DECONGEL®
A PRODUCT OF CBI POLYMERS

TITLE: Surface Decontamination of Copper Compounds (Copper (elemental), Copper (I) Oxide) by DeconGel™ 1101

ABSTRACT

Surface decontamination efficacy determination of DeconGel™ 1101 on stainless steel, carbon steel, concrete, Lexan, and rubber surfaces contaminated with elemental copper and copper (I) oxide (Cu_2O) was performed with ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) according to Environmental Protection Agency (EPA) SW-846 Methods: 3005A (sampling) and 6010C (analysis).

HAZARDOUS MATERIALS RELEVANCE

Copper and its compounds such as copper (I) oxide are commonly used as components of semiconductors, pigments, fungicides, and as antifouling agents for marine paints. Due to its toxicity toward aquatic organisms, copper is considered an environmentally persistent pollutant. Elemental copper and copper (I) oxide were chosen as a representative copper compounds for evaluating DeconGel's efficacy; DeconGel is expected to have similar efficacy towards the wide range of copper compounds.

SUMMARY RESULTS

- As seen in Tables 1 and 2, excellent surface decontamination was achieved by applying DeconGel 1101 onto contaminated surfaces, resulting in encapsulation of Copper contaminants by DeconGel's active components. Decontamination efficacies of DeconGel 1101 on copper elemental ranged from 98.0% (on concrete) to 99.4% (on rubber) to 99.5% (on Lexan) to 99.5% (on carbon steel) to 99.9% (on stainless steel) as determined by residual swipe analysis; decontamination efficacies of DeconGel 1101 on copper (I) oxide ranged from 94.7% (on concrete) to 98.9% (on carbon steel) to 99.7% (on stainless steel) as determined by residual swipe analysis.
- Copper (I) oxide was evidenced to react with concrete surfaces, forming a fixed residue that was not able to be completely removed by DeconGel. Nevertheless, DeconGel showed acceptable decontamination efficacy of loose copper (I) oxide contamination from such surfaces.
- Optimized experimental and analytical methods were successfully developed following standardized EPA sampling and analysis methods as guidelines for determination of inorganic compounds in aqueous samples. When deemed necessary, experimental methods were customized to afford complete dissolution of inorganic contaminants, and to ensure accurate decontamination efficacy determination of DeconGel.

RESULTS

Tables 1 and 2 show the decontamination efficacies of DeconGel 1101 on stainless steel, carbon steel, and concrete surfaces contaminated with copper compound (Cu_2O) as determined by residual swipe testing.

Table 1. Decontamination efficacies of DeconGel 1101 on Copper (elemental) on stainless steel, carbon steel, concrete, rubber, and Lexan surfaces as determined by residual swipe testing.

Swipe Testing (ppm)		Formulation
		DeconGel 1101
Stainless Steel	Control	396.3 ± 16.3
	Residual	0.56 ± 0.59
	Decon. Efficacy (%)	**99.9 ± 8.9**
Carbon Steel	Control	396.1 ± 10.1
	Residual	1.81 ± 0.81
	Decon. Efficacy (%)	**99.5 ± 7.0**
Concrete	Control	352.0 ± 8.2
	Residual	7.0 ± 4.0
	Decon. Efficacy (%)	**98.0 ± 2.9**
Rubber*	Control	61.0 ± 6.0
	Residual	0.34 ± 0.40
	Decon. Efficacy (%)	**99.4 ± 9.9**
Lexan*	Control	59.7 ± 1.2
	Residual	0.28 ± 0.34
	Decon. Efficacy (%)	**99.5 ± 4.9**

2000x dilution factor for samples and controls
*12000x dilution factor for samples and controls

Table 2. Decontamination efficacies of DeconGel 1101 on Copper (I) Oxide on stainless steel, carbon steel, and concrete surfaces as determined by residual swipe testing.

