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TITLE: Surface Decontamination of PCBs (PCB-laden oil) by DeconGel™

ABSTRACT

Field testing aboard the USS Missouri maritime museum vessel showed that excellent surface decontamination was achieved by applying DeconGel™ 1102 onto contaminated surfaces, resulting in encapsulation of PCB contaminant by DeconGel's active components. For all contaminated surfaces tested, EPA PCB limit standards (Regulations 761.79, 761.123) of ≤ 10 ug/100 cm^2 were achieved upon decontamination with DeconGel 1102. Additionally, "in house" surface decontamination efficacy determination of DeconGel 1101 and 1102 on stainless steel, aluminum, and concrete surfaces contaminated with PCB (polychlorinated biphenyls) oil performed with GC/MS (Gas Chromatography/Mass Spectrometry) according to Environmental Protection Agency (EPA) SW-846 Methods: 3500C (Sampling) and 8270C (Analysis), demonstrated 100% efficacy on various substrates including concrete, aluminum, and stainless steel as determined by residual swipe analysis.

HAZARDOUS MATERIALS RELEVANCE

PCBs were widely used as industrial dielectric additives in transformer and capacitor coolants and insulating fluids. Due to undesirable carcinogenicity, PCB production has been banned since the 1970s. PCBs are considered chemically inert and resist environmental degradation, and as such remain environmentally persistent pollutants.

SUMMARY RESULTS

- USS Missouri maritime museum vessel contains several areas with limited access to the public due to PCB oil contamination. Field testing aboard the USS Missouri maritime museum vessel showed that excellent surface decontamination was achieved by applying DeconGel 1102 onto contaminated surfaces, resulting in encapsulation of PCB contaminant by DeconGel's active components. For all contaminated surfaces tested, EPA PCB limit standards (Regulations 761.79, 761.123) of ≤ 10 ug/100 cm^2 were achieved upon decontamination with DeconGel 1102. Table 1 below summarizes these results.
- Additional "in house" tests show that excellent surface decontamination was achieved by applying both DeconGel 1101 and 1102 via brushing onto contaminated surfaces, resulting in encapsulation of PCB contaminant by DeconGel's active components. Decontamination efficacies of brushed DeconGel 1101 & 1102 were 100% on concrete, aluminum, and stainless steel as determined by residual swipe analysis.

- "In house" tests show decontamination efficacies of poured DeconGel 1101 ranging from 83.9% (1st application) to 98.6% (2nd application, 3 days after 1st application) to 98.8% (2nd application, 7 days after 1st application) on concrete, 92.4% on aluminum (one application), and 92.4% on stainless steel (one application), as determined by residual swipe analysis. Decontamination efficacies of poured DeconGel 1102 ranged from 87.2% (1st application) to 98.8% (2nd application, 3 days after 1st application) to 99.0% (2nd application, 7 days after 1st application) on concrete, 94.1% on aluminum (one application), and 94.1% on stainless steel (one application) as determined by residual swipe analysis.
- Optimized experimental and analytical methods were successfully developed following standardized EPA sampling and analysis methods as guidelines for determination of organic compounds dissolved in a suitable solvent able to completely solvate PCBs as well as DeconGel components. Additionally, analytical methods and associated equipment -GC column, GC gradient program, MS sample ionization parameters, PCB analyses for maritime museum vessel- were appropriately developed and outsourced to ensure accurate decontamination determination of DeconGel.

RESULTS

Figure 1 below shows photos taken during the field testing aboard the USS Missouri PCB decontamination field testing. Table 1 shows the decontamination efficacies of DeconGel 1102 on multiple contaminated sites aboard the USS Missouri maritime museum vessel; Table 2 shows the decontamination efficacies of DeconGel 1101 and 1102 in "in house" tests on stainless steel, aluminum, and concrete surfaces contaminated with PCB oil as determined by residual swipe testing.

Figure 1. Field testing aboard USS Missouri maritime museum vessel.

Table 1. Decontamination efficacies of DeconGel 1102 on PCB oil on stainless steel, cementacious leveling compound surface, painted deck plate, and brass surfaces as determined by residual swipe testing.

