- Anti-allergic, non toxic, non sensitizing
- Natural biocide
- Easy to use - application appropriate grades
- Homogenous particle distribution
- Dispersions are free of any fillers - very small structures / layers are accessible
- Processable at high temperatures (> 300°C)
- Stable in UV-light
- Resistant to cleaning or washing
- Silver depot

- Long lasting / permanent antimicrobial effect
- Excellent leach-resistance
- High efficiency - low additive concentration

## 3 Application areas

### 3.1. Varnishes & coatings

For the manufacture of antimicrobial varnishes, two possibilities can be chosen. agpure® can be mixed with the pigment paste and subsequently incorporated into the varnish, or simply combined with the readymade varnish. The stability of the obtained dispersion should be controlled. Coagulation or precipitations should not occur within days subsequent to the mixing process.

For aqueous based or highly polar varnishes our W10, W50 and W2 grades are recommended. Organic solvent based, nonpolar varnishes or sols for sol/gel coating should be formulated with W3, I or W2 grades.

It is strongly recommended that the dosage of agpure® is adapted to the required antimicrobial efficacy of the specific varnish formulation. Standard dosages may be obtained through our laboratory.

Slight discoloration may occur, whereas the transparency of the resulting varnish should not be affected. We recommend controlling of the curing process and storage conditions.

With SANPURE® K130 a readymade sol/gel coating for invisible antimicrobial functionalization is available. Curing is best at temperatures of about 130 °C.

### 3.2. Paints

State of the art organic biocides for fungicidal paints are sensitizing and cause allergic reactions. Even more their biocidal effect is due to their volatility and degradability non permanent.

Non sensitizing, permanent active fungicidal mineral fillers containing paints are best formulated with agpure® W2 grades.

### 3.3. Textiles & Fibers

agpure® products are widely used for textiles and fibers. It can be applied in various ways ranging from coating, finishing and fiber compounds. agpure® products can be distinguished by their excellent stability at high temperatures (<300°C). Consequently there are no restrictions in the choice of polymer material.

Use biocides safely. Always read the label and product information before use!

For fiber spinning processes, agpure® masterbatches are recommended. Our standard product is agpure® PBT6500 that is based on Polybutylene terephthalate. Furthermore available standard polymers that lend themselves for processing are: Polyolefins (PP, PE), Polyester (PET), Polyamide (PA) among others. The particle size distribution of nanosilver persists in the fibers resulting in the best efficiency and highest washability without loss of the antimicrobial effect.

Tests at the Hohenstein Institute during the "Feldstudie Antimikrobielle Textilien" - AiF Project-No.: 17832 N showed that

- the antimicrobial activity of agpure® blended PES fiber against K. pneumoniae and S. aureus according to DIN EN ISO 20743 is still significant after 100 washing cycles and
- the antimicrobial activity of agpure® blended PA spunbond fiber against K. pneumoniae and S. aureus according to DIN EN ISO 20743 is still significant after even 200 washing cycles.

agpure® is designed for use in dyes and as a component for finishing. Possible textile substrates include natural as well as synthetic fibers. agpure® grades can be formulated both with aqueous or solvent based dispersions. Microbiological evaluations to determine ideal nanosilver levels are recommended. In some cases color shifts are possible. Preliminary tests concerning UV stability and washability should be performed.

## 4 Product Use Recommendations

### 4.1. Miscibility

agpure® dispersions are miscible with water at any ratio. Precipitation or agglomeration will not occur with pure water. Such dispersions show excellent stability.

In case of addition of other solvents, salts or solids, agglomeration might occur. Preliminary tests are recommended to assess compatibilities with other components.

agpure® has a negative zeta potential.

Please ask for the suitable agpure grade.

### 4.2. Dispersing agpure®

Please carry out the following instructions to handle agpure® properly:

- Don't use saturated or highly concentrated saline solutions.

- Dispersions will not stable at pH-values below 4.
- Mix vigorously; the use of dispersing instruments (e.g. ULTRA-TURRAX®) is recommended if the dispersion is not satisfying.

A small amount of clumping and/or settling during shipping and storage might occur at our liquid agpure grades. Shaking by hand is usually enough to redisperse particles within the dispersion.

