Inactivation of quaternary disinfectants by cleaning cloths containing laundry detergent residues is cause for concern.

Process Cleaning Solutions has initiated the following study to provide evidence of the efficacy of two commonly used health care disinfectants after exposure to cotton and micro fiber cleaning cloths that have been laundered. We could not find any currently published studies of disinfectant efficacy after exposure to cleaning cloths containing laundering detergent residues.

There are reports in reviewed literature that detergent residues must be effectively rinsed before application of disinfectants to prevent chemical inactivation of disinfectant. It is common knowledge that not all laundering detergents are removed in the rinse cycle. What effect the residual detergent residues left in cleaning cloths after laundering have on the efficacy of disinfectants is unknown?

To provide evidence on the efficacy of commonly used disinfectants when used with laundered cleaning cloths the following study was initiated.

New cotton cloths 16 inches x 16 inches size were purchased from local retailer – 90 cloths.

New PCS micro fiber cloths containing 80% polyester and 20% polyamide 14 inch x 14 inch size and 30 gram weight - 90 cloths.

The cotton and micro fiber cloths were washed separately with hot water wash cycle, normal rinse cycle, dried on cotton cycle and allowed to cool. A total of five washing and drying cycles for all cloths. Each wash cycle had 45 cloths and 2.25 ounces of Liquid Tide added to a top loading washing machine.

All cloths were washed with Tide Liquid laundry detergent with biodegradable anionic and non anionic surfactants and enzymes listed as ingredients on the label.

The cloths where then folded and placed into Nacecare 6 liter buckets with lids - 10 cotton cloths and 15 micro fiber cloths per bucket.

The buckets and cotton and micro fiber cloths and sealed unopened containers of PCS 2% Stabilized Bleach and a Quaternary disinfectant with claims for 30 different microbes at a 1 to 250 dilution as a one step cleaner disinfectant were delivered to Aquatox for completion of the study.
Aquatox portion of the study included.

Aquatox is accredited by CALA and a recognized GLP ecotoxicity testing laboratory.

PCS Stabilized Bleach was diluted to 1000 parts per million. Next, 1.8 liters of diluted solution was added to each bucket containing 10 cotton cloths and 15 micro fiber cloths. To saturate the cloths, the lids on the containers were closed and allowed to sit for 4 hours at which point the cloths were wrung out with Nacecare wringer/bucket. The bleach solution from cotton and micro fiber cloths were tested separately.


The Quaternary disinfectant was diluted to recommended disinfection dilution and 1.8 liters of diluted disinfectant solution was poured over cotton and micro fiber cloths. Lids on buckets were closed and allowed to sit for 4 hours, at which point the cloths were wrung out using a separate Nacecare wringer/bucket and disinfectant solution was used as test solution from both cotton and micro fiber cloths.


All products were diluted with hard water as per Quaternary disinfectant label claim and no organic challenge was used.
Results and discussion.

PCS 2% Stabilized Sodium Hypochlorite diluted to 1000 parts per million. 1.8 liters of diluted solution was used to saturate 10 cotton and 15 micro fiber cloths laundered with Tide Liquid Laundry, five cycles. Saturated cloths were allowed to sit in closed 6 liter bucket for 4 hours before extracting test solution.

<table>
<thead>
<tr>
<th>AOAC</th>
<th>Staphylococcus aureus</th>
<th>10 replicates, 5 minute contact time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>No Growth</td>
<td>Pass</td>
</tr>
<tr>
<td>Micro fiber</td>
<td>No Growth</td>
<td>Pass</td>
</tr>
</tbody>
</table>

AOAC  Staphylococcus aureus  10 replicates, 10 minute contact time

| Cotton     | No Growth              | Pass                                 |
| Micro fiber| No Growth              | Pass                                 |

AOAC  Pseudomonas aeruginosa  10 replicates, 10 minute contact time

| Cotton     | No Growth              | Pass                                 |
| Micro fiber| No Growth              | Pass                                 |

Quaternary disinfectant diluted as per label instruction for disinfecting environmental surfaces. 1 to 250 parts water. 1.8 liters of diluted solution was used to saturate 10 cotton and 15 micro fiber cloths laundered with Tide Liquid Laundry, five cycles. Saturated cloths were allowed to sit in closed 6 liter bucket for 4 hours before extracting test solution.

