GRAPHINKS

Water and solvent-based GRM inks and coatings

General Information

GRAPHINKS™ are printable graphene and related material (GRM) inks and coatings that bring multi-functionality (high electrical and thermal conductivity, fire retardation, UV protection, etc.), produced via a high pressure homogenisation process that offers high yield and uniform size distribution. We have 'standard' graphene inks for different deposition methods from inkjet to screen printing.

Ink	Solvent	General Information
Graphink 1	Water	Inkjet printing ink: Coatings, printed electronics, antennas, sensors, energy storage devices, etc.
Graphink 1 high concentration	Water	Low viscosity ink, printing ink for laser sintering processes
Graphink 2/CMC	Water	Screen printing ink: Coatings, printed electronics, antennas, sensors, energy storage devices, etc.
Graphink 2/PU	Water	Ink for textiles coatings (thermal management, wicking)
Graphink 2/PAI	Water	Electrically conductive anti-corrosion coating, high–temperature coatings
Graphink 2 binder-free	Water	For clients who want to blend with their own binders/polymers/inks
Graphink-IPA	*Iso*-propanol	Coatings on polymers or metal substrates
Hexagonal boron nitride (hBN) Inks	Water / *iso*-propanol	Dielectric ink, inkjet to screen printable formulations for coatings on various substrates

GRAPHINKS™ are available in a number of grades suited to a wide range of applications

Applications include:

- Communication devices such as RF-ID Antennas, smart textiles, printed circuits and interconnects.
- Sensors for health monitoring or in smart packaging.
- Electrodes in solar cells or energy storage devices including batteries and supercapacitors.
- Textile coatings for enhanced thermal management, wicking and breathability properties.
- Barrier coatings on polymer films/paper

Custom Grades

Besides the commercial grades, Versarien has a number of inks, dispersions and coatings in development and is able to produce various aqueous, solvent and polymer based graphene inks, dispersions and coatings to meet its clients' needs.

GRAPHINK™ 1

Water-based few-layer graphene (FLG) ink

Technical Information

Ink Characteristics

SOLVENT	VISCOCITY (@100s^{-1})	GRAPHENE CONTENT	TOTAL SOLID CONTENT
Water	~2-3 cP (mPa.s)	0.2-0.5 g/L	~0.1 wt.%

Graphene Characteristics

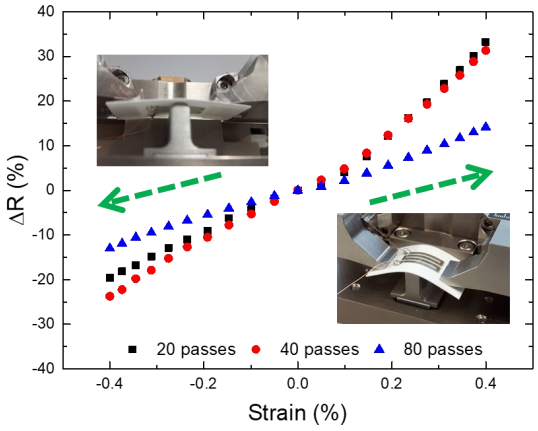
FLAKE TYPE	LATERAL SIZE	THICKNESS
Few-layer graphene	80-500 nm	Few-layer, <3 nm

Film Characteristics

DEPOSITION METHOD	DRYING CONDITIONS	SHEET RESISTANCE AT THICKNESS	TRANSPARENT FILMS	SUBSTRATES	CLEAN-UP SOLVENT
Inkjet Printing/ Vacuum Filtration/ Meyer Bar Coating	100°C for 10 min	~4 kΩ/□@80nm, ~30 Ω/□@2µm (vacuum filtered films)	Yes	Glass, Paper, Plastics	Water

Inkjet Printing Guidance

- This ink has been developed using a Drop-on-Demand (DoD) Dimatix Materials Printer, DMP-2800 (FUJIFILM Dimatix Inc., USA) using Dimatix Materials Cartridges.
- Jetting profiles and cleaning procedure files can be sent electronically following purchase of the ink. This does not guarantee successful printing and will require optimisation at the customer's end.
- Versarien are happy to help develop the ink with you for your inkjet printing needs and can increase concentrations or add rheology modifiers and other additives in line with the client's requests.



Resistance change under mechanical deformation of Graphink 1 inkjet printed strain gauges on paper substrates

More info on our inkjet printed Graphink 1 can be found on p57-59 of:

"Production and processing of graphene and related materials," 2D Materials, 7, 022001 ***(2020)***

GRAPHINK™ 2/CMC

Water-based GNP ink with sodium carboxymethylcellulose

Technical Information

Ink Characteristics

SOLVENT	VISCOCITY (@100s^{-1})	GRAPHENE CONTENT	TOTAL SOLID CONTENT
Water	~10000 cP (mPa.s) @ 1 s^{-1} ~600-800 cP (mPa.s) @ 100 s^{-1}	100 g/L	~10.3 wt.%

Graphene Characteristics

FLAKE TYPE	LATERAL SIZE	THICKNESS
Mixture of few-layer graphenes and graphene nanoplatelets	1000 ± 500 nm	~10 ± 5 nm

