TITLE: Surface Decontamination of Aluminum Compounds (Elemental Aluminum Powder (Al), Aluminum Oxide (Al_2O_3), Aluminum Chloride ($AlCl_3$) and Aluminum Potassium Sulfate ($AlK(SO_4)_2$)) by DeconGel™

ABSTRACT

Surface decontamination efficacy determination of DeconGel™ on stainless steel, carbon steel, and concrete surfaces contaminated with aluminum compounds (elemental aluminum powder (Al), aluminum oxide (Al_2O_3), aluminum chloride ($AlCl_3$), and aluminum potassium sulfate ($AlK(SO_4)_2$)) was performed using 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

Aluminum and its compounds are widely used in a number of industries including consumer goods such as cosmetics and aluminum cans. Aluminum compounds can become easily airborne and as such are considered inhalation hazards. Aluminum powder, aluminum oxide, aluminum chloride, and aluminum potassium sulfate were chosen as representative aluminum compounds for evaluating DeconGel's efficacy; DeconGel is expected to have similar efficacy towards the wide range of aluminum compounds.

SUMMARY RESULTS

- Excellent surface decontamination was achieved by applying DeconGel onto surfaces contaminated with aluminum compounds resulting in encapsulation of contaminants by DeconGel's active components. Decontamination efficacies of DeconGel for aluminum compounds (except aluminum powder elemental which is corrosive and reacts with the metal surfaces evaluated) were from greater than 93.0% (on concrete) to greater than 95.4% (on carbon steel) to greater than 96.4% (on stainless steel) as determined by residual swipe analysis.
- Aluminum powder is reactive to some metal surfaces including carbon steel and stainless steel. DeconGel could not completely remove aluminum elemental powder that reacted with and created a fixed deposit on steel surfaces. Nevertheless, DeconGel showed excellent decontamination efficacy on loose aluminum powder contaminant from such surfaces.
- Optimized experimental and analytical methods were successfully developed following standardized EPA sampling and analysis methods as guidelines for determination of inorganics in aqueous samples. When necessary, the digestion methods were customized to result in the complete dissolution of the inorganic contaminants and to ensure accurate decontamination efficacy determination of DeconGel.

RESULTS

Tables 1 through 4 show the decontamination efficacies of DeconGel on stainless steel, carbon steel, and concrete surfaces contaminated with elemental aluminum powder (Al), aluminum oxide (Al_2O_3), aluminum chloride ($AlCl_3$) and aluminum potassium sulfate ($AlK(SO_4)_2$) as determined by residual swipe testing.

Table 1. Decontamination efficacies of DeconGel on aluminum powder (Al) on stainless steel, carbon steel, and concrete surfaces as determined by residual swipe testing.

Swipe Testing (ppm)		Formulation
		DeconGel
Stainless Steel*	Control	1113.0 ± 17.0
	Residual	23.3 ± 5.3
	Decon. Efficacy (%)	**97.9 ± 2.0**
Carbon Steel*	Control	944.7 ± 0.2
	Residual	4.7 ± 4.3
	Decon. Efficacy (%)	**99.5 ± 4.6**
Concrete	Control	511.7 ± 12.7
	Residual	1.8 ± 0.2
	Decon. Efficacy (%)	**99.6 ± 3.8**

2280x dilution factor for samples and controls

Table 2. Decontamination efficacies of DeconGel against aluminum oxide (Al_2O_3) on stainless steel, carbon steel, and concrete surfaces as determined by residual swipe testing method.

Swipe Testing (ppm)		Formulation
		DeconGel
Stainless Steel	Control	420.8 ± 7.0
	Residual	1.4 ± 0.6
	Decon. Efficacy (%)	**99.7 ± 7.7**
Carbon Steel	Control	505.5 ± 22.4
	Residual	0.3 ± 0.3
	Decon. Efficacy (%)	**99.9 ± 14.4**
Concrete	Control	420.2 ± 6.1
	Residual	1.3 ± 0.7
	Decon. Efficacy (%)	**99.7 ± 5.9**

2280x dilution factor for samples and controls

Table 3. Decontamination efficacies of DeconGel against aluminum chloride ($AlCl_3$) on stainless steel, carbon steel, and concrete surfaces as determined by residual swipe testing method.