<table>
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<th>AOAC</th>
<th>Staphylococcus aureus</th>
<th>10 replicates, 10 minute contact time</th>
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</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Growth on all test cylinders</td>
<td>Failed</td>
</tr>
<tr>
<td>Micro fiber</td>
<td>Growth on all test cylinders</td>
<td>Failed</td>
</tr>
</tbody>
</table>

AOAC  Pseudomonas aeruginosa  10 replicates, 10 minute contact time

| Cotton     | Growth on all test cylinders | Failed                        |
| Micro fiber| Growth on all test cylinders | Failed                        |
Discussion.

Laundered cotton and micro fiber cloths containing residual detergents can inactivate quaternary disinfectants.

Tide Liquid laundry detergent list anionic and non ionic surfactants and enzymes as ingredients. Previous studies have demonstrated anionic surfactants incompatibility with cationic surfactants (Quaternary Disinfectants)

This study provides a link between the numerous studies in recent years that demonstrate low level exposure to quaternary disinfectants promotes bacterial resistance and cross resistance to antibiotics but not at disinfection concentrations.

Public Health Officials and Infection Control Practitioners need to review how disinfectants are applied to surfaces. This study clearly indicates applying quaternary disinfectants following manufactures label instructions for disinfection with laundered cleaning cloths may not be effectively decontaminating surfaces and may lead to the further expansion of resistant pathogens.

Quaternary disinfectants may not be effective even if indicator test strips indicate disinfectant is present as the chemical formulation of disinfectant is changed with the introduction of additional chemicals from cleaning cloths.

This study highlights the importance of converting to evidence based cleaning practices.

Inactivation of quaternary disinfectants by cleaning cloths containing laundry detergent residues is cause for concern.

This study confirms the efficacy of PCS Stabilized Bleach diluted to 1000 ppm when stored in closed container with laundered micro fiber or cotton cloths for four hours and no organic soils are present.
SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.
Location: Peterborough ON
Substance: 2% Stabilized Bleach
Chemical Lot Number: 080083

Sample Type: Chemical
Submitted By: M. Rochon
Date Received: 2010-12-16
Date Tested: 2010-12-22


TEST RESULTS

Date Recorded: 2010-12-24
Analyst(s): SSH

<table>
<thead>
<tr>
<th>Primary Subculture / Secondary Subculture</th>
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Results Summary

Number of carrier sets with growth: 0
Number of carrier sets without growth: 10

Control Results

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<tr>
<th>Tube</th>
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<tbody>
<tr>
<td>Viability Controls</td>
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<tr>
<td>Negative Controls</td>
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</tbody>
</table>

"=" = no growth observed
"+" = growth observed

Data Reviewed By: 2011-01-06
Date: 2011-01-06

TEST CONDITIONS

Test Organism: *Staphylococcus aureus*
Carrier Titre: $3.0 \times 10^6$
Carrier Drop Time Interval: 1 min ± 5 sec
Primary Medium: Letheen Broth + 0.1% Sodium thiosulfate
Secondary Medium: Fluid Thioglycollate Medium

Use Dilution: 20:1
Dilution Water: Hard (400 ppm)
Exposure Temp.: 20 ± 1 °C
Exposure Period: 5 min
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered cotton cloths at 20°C.

• This product passed the screening test.
• Control results are acceptable.