Description	CONTAMINATED SURFACE MATERIAL	Before Decon (ug/100cm^2)	DeconGel 1102* After 1st application (ug/100cm^2)	DeconGel 1102* After 2nd application (ug/100cm^2)
2-111-2-Q Gen Wksp Oil on #8 Radial Press	**Stainless steel**	89.1ug/ 100cm^2 Aroclor 1254	<1.00ug/ 100 cm^2 (wire brush utilized)	<1.00ug/ 100cm^2 (wire brush utilized)
2-68-0-L Crew Living Space oil on deck from winch (underlayment)	**Cementacious leveling compounds**	14.7ug/ 100cm^2 Aroclor 1254	1.82 ug/ 100 cm^2 Aroclor 1260 (Stand up wire brush utilized)	6.14ug/ 100cm^2 Aroclor 1260 (Stand up wire brush utilized)
4-79-2-C Fwd Battery Plot oil on deck from overhead metal panel	**Painted metal deck plate**	661ug/ 100cm^2 Aroclor 1254	<1.00ug/ 100 cm^2 (brushing with a paint brush)	<1.00ug/ 100cm^2 (brushing with a paint brush)
			3.32 ug/ 100 cm^2 Aroclor 1260 (scrubbing)	<1.00ug/ 100cm^2 (scrubbing)
4-74-2-M 16" FWD Magazine cosmolene film on brass	**Brass**	132ug/ 100cm^2 Aroclor 1254 213ug/ 100cm^2 Aroclor 1260 Total PCBs 345 ug/ 100cm^2	<1.00ug/ 100cm^2 (scrubbing)	<1.00ug/ 100cm^2 (scrubbing)

Above data are from an independent lab. Sample analysis performed by SGS North America Inc.; Environmental Services (Anchorage, AK).

* PCB surface limit standards (following EPA Regulations 761.79, 761.123) ≤ 10 ug/100 cm^2.

Table 2. Decontamination efficacies of DeconGel 1101 and 1102 on PCB oil on stainless steel, aluminum, and concrete surfaces as determined by residual swipe testing. (In house evaluations)

Swipe Testing (ppm)		Formulation DeconGel 1101	Formulation DeconGel 1102
Stainless Steel	Control	762.3 ± 4.93	762.3 ± 4.93
	Residual (non-brushed)	57.68 + 0.42	44.72 + 0.51
	Residual (brushed)	ND*	ND
	Decon. Efficacy (non-brushed) (%)	**92.4 ± 0.10**	**94.1 ± 0.10**
	Decon. Efficacy (brushed) (%)	**100****	**100****
Aluminum	Control	764.4 ± 5.32	764.4 ± 5.32
	Residual (non-brushed)	57.78 ± 0.31	44.86 ± 0.41
	Residual (brushed)	ND	ND
	Decon. Efficacy (non-brushed) (%)	**92.4 ± 0.10**	**94.1 ± 0.10**
	Decon. Efficacy (brushed) (%)	**100****	**100****
Concrete	Control	645.6 ± 3.69	645.6 ± 3.69
	Residual 1[1] (non-brushed)	103.7 ± 0.88	82.58 ± 0.60
	Residual 1 (brushed)	ND	ND
	Decon. Efficacy (1st Application) (non-brushed) (%)	**83.9 ± 0.18**	**87.2 ± 0.11**
	Decon. Efficacy (1st Application) (brushed) (%)	**100****	**100****
	Residual 2[2] (non-brushed)	9.18 ± 0.79	7.68 ± 0.78
	Residual 2 (brushed)	ND	ND
	Decon. Efficacy (2nd Application/ 72hrs after 1st Application) (non-brushed) (%)	**98.6 ± 0.10**	**98.8 ± 0.15**
	Decon. Efficacy (2nd Application/ 72hrs after 1st Application) (brushed) (%)	**100**	**100**
	Residual 3[3] (non-brushed)	7.87 ± 0.45	6.61 ± 0.66
	Residual 3(brushed)	ND	ND
	Decon. Efficacy (2nd Application/ 168 hrs after 1st Application) (non-brushed) (%)	**98.8 ± 0.10**	**99.0 ± 0.12**
	Decon. Efficacy (2nd Application/ 168 hrs after 1st Application) (brushed) (%)	**100**	**100**