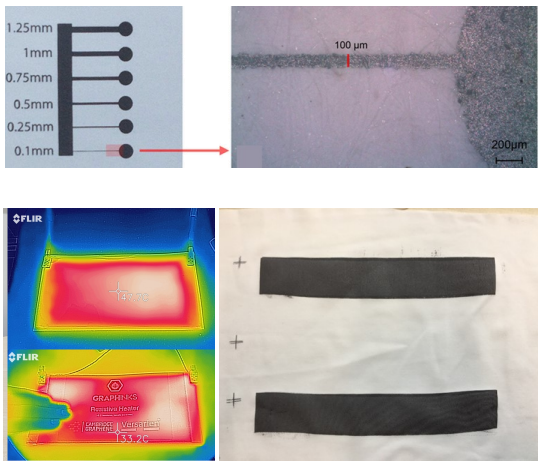
Film Characteristics

DEPOSITION METHOD	DRYING CONDITIONS	SHEET RESISTANCE AT THICKNESS	SUBSTRATES	CLEAN-UP SOLVENT
Flexo/ Gravure/ Screen Printing/ Blade/ Meyer Bar Coating	100°C for 10 min Blow dry with compressed air/ nitrogen	<10 Ω/□@25µm	Glass, Paper, Plastics, Textile	Water

Graphink 2/CMC is compatible with DuPont™ Intexar™ for use in clothing manufacturing processes

Screen Printing Guidance

- This ink has been developed using a flat– bed screen printing machine using screens with a waterproofed and hardened polyester mesh with mesh size ranging from **15 to 120**.
- Depending on the printing technique and the machine, the viscosity of the ink may need to be reduced using deionised water only.
- **Cleaning:** Reclaim excess ink from the screen using a spatula, use disposable cleaning wipes followed by rinsing and washing processes with detergent and water. Scrub the screen lightly with a brush, then wash out the screen with water and leave to air dry. Repeated cleaning processes may be necessary.



Graphink 2/CMC screen printed patterns on paper (top), Meyer bar coatings for electrothermal heater applications (left), screen printed conductive circuits on textiles (right).

More info on our screen printed Graphink 2/CMC can be found on p59-61 of:

"Production and processing of graphene and related materials," 2D Materials, 7, 022001 ***(2020)***

Application of our Graphink 2/CMC in RFID applications:

"Screen-printed and spray coated graphene-based RFID transponders," 2D Materials, 7, 015019 **(2020)**

GRAPHINK™ 2/PU

Water-based GNP ink with polyurethane

Technical Information

Ink Characteristics

SOLVENT	VISCOCITY (@100s^{-1})	GRAPHENE CONTENT	TOTAL SOLID CONTENT
Water	~4-5 cP (mPa.s)	80 g/L	~12.8 wt.%

Graphene Characteristics

FLAKE TYPE	LATERAL SIZE	THICKNESS
Mixture of few-layer graphenes and graphene nanoplatelets	1000 ± 500 nm	~10 ± 5 nm

Film Characteristics

DEPOSITION METHOD	DRYING CONDITIONS	SUBSTRATES	CLEAN-UP SOLVENT
Dip coating, inkjet and screen printing	Air dry or 100°C for 10 min for fast drying (dependent on substrate)	Glass, Paper, Plastics, Textiles	Water, Detergent

General Information

- Graphink 2/PU is a water based graphene dispersion with polyurethane designed for textile coating applications (organics, synthestics and leathers). Dilution with deionised water can be used to reduce graphene and PU concentrations. We would not recommend the addition of other non-aqueous solvents unless small scale compatibility trials are performed first.
- Final film characteristics depends on the parameters such as coating method, film thickness, binder/additive amount, type and the substrate.
- Versarien are happy to help develop the ink with you for your printing/coating needs and can increase graphene concentrations or add rheology modifiers and other additives in line with the client's requests.

Graphink 2/PU printed garments for enhanced thermal management and wicking.

GRAPHINK™ 2 binder-free

Water-based graphene nanoplatelet (GNP) dispersion

Technical Information

Ink Characteristics

SOLVENT	VISCOCITY (@100s^{-1})	GRAPHENE CONTENT	TOTAL SOLID CONTENT
Water	~1-2 cP (mPa.s)	100 g/L	~9.5 wt.%

Graphene Characteristics

FLAKE TYPE	LATERAL SIZE	THICKNESS
Mixture of few-layer graphenes and graphene nanoplatelets	1000 ± 500 nm	~10 ± 5 nm

Film Characteristics

DEPOSITION METHOD	DRYING CONDITIONS	SHEET RESISTANCE AT THICKNESS	SUBSTRATES	CLEAN-UP SOLVENT
Binder free Graphink 2 dispersion can be formulated with different binders and rheology modifiers for the desired application. Film properties will be dependent on the final formulation.				Water, Detergent

Formulation Guidance

- Graphink 2 is a water-based graphene dispersion with no binders or rheology modifiers added to it. It provides the customer the freedom to formulate a water-based graphene ink suitable for application with their binder or additives of choice. We would not recommend the addition of other non-aqueous solvents unless small scale compatibility trials are performed first.
- Final film characteristics depends on the parameters such as coating method, film thickness, binder/additive amount, type and the substrate.
- Versarien are happy to help develop the ink with you for your printing/coating needs and can increase graphene concentrations or add rheology modifiers and other additives in line with the client's requests.

Credit: James Macleod

More info on the formulation of our Graphinks can be found on p52-57 of:

"Production and processing of graphene and related materials," 2D Materials, 7, 022001 ***(2020)***

Commercial/Safety Information

Packaging

GRAPHINKs are packaged in various sized plastic containers dependent on quantities ordered:

- 60, 150, 250, 500 mL leak-proof bottles (Nalgene™ Wide-Mouth Lab Quality HDPE Bottles)
- 