### 4.3. Use levels

Please find below a helpful table, how to dose agpure® into your product at typical concentrations correctly. Table 2 gives you the dosage in g/kg whereas Table 3 gives you the dosage in % w/w.

agpure grade	W10	W50	W3 / I	WS T	W2	PBT 6500
Final silver conc.						
100 ppm	1,0	0,22	3,3	0,66	2,50	15,4
250 ppm	2,5	0,55	8,3	1,66	6,25	38,5
500 ppm	5,0	1,11	16,7	3,34	12,5	76,9
1.000 ppm	10,0	2,22	33,3	6,66	25,0	154

Table 2: Dosage of agpure®-product to achieve final nanosilver concentration in the product. (in g/kg)

agpure grade	W10	W50	W3 / I	WS T	W2	PBT 6500
Final silver conc.						
100 ppm	0,10	0,02	0,33	0,25	0,25	1,54
250 ppm	0,25	0,06	0,83	0,63	0,63	3,85
500 ppm	0,50	0,11	1,67	1,25	1,25	7,69
1.000 ppm	1,00	0,22	3,33	2,50	2,50	15,4

Table 3: Amount of agpure®-product, that has to be dosed, to achieve final nanosilver concentration in the product. (in % w/w )

## 5 Antimicrobial Efficacy

### 5.1. Mode of action

agpure® provides antimicrobial activity to all properly equipped products. agpure® exhibits strong activity against all gram-positive and gram-negative Bacteria, even antibiotic-resistant strains, yeast and fungi. (Viruses can be inactivated by unbound nanosilver particles.)

Due to the different modes of action (reduction of germ adherence, disturbance of the germs' K<sup>+</sup>-metabolism and irreversible reaction with S-containing amino acids) and due to the marginal Ag<sup>+</sup>-release, agpure® containing products do not induce or propagate bacterial resistance.

Products properly equipped with antimicrobial agpure® are non-toxic to humans and animals and safe to the environment. Due to the slow release of silver-ions (oxidation of metallic silver followed by elution of Ag<sup>+</sup>-ions) the antimicrobial effect of products supplemented with agpure® is very persistent.

The high surface/volume-ratio of agpure® silver nanoparticles provides the high efficiency of agpure® treatments/finishing. Low levels of silver are enough for lifetime protection against microbial attack.

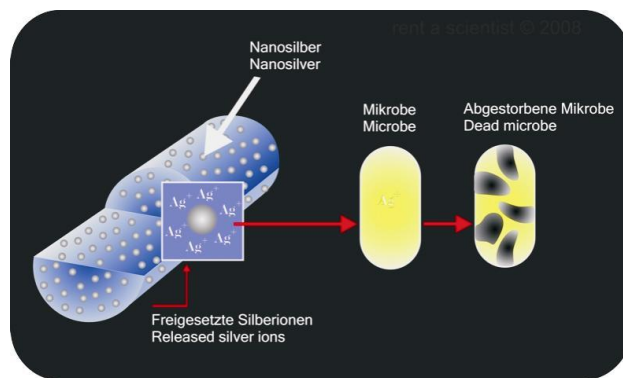


Figure 2: Mode of antimicrobial action

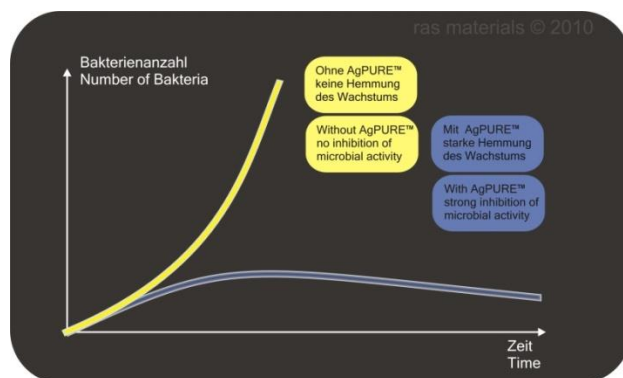


Figure 3: Inhibition of microbial growth

### 5.2. Efficacy testing

agpure® is a long-term shield against microbial growth. It is not a sterilizing agent and does not have long range effects. Test procedures for the verification of the antimicrobial effect based on strong release / long range action of a biocide (e.g. zone of inhibition test) will not respond to agpure® products.

Therefore several research institutes agreed to use verified international test methods to determine antimicrobial action of agpure® nanosilver products:

Rigid surfaces: JIS Z 2801:2000 or ISO 22196:2007

Textiles: JIS L 1902:2002 or DIN EN ISO 20743:2007

A grading scheme (Table 4) was introduced to judge the antimicrobial activity of products tested according to the test methods mentioned above.

Antimic. Act.	Slight	Significant	Strong
<b>Test results</b>			
<b>Reduction (R-) Value (log-steps)</b>	≥ 0,5 to < 1	≥ 1 to < 3	≥ 3
<b>%-Reduction of viable cells</b>	≥ 67 % to < 90 %	≥ 90 % to < 99,9 %	≥ 99,9 %

Table 4: Grading scheme. Because of the instability of bacterial growth, the biological variance (lab standard ± 0.5 log steps) has to be considered in this grading scheme, especially at slight efficacy).