Swipe Testing (ppm)		Formulation
		DeconGel
Stainless Steel	Control	325.0 ± 7.9
	Residual	3.6 ± 2.3
	Decon. Efficacy (%)	**98.9 ± 0.7**
Carbon Steel	Control	319.2 ± 18.4
	Residual	4.9 ± 1.4
	Decon. Efficacy (%)	**98.5 ± 5.9**
Concrete	Control	369.4 ± 73.7
	Residual	25.8 ± 4.4
	Decon. Efficacy (%)	**93.0 ± 18.7**

2280x dilution factor for samples and controls

Table 4. Decontamination efficacies of DeconGel on aluminum potassium sulfate ($AlK(SO_4)_2$) on stainless steel, carbon steel, and concrete surfaces as determined by residual swipe testing method.

Swipe Testing (ppm)		Formulation
		DeconGel
Stainless Steel	Control	441.8 ± 20.7
	Residual	15.9 ± 3.9
	Decon. Efficacy (%)	**96.4 ± 4.9**
Carbon Steel	Control	442.0 ± 13.6
	Residual	20.4 ± 7.4
	Decon. Efficacy (%)	**95.4 ± 4.2**
Concrete	Control	399.8 ± 47.5
	Residual	20.1 ± 3.3
	Decon. Efficacy (%)	**95.0 ± 11.4**

2280x dilution factor for samples and controls

NOTES

- ASTM method E1728-03, a standardized swipe testing method used for the 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 25% to 35% wt, and/or by heating samples to higher temperatures using a HotBlock™ Sample Heater (Environmental Express; Mt. Pleasant, SC) to facilitate the complete digestion/dissolution 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, 0.05 g of contaminant was evenly applied on 1) stainless steel (commercial grade, surface area: 56.3 cm^2), 2) carbon steel (commercial grade, surface area: 100 cm^2), or 3) concrete (industrial grade, surface area: 56.3 cm^2) coupons. Approximately 6.0 g of DeconGel was poured onto the contaminated surface and let to dry for 24-48 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 samples were suspended in 100 mL aqueous acidic solution (20% HCl, 15% HNO_3, 65% deionized (DI) H_2O) for 24 hours and were then analyzed via ICP-OES (see below).

Control Methods

For swipe control samples, the respective amount of contaminant was evenly applied on 1) stainless steel (commercial grade, surface area: 56.3 cm^2), 2) carbon steel (commercial grade, surface area: 100 cm^2), or 3) concrete (industrial grade, surface area: 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

Aluminium metal, Al, finest powder grade, (CAS# 7429-90-5, Fisher Scientific; Fair Lawn, NJ), was used as received.

Aluminium oxide, Al_2O_3, 60-325 Mesh, (CAS# 1344-28-1, Fisher Scientific; Fair Lawn, NJ), was used as received.

Aluminum Chloride, $AlCl_3$, fine crystalline solid, (CAS# 7446-70-7, Fisher Scientific; Fair Lawn, NJ), was used as received.

Aluminum Potassium Sulfate, $AlK(SO_4)_2$, fine crystalline solid, (CAS# 7784-24-9, Fisher Scientific; Fair Lawn, NJ), was used as received

A 1000 ppm calibration standard of each contaminant was prepared using the aluminum and aluminum compounds in freshly prepared aqueous acidic solution (20% HCl, 15% HNO_3, 65% DI H_2O). DI H_2O ($\geq$ 17 M-Ohm) was used as the blank sample.

Analytical Instrumentation.

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

Analyte (aluminum) analyzed at 308.2 nm.

Pump Speed: 0.5 mL/min

APPLICATION INSTRUCTIONS FOR END-USERS

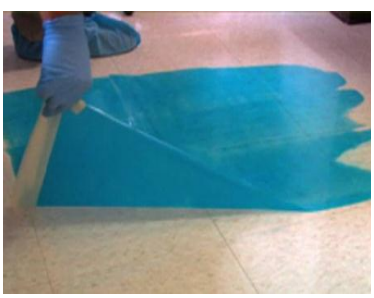
Use product directly as is from container. DO NOT DILUTE. Masking or painters tape can be applied along one edge of the area that is to be decontaminated to aid creating a peeled edge to grip for peeling the dried film. Apply DeconGel using a paint brush, a trowel, a handheld sprayer, or an industrial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

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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