Swipe Testing (ppm)		**Formulation**
		DeconGel 1101
Stainless Steel	Control	526.5 ± 41.9
	Residual	1.50 ± 0.40
	Decon. Efficacy (%)	**99.7 ± 8.7**
Carbon Steel	Control	499.7 ± 33.9
	Residual	5.52 ± 3.53
	Decon. Efficacy (%)	**98.9 ± 6.9**
Concrete*,[1]	Control	55.8 ± 1.4
	Residual	2.95 ± 1.67
	Decon. Efficacy (%)	**94.7 ± 3.9**

2000x dilution factor for samples and controls

[1] 12000x dilution factor for samples

* Copper (I) oxide reacted with concrete surface, resulting in a fixed residue on the contaminated surface that could not be completely removed by DeconGel.

NOTES

- Application of a homogenous, thin layer of Copper contaminant on the respective substrate facilitated an optimized interaction between contaminant and DeconGel, and an accurate measure of DeconGel's decontamination efficacy in a scaled-down yet real-world setting. No less than 6.0 g of DeconGel was used for each experiment to allow an optimized interaction between contaminant and DeconGel. Copper (elemental) and copper (I) oxide readily dissolve in aqueous acidic solutions used to prepare all samples and controls (20% HCl, 15% HNO_3, 65% DI H_2O).
- Copper (I) oxide undergoes a chemical reaction with concrete surface which prevents some contamination from being sampled (swipe testing) and encapsulated into dry DeconGel (direct gel testing). Nevertheless DeconGel showed acceptable decontamination efficacy against loose copper (I) oxide contamination.
- ASTM method E1728-03, a standardized swipe testing method used for sampling of inorganic contaminants, was the integral method used to accurately evaluate DeconGel's decontamination efficacy. GhostWipe™ (Environmental Express; Mt. Pleasant, SC) swipes (pre-wetted with DI H_2O) were utilized in this swipe testing method.
- Standardized EPA SW-846 Sampling Method 3005A "Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy" was followed as a guideline to prepare all samples and controls. When deemed necessary, digestion methods were customized by increasing hydrochloric and nitric acid concentrations from 15% to 25% wt, and/or by heating samples to higher temperatures using a HotBlock™ Sample Heater (Environmental Express; Mt. Pleasant, SC) to afford the complete digestion of the inorganic contaminants. All samples, controls, and standards were prepared using the

same dissolution solution and experimental conditions to ensure both correct instrument calibration and accurate analytical results.

- ICP-OES instrumentation is a sensitive and accurate analytical tool for qualitative and quantitative determination of a large number of inorganic compounds. Standardized EPA SW-846 Analytical Method 6010C "Inductively Coupled Plasma-Atomic Emission Spectrometry" was followed as a guideline to prepare all samples and controls.
- To ensure accurate determination of DeconGel decontamination efficacy, calibration standards of the analyte of interest were prepared using either a sufficiently pure analyte or an appropriate ICP-MS Standard (Ricca Chemical Company; Arlington, TX); the respective standards were diluted to a known concentration (ppm) using the same digestion method as the one used for samples and controls. Instrument blank controls were DI H_2O ($\geq$17 M-Ohm).

CALCULATIONS

Decontamination Efficacy (Swipe Testing) =

[(Contaminant (ppm) of Swipe Control) – (Contaminant (ppm) of Residual Swipe)/Contaminant (ppm) of Swipe Control] x 100%

MATERIALS AND METHODS

Sample Method

In a typical procedure, 0.050 g copper contaminant was evenly applied on 1) stainless steel (surface area: 56.3 cm^2), 2) carbon steel (surface area: 100 cm^2), 3) concrete (industrial grade, surface area: 56.3 cm^2), 4) rubber (surface area: 56.3 cm^2), or 5) Lexan (surface area: 56.3 cm^2) coupons. Approximately 6.0 g of DeconGel 1101 was poured onto the contaminated surface and let to dry for 24 h. Dried DeconGel samples were peeled off the contaminated surface, and the surface was swipe tested (ASTM method E1728-03) using a GhostWipe™ swipe (Environmental Express; Mt. Pleasant, SC). Swipe and gel samples were suspended in 100 mL aqueous acidic solution (20% HCl, 15% HNO_3, 65% deionized (DI) H_2O) for 24 h. When deemed necessary, samples were heated to 94^{o}C for 4-24 h to effectively complete dissolution of inorganics using a HotBlock™ Sample Heater (Environmental Express; Mt. Pleasant, SC). Samples were allowed to cool to room temperature and were then analyzed via ICP-OES (see below).