3860x dilution factor for samples and controls

* ND: not detected, limit of detection (LOD) for PCBs approximates 250 ppb

** An ND value for residual experiments results in a Decontamination Efficacy of 100%

[1] Standard 24 h decontamination protocol utilized (24 h required DeconGel drying time)

[2] 2nd DeconGel application (3 days/72 h after 1st application)

[3] 2nd DeconGel application (7 days/168 h after 1st application)

NOTES:

- For decontamination studies on the maritime museum vessel USS Missouri, PCB surface limit standards following EPA Regulations 761.79, 761.123 were used as references to determine surface decontamination efficacies; for all surfaces decontaminated, PCB levels were determined to be below the ≤ 10 ug/100 cm^2 limit (see Table 1).
- Gauze pads pre-wetted with hexanes were used to sample 100cm^2 of coverage area before and after decon at the sites of USS Missouri that were decontaminated. Sample wipes were put into tightly sealed pre-labeled amber glass containers and sent to SGS North America Inc.; Environmental Services (Anchorage, AK) for independent lab sample testing of PCB oil.
- ASTM method E1728-03, a standardized swipe testing method used for sampling of contaminants, was the integral method used to accurately evaluate DeconGel's decontamination efficacy. Air-dried GhostWipe™ (Environmental Express; Mt. Pleasant, SC) swipes wetted with DMSO solvent were utilized in this swipe testing method (In house evaluations).
- Standardized EPA SW-846 Sampling Method 3500C "Organic Extraction and Sample Preparation" was followed as a guideline to prepare all samples and controls. All samples, controls, and standards were prepared using the same solvent and appropriate experimental conditions to ensure accurate and GC/MS instrumental analysis.
- GC/MS instrumentation is a sensitive and accurate analytical tool for qualitative and quantitative determination of a large number of organic compounds. Standardized EPA SW-846 Analytical Method 8270C "Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)" and EPA SW-846 Method 8082A "Determination of PCBs by Gas Chromatography" were followed as a guideline to prepare all samples and controls.
- To ensure accurate determination of DeconGel decontamination efficacy, a standard curve of the analyte of interest was prepared using sufficiently pure analyte; the respective standards were diluted to a known concentration (ppm) using the same solvent as used for samples and controls.
- For decontamination studies conducted at CBI Polymers, due to the dynamic nature of PCB oil contaminant leaching/migration within porous substrates such as concrete, consecutive DeconGel film applications were conducted in attempts to provide superior PCB oil decontamination over what is achieved when utilizing a singular DeconGel film application on porous surfaces. After the first decontamination round, a second application of DeconGel was applied for both the poured- (non-brushed) and brushed-film decontamination series, performed either 3 days or 7 days after the first DeconGel film application. Gratifyingly, employing a second DeconGel film application facilitated excellent surface decontamination (see Table 2).

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, 0.215 g PCB-laden mineral oil (approx. 33145 ppm (wt/wt)) contaminant was evenly applied via brushing on 1) aluminum (surface area: 56.3 cm^2), 2) stainless steel (surface area: 56.3 cm^2), or 3) concrete (industrial grade, surface area: 56.3 cm^2) coupons. Approximately 6.0 g of DeconGel 1101 or 1102 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 an air-dried GhostWipe™ swipe (Environmental Express; Mt. Pleasant, SC) wetted with DMSO solvent (2 mL). Swipe samples were suspended in 50 mL DMSO for 24 h. Samples were then analyzed via GC/MS following EPA SW-846 Method 8082A, "Determination of PCBs by Gas Chromatography" (see below).