Date: 2011-01-06
Approved By: [Signature]
Project Manager
SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.
Location: Peterborough ON
Substance: 2% Stabilized Bleach
Chemical Lot Number: 080083

TEST RESULTS

Date Recorded:
Analyst(s):

Primary Subculture / Secondary Subculture

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Results Summary
Number of carrier sets with growth: 0
Number of carrier sets without growth: 10

Control Results
Tube: 1 2
Viability Controls: + +
Negative Controls: - -

"-" = no growth observed
"+" = growth observed

TEST CONDITIONS

Test Organism: Staphylococcus aureus
Carrier Titre: 3.0 x 10⁵
Carrier Drop Time Interval: 1 min ± 5 sec
Primary Medium: Lethen Broth + 0.1% Sodium thiosulfate
Secondary Medium: Fluid Thioglycollate Medium
Use Dilution: 20:1
Dilution Water: Hard (400 ppm)
Exposure Temp.: 20 ± 1 °C
Exposure Period: 10 min
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered cotton cloths at 20°C.

• This product passed the screening test.
• Control results are acceptable.

Date: 2011-01-06
Approved By: Project Manager
SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.
Location: Peterborough ON
Substance: 2% Stabilized Bleach
Chemical Lot Number: 080083

Sample Type: Chemical
Submitted By: M. Rochon
Date Received: 2010-12-16
Date Tested: 2010-12-23


TEST RESULTS

Date Recorded: 2010-12-25
Analyst(s): SSH

Primary Subculture / Secondary Subculture

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Results Summary

Number of carrier sets with growth: 0
Number of carrier sets without growth: 10

Control Results

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</table>
Viability Controls: + | + |
Negative Controls: - | - |

"-" = no growth observed
"+" = growth observed

TEST CONDITIONS

Test Organism: Staphylococcus aureus
Carrier Titre: $4.2 \times 10^5$
Carrier Drop Time Interval: 1 min ± 5 sec
Primary Medium: Letheen Broth + 0.1% Sodium thiosulfate
Secondary Medium: Fluid Thiglycollate Medium
Use Dilution: 20:1
Dilution Water: Hard (400 ppm)
Exposure Temp.: 20 ± 1 °C
Exposure Period: 5 min
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered microfibre cloths at 20°C.

• This product passed the screening test.
• Control results are acceptable.

Date: 2011-01-06
Approved By: Project Manager
SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.  
Location: Peterborough ON  
Substance: 2% Stabilized Bleach  
Chemical Lot Number: 080083  
Sample Type: Chemical  
Submitted By: M. Rochon  
Date Received: 2010-12-16  
Date Tested: 2010-12-23  

TEST RESULTS

Date Recorded: 2010-12-25  
Analyst(s): SSH

<table>
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<th>Primary Subculture</th>
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Results Summary

Number of carrier sets with growth: 0  
Number of carrier sets without growth: 10

Control Results

Tube: 1  2  
Viability Controls: +  +  
Negative Controls: -  -

"-" = no growth observed  
"+" = growth observed

Data Reviewed By: 2011-01-06

TEST CONDITIONS

Test Organism: Staphylococcus aureus  
Carrier Titre: $4.2 \times 10^5$  
Carrier Drop Time Interval: 1 min ± 5 sec  
Primary Medium: Lethal Broth + 0.1% Sodium thiosulfate  
Secondary Medium: Fluid Thioglycollate Medium  
Use Dilution: 20:1  
Dilution Water: Hard (400 ppm)  
Exposure Temp.: 20 ± 1 °C  
Exposure Period: 10 min  
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered microfibre cloths at 20°C.

*This product passed the screening test.  
*Control results are acceptable.

Date: 2011-01-06  
Approved By: Project Manager
Work Order : 218308  
Sample Number : 29360

SAMPLE IDENTIFICATION

Company : Process Cleaning Solutions Ltd.  
Location : Peterborough ON  
Substance : 2% Stabilized Bleach  
Chemical Lot Number: 080083

Sample Type : Chemical  
Submitted By : M. Rochon  
Date Received : 2010-12-16  
Date Tested : 2010-12-29


TEST RESULTS

Date Recorded : 2010-12-31  
Analyst(s) : SSH

Primary Subculture / Secondary Subculture

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Results Summary

Number of carrier sets with growth : 0  
Number of carrier sets without growth : 10

Control Results

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<tr>
<td>Negative Controls :</td>
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"-" = no growth observed  
"+" = growth observed