Control Methods

For swipe control samples, a respective amount of contaminant was evenly applied on 1) stainless steel (56.3 cm^2), 2) carbon steel (commercial grade, 100 cm^2), or 3) concrete (industrial grade, 56.3 cm^2) coupons, and the surface was swipe tested (ASTM method 1728-03) using a GhostWipe™ swipe (Environmental Express; Mt. Pleasant, SC). Swipe samples were suspended in 100 mL aqueous acidic solution (20% HCl, 15% HNO_3, 65% DI H_2O) for 24 h and analyzed via ICP-OES (see below).

Reagents and Standards

Reagent grade Copper (elemental), (CAS# 7440-50-8, Fisher Scientific; Fair Lawn, NJ) was used as received.

Reagent grade Copper (I) Oxide, Cu_2O, (CAS# 1317-39-1, Fisher Scientific; Fair Lawn, NJ) was used as received.

1000 ppm calibration standards were prepared using reagent grade copper (elemental) and Cu_2O in freshly prepared aqueous acidic solution (20% HCl, 15% HNO_3, 65% DI H_2O). DI H_2O was used as the blank sample.

Analytical Instrumentation

A Thermo ICP-OES instrument model radial iCap 6300 was used to determine copper compound concentration (ppm) of all samples and controls using a freshly prepared 1000 ppm calibration standard.

Analyte (copper) analyzed at 327.4 nm

Pump Speed: 0.5 mL/min

APPLICATION INSTRUCTIONS FOR END-USERS

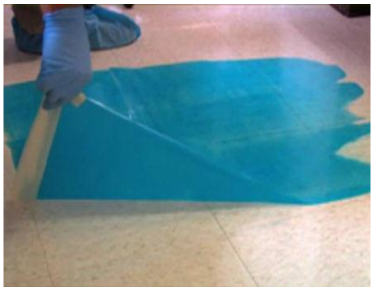
Use product directly as is from container. DO NOT DILUTE. Masking or painters tape can be applied along one edge of the area that is to be decontaminated to aid creating a peeled edge to grip for peeling the dried film. Apply DeconGel using a paint brush, a trowel, a handheld sprayer, or an industrial grade sprayer (use DeconGel 1120 or 1121 for spray application).

The thickness of the gel and the number of coats is dictated by the surface to be decontaminated. Coating thickness required for good peel characteristics varies with substrate and generally increases with substrate porosity. It is recommended that first time customers test DeconGel on a small sample area to confirm the required film thickness and dry time for their specific application. If the film is difficult to peel, please apply an additional coat. A razor blade is useful to start the peel. Lay the blade nearly flat and fillet the edge of the film to create a tab that can be pulled. For surfaces that the gel adheres to well, such as concrete, 12" – 24" strips can be cut in the film resulting in less force being required to peel the film.

- Let DeconGel dry for 24 hours

Dry time will vary depending on humidity, temperature, air flow and thickness of the DeconGel. This can take from as little time as an hour for thin coats in a dry environment with plenty of airflow, to overnight or longer if thicker coats are applied in humid environments. Dry times exceeding 24 hours may sometimes be required for good peel performance on bare concrete, wood and other highly porous substrates and substrates with deep cracks or grooves. However, 18-24 hours is often sufficient dry time on good quality concrete. It is recommended that users test a small area to determine drying time prior to applying DeconGel for an entire job. Supplemental heat or air circulation will accelerate DeconGel's drying time for any job.

- Peel DeconGel off the surface by starting from one of the edges

When dry, the product locks the contaminants into a polymer matrix. The film containing the encapsulated contamination can then be peeled. DeconGel peels from most non-porous and porous hard surfaces if the dried film is thick enough. If the film is difficult to peel, add another coat, let dry, and peel. In most cases the DeconGel will come off in a single sheet but for odd shaped surfaces you may be required to score DeconGel in order to peel it off.

- Dispose of the dried DeconGel in accordance with the local, state and Federal disposal regulations of the contaminant/substance you are removing. DeconGel itself has no special disposal restrictions.

For questions about DeconGel or to place an order, visit our website at www.decongel.com or contact us at:
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