A lot of test results with agpure® treated products were obtained in the last years in our laboratories or by external independent Institutes (Table 5):

Application	R-Value	Strain
PET-Microfiber Cloth	3	<i>S. aureus</i>
	3	<i>K. pneumonia</i>
	> 4	<i>E. coli</i>
	2	<i>C. albicans</i>
PP staple fiber	2	<i>E. coli</i>
Soft PVC	3	<i>E. coli</i>
PA tubes	> 3	<i>P. aeruginosa</i>
Silicone	> 3	<i>S. aureus</i>
Laquer	3	<i>E. coli</i>
Silvercoating for Med.	> 4	<i>S. epidermidis</i>
Disposable coverall	> 5	<i>L. pneumophila</i>

Table 5: Typical microbiological test results, test methods: Rigid surfaces: JIS Z 2801:2000 or ISO 22196:2007; for Textiles: JIS L 1902:2002 or DIN EN ISO 20743:2007

The SN 195921 is a test method to test the antifungal activity.

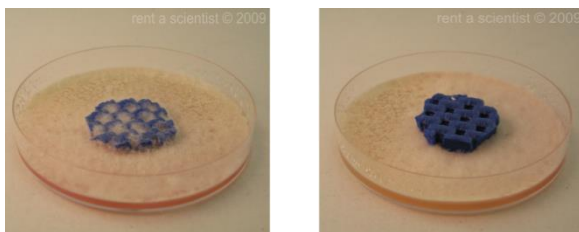


Figure 4: SN 195921 test: Left: Blank PVC-sample after 2 weeks Right: Fungicidal activity of PVC-sample after 2 weeks with agpure®

The antimicrobial activity is certified:



Figure 5: Certificates on the antimicrobial efficacy of products treated with agpure® nanosilver

The detection and certification of the antimicrobial activity of products containing agpure® must be executed with approved microbiological test routines.

In order to support our clients in the design of antimicrobial products, we provide our chemical and biological know-how. We recommend to carefully test all factors that may influence the release of bioactive silver.

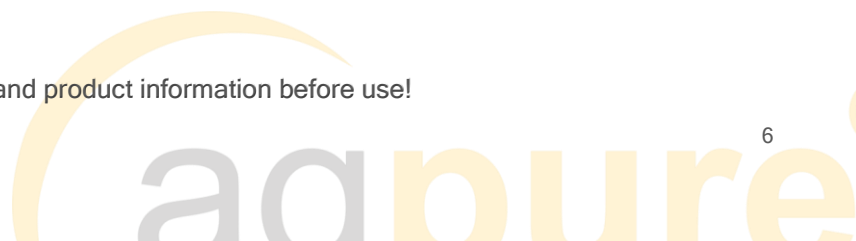
RAS AG is providing extensive testing facilities to assist the customer in developing an antimicrobial product, containing the optimal dosage of agpure® nanosilver.

### 5.3. Recommended dosage

Depending on the dosage of agpure® nanosilver (100 - 2000 ppm nanosilver) in the product, one can achieve a bacterial reduction of 90% up to 99,999% (Reduction value: 1 - 5 log steps)

Antimic. Act.	Slight	Significant	Strong
<b>Application</b>			
Textile via coat	50	100	250
Textile via MB	100	200	400
Coatings	250	500	1000
Med. Device	400	800	1500

Table 6: Final nanosilver concentration to achieve activity in certain applications. Typical values of antimicrobial activity according to JIS Z 2801:2000, ISO 22196:2007, JIS L 1902:2002 or DIN EN ISO 20743:2007-10



## 6 Handling Precautions

When handling agpure® products, due attention should be paid to the information and details in the material safety data sheets and the technical information in the technical product data sheets. Furthermore, all precautions necessary for handling chemicals must receive careful attention.

Avoid contact with skin, eyes and clothing. When using do not eat, drink or smoke.

Please use chemical resistant disposable gloves and eye protection.

Wash off affected skin with plenty of water. Remove contaminated clothing and wash off affected cloth with plenty of water.

## 7 Risk assessment

### 7.1. Nanotechnology risks and benefits - R&D projects

agpure® was selected as the official nanosilver reference- and testing materials (NM-300 K silver) for the “OECD - sponsorship program”



NM-300 DIS  
Ag dispersant

Sample identification No: 0000  
for in vitro use only – single use only

There were many international and national research projects on the safety of nanomaterials which are using agpure® nanosilver.