Data Reviewed By : 2011-01-06  
Date : 2011-01-06

TEST CONDITIONS

Test Organism : Pseudomonas aeruginosa  
Carrier Titre : 7.0 x 10^5  
Carrier Drop Time Interval : 1 min ± 5 sec  
Primary Medium : Letheen Broth + 0.1% Sodium thiosulfate  
Secondary Medium : Fluid Thioglycollate Medium

Use Dilution : 20:1  
Dilution Water : Hard (400 ppm)  
Exposure Temp. : 20 ± 1 °C  
Exposure Period : 10 min  
Neutralization : Confirmed

COMMENTS

Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered cotton cloths at 20°C.

• This product passed the screening test.  
• Control results are acceptable.

Date : 2011-01-06  
Approved By: [Signature]  
Project Manager
AQUATOX
AquaTox Testing & Consulting Inc.
11B Nicholas Beaver Rd.
RR 3
Guelph ON N1H 6H9
Tel: (519) 763-4412 Fax: (519) 763-4411

Work Order : 218308
Sample Number : 29360

SAMPLE IDENTIFICATION
Company : Process Cleaning Solutions Ltd.
Location : Peterborough ON
Substance : 2% Stabilized Bleach
Chemical Lot Number : 080083
Sample Type : Chemical
Submitted By : M. Rochon
Date Received : 2010-12-16
Date Tested : 2010-12-29

TEST RESULTS
Date Recorded : 2010-12-31
Analyst(s) : SSH

Primary Subculture / Secondary Subculture

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Results Summary
Number of carrier sets with growth : 0
Number of carrier sets without growth : 10

Control Results
Tube : 1 2
Viability Controls : + +
Negative Controls : - -

"-" = no growth observed
"+" = growth observed

TEST CONDITIONS
Test Organism : Pseudomonas aeruginosa
Carrier Titre : $7.0 \times 10^3$
Carrier Drop Time Interval : 1 min ± 5 sec
Primary Medium : Letheen Broth + 0.1% Sodium thiosulfate
Secondary Medium : Fluid Thioglycollate Medium
Use Dilution : 20:1
Dilution Water : Hard (400 ppm)
Exposure Temp. : 20 ± 1 °C
Exposure Period : 10 min
Neutralization : Confirmed

COMMENTS
Tested a use dilution of 20:1 made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered microfibre cloths at 20°C.

•This product passed the screening test.
•Control results are acceptable.

Date : 2011-01-06
Approved By: [Signature]
Project Manager
Work Order: 218308
Sample Number: 29362

SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.
Location: Peterborough ON
Substance: Neutral Disinfectant Concentrate (15.36% Didecyl
Dimethyl Ammonium Chloride)
Chemical Lot Number: 100099
Reference(s): AOAC Official Method 955.15. Testing
Disinfectants against *Staphylococcus aureus*. Use

Date Recorded: 2010-12-23
Analyst(s): SSH

Primary Subculture / Secondary Subculture

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Results Summary

- Number of carrier sets with growth: 10
- Number of carrier sets without growth: 0

Control Results

- Tube: 1 2
- Viability Controls: + +
- Negative Controls: – –

'–' = no growth observed
'+ ' = growth observed

TEST CONDITIONS

Test Organism: *Staphylococcus aureus*
Carrier Titre: 6.5 x 10^6 sec
Carrier Drop Time Interval: 1 min ± 5 sec
Primary Medium: Lethene Broth + 5 g/L Sodium thiosulfate
Secondary Medium: Lethene Broth + 5 g/L Sodium thiosulfate

Use Dilution: 5 mL/L
Dilution Water: Hard (400 ppm)
Exposure Temp.: 20 ± 1 °C
Exposure Period: 10 min
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 5 mL/L made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered microfibre cloths at 20°C.

- This product did not pass the screening test.
- Control results are acceptable.