Control Methods

For Swipe Control samples, a respective amount of contaminant was evenly applied via brushing on 1) aluminum (surface area: 56.3 cm^2), 2) stainless steel (surface area: 56.3 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 an air-dried GhostWipe™ swipe (Environmental Express; Mt. Pleasant, SC) wetted with DMSO solvent (2 mL). Swipe samples were suspended in 50 mL DMSO for 24 h. Samples were then analyzed via GC/MS following EPA SW-846 Method 8082A, "Determination of PCBs by Gas Chromatography" (see below).

Reagents & Standards

PCB standard Aroclor 1016 (CAS# 12674-11-2, Ultra Scientific; Kingston, RI) was dissolved in DMSO solvent used to generate standard curves.

PCB-laden mineral oil was confirmed to be Aroclor 1016 by GC/MS analysis and was found to have an Aroclor 1016 concentration of approximately 33145 ppm (wt/wt).

Analytical Instrumentation.

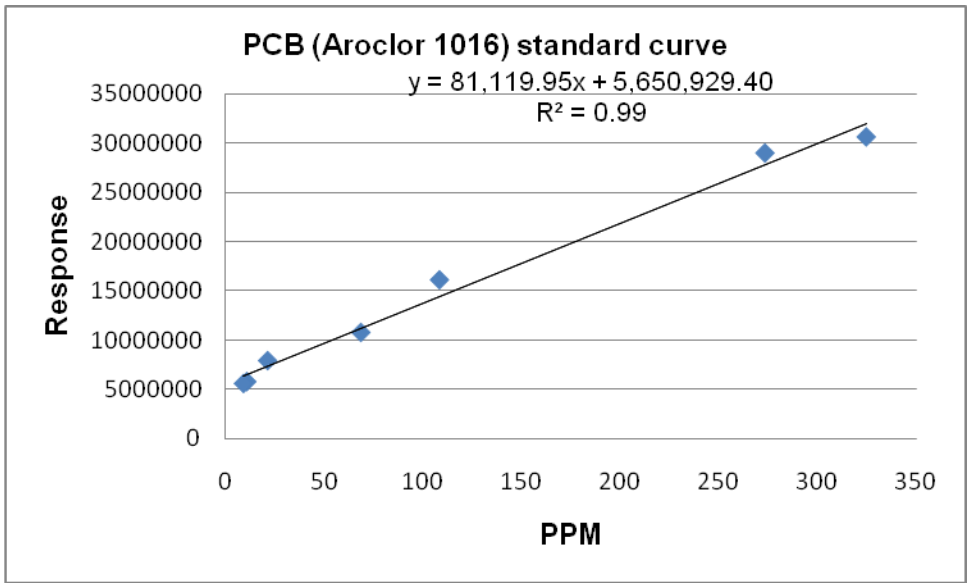
A Thermo DSQII GC/MS with autosampler in positive mode was used to determine PCB (Aroclor 1016) concentration (ppm, wt/wt) of all samples and controls, using a Restek (Bellefonte, PA) Rtx-5 capillary column (30 m x 0.25 mm, 0.5 um).

A 7-point standard curve derived from three independently prepared stock solutions was prepared using DMSO as the working solvent. The calibration curve exhibits a curve fitting as approximated by the coefficient of determination of linear regression R^2, where $R^2 = 0.99$ (see Figure 1).

GC method: start at 100 ^oC, hold for 1 min, ramp at 15 ^oC/min to 320 ^oC, hold 5 min.

PCB (di-chlorinated biphenyl) GC/MS data: 10.5 min; $M^+ = 222$.

Figure 1. PCB-laden mineral oil standard calibration curve



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.

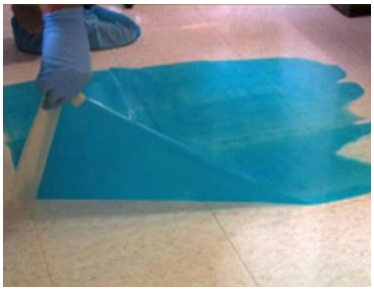
The thickness of the gel and the number of coats is dictated by the surface to be decontaminated. Coating thickness required for good peel characteristics varies with substrate and generally increases with substrate porosity. It is recommended that first time customers test DeconGel on a small sample 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 hrs 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 be able 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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