- UMSICHT
  - Ecological fate of nanosilver
- SILBERNANOPARTIKEL
  - Risk potential of nanosilver in medical devices
- OECD-WPMN Silver
  - Chemical Database (Tox, etc.)
  - Data set for FDA, EPA, EFSA...
  - NANEX, ENPRA, ...
- LICARA nano

Overall result of these independent research projects is that there is no harm for humans, animals or the environment resulting from agpure® in carefully equipped products.

For details on nanosilver research ask our experts. They will provide detailed information and scientific literature to interested customers, research institutes and the public.

### 7.2. Exposure

Exposure of silver nano particles during the production process was not detectable. (REACH-NanoHazEx: Rip-oN 3)

No abrasion of nano particles is detectable from polymer materials. (Vorbau et al. 2010)

### 7.3. Safe to human tissue

agpure® containing microfiber cloth: No irritations on the skin of the test persons even those having atopic eczema (Test report Dermatonnier, DT-NR: 16/01/06)

agpure® nanosilver causes no sensitization to the laboratory animals (according to Local Lymph Node Assay - LLNA, Test report BSL Bioservice, Project No.: 070516)

## 8 Storage and Disposal

### 8.1. Recommended Storage

agpure® W grades can be stored in original containers for 12 months at a temperature range of 10-30°C. Contents of unsealed containers should be used as soon as practicable. Subsequent to any removal of material, the containers should be closed tightly. Keep product protected against frost.

If it is not possible to store the product in the original containers, please take notice of the following advice:

- Use opaque containers
- HDPE recommended
- Other polymers are not proven for long term storage.
- Glassware has limited qualification only suitable for high concentrates.

Once opened, we recommend, that agpure® W50 is completely emptied, to assure product quality.

agpure® PBT6500 can be stored in original package for 6 month at a temperature range of 10-30 °C. Open packages should be used up soon.

It has to be ensured that no external particles are brought into the master batch through opening or taking out master batch of the bag. External particles can reduce considerably the usability of master batch even up to production out time or production loss especially on the field of microfibers.

The water content of the master batch has to be determined by the user. If necessary the master batch has to be dried before use. With which degree of moisture the master batch will still be usable is incumbent upon the user.

SANPURE® K130 sol for sol/gel coatings are highly sensitive for improper storage conditions and processing conditions. Please take care that

Use biocides safely. Always read the label and product information before use!

SANPURE K130 is stored below 23 °C and processed at a relative humidity below 50 %.

## 8.2. Disposal

Avoid contamination of water, food or feed by storage or disposal.

Plastic drums which cannot be reconditioned and recycled should be punctured or crushed, and disposed at landfill or by other procedures approved by state or local authorities.

## 9 Available Packaging

### agpure® W10, W3:

1 kg in HDPE Bottles, Narrow Mouth, UN Approved (3H1/X1.9/250) with Thread. Screw closure PP, black, with tamper evident ring and teflon cup seal.

5 kg in HDPE jerry cans, UN Approved (3H1/X/250). with Thread. Screw closure PE, black, with tamper evident ring and cup seal.

### agpure® W50:

0,50kg and 1,00 kg in HDPE Bottles, Narrow Mouth, UN Approved (3H1/X1.9/250) with Thread. Screw closure PP, black, with tamper evident ring and teflon cup seal.

Once opened, we recommend, that agpure® W50 is completely emptied, to assure product quality.

### agpure® ST, W2:

1l, 6l or 20l HDPE cans with screw cap and elastomeric sealing, UN Approved (1H2/X20/S).

### agpure® PBT6500:

25 kg in fibre-reinforced PE-bag.

## 10 Regulatory

agpure® is a proven auxiliary for biological active finish of textiles according to Oeko-Tex® Standard 100: ([https://www.oeko-tex.com/de/manufacturers/certified\\_products/active\\_chemical\\_products/products\\_with\\_biological\\_activity/products\\_with\\_biological\\_activity.html](https://www.oeko-tex.com/de/manufacturers/certified_products/active_chemical_products/products_with_biological_activity/products_with_biological_activity.html))

Certification in accordance with DIN EN ISO 13485:2010, regulation under progress.

agpure® is notified according to Regulation (EU) No. 528/2012 (Biocides) under N-73054:



- Disinfectants for private usage and the public sector as well as other biocide products (PT 2)
- Disinfectants for the food and animal feed sector (PT 4)
- Fibre, leather, rubber and polymerised materials preservatives (PT 9)

## 11 Legal note

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Scientific literature cited in this data sheet can be provided on request.

## 12 Contact data

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