Date: yyyymm-dd
Approved By: Project Manager
Work Order : 218308  
Sample Number : 29362  

SAMPLE IDENTIFICATION

Company : Process Cleaning Solutions Ltd.  
Location : Peterborough ON  
Substance : Neutral Disinfectant Concentrate (15.36% Didecyl Dimethyl Ammonium Chloride)  
Chemical Lot Number: 100099  

Sample Type : Chemical  
Submitted By : M. Rochon  
Date Received : 2010-12-16  
Date Tested : 2010-12-23

TEST RESULTS

Date Recorded : 2011-12-25  
Analyst(s) : SSH

Primary Subculture / Secondary Subculture

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Results Summary
Number of carrier sets with growth : 10
Number of carrier sets without growth : 0

Control Results
Tube : 1 2
Viability Controls : + +
Negative Controls : – –

"-" = no growth observed  
"+" = growth observed

TEST CONDITIONS

Test Organism : Staphylococcus aureus  
Carrier Titre : 4.2 x 10<sup>5</sup>  
Carrier Drop Time Interval : 1 min ± 5 sec  
Primary Medium : Letheen Broth  
Secondary Medium : Letheen Broth  
Use Dilution : 5 mL/L  
Dilution Water : Hard (400 ppm)  
Exposure Temp. : 20 ± 1 °C  
Exposure Period : 10 min  
Neutralization : Confirmed

COMMENTS

Tested a use dilution of 5 mL/L made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered cotton cloths at 20°C.

*This product did not pass the screening test.  
*Control results are acceptable.

Date : 2011.01.04  
Approved By: Project Manager
SAMPLE IDENTIFICATION

Company: Process Cleaning Solutions Ltd.
Location: Peterborough ON
Substance: Neutral Disinfectant Concentrate (15.36% Didecyl Dimethyl Ammonium Chloride)
Chemical Lot Number: 100099

TEST RESULTS

Date Recorded: 2010-12-31
Analyst(s): SSH

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Results Summary
Number of carrier sets with growth: 10
Number of carrier sets without growth: 0

Control Results
Tube: 1 2
Viability Controls: + +
Negative Controls: - -

"-" = no growth observed
"+" = growth observed

TEST CONDITIONS

Test Organism: Pseudomonas aeruginosa
Carrier Titre: $7.7 \times 10^5$
Carrier Drop Time Interval: 1 min ± 5 sec
Primary Medium: Letheen Broth
Secondary Medium: Letheen Broth
Use Dilution: 5 mL/L
Dilution Water: Hard (400 ppm)
Exposure Temp.: 20 ± 1 ºC
Exposure Period: 10 min
Neutralization: Confirmed

COMMENTS

Tested a use dilution of 5 mL/L made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered microfibre cloths at 20ºC.

• This product did not pass the screening test.
• Control results are acceptable.
SAMPLE IDENTIFICATION

Company : Process Cleaning Solutions Ltd.  
Location : Peterborough ON  
Substance : Neutral Disinfectant Concentrate (15.36% Didecyl Dimethyl Ammonium Chloride)  
Chemical Lot Number: 100099  

TEST RESULTS

Date Recorded : 2010-12-31  
Analyst(s) : SSH

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</tr>
</tbody>
</table>

Results Summary

Number of carrier sets with growth : 10  
Number of carrier sets without growth : 0

Control Results

Tube : 1 2  
Viability Controls : + +  
Negative Controls : – –

"–“ = no growth observed  
"+“ = growth observed

TEST CONDITIONS

Test Organism : Pseudomonas aeruginosa  
Carrier Titre : $7.7 \times 10^{-5}$  
Carrier Drop Time Interval : 1 min ± 5 sec  
Primary Medium : Letheen Broth  
Secondary Medium : Letheen Broth  
Use Dilution : 5 mL/L  
Dilution Water : Hard (400 ppm)  
Exposure Temp. : 20 ± 1 °C  
Exposure Period : 10 min  
Neutralization : Confirmed

COMMENTS

Tested a use dilution of 5 mL/L made up at 1.8 L in 400 ppm hard water and held for 4 hours on laundered cotton cloths at 20°C.

*This product did not pass the screening test.  
*Control results are acceptable.

Date : 2011-01-06  
Approved By: [Signature]  
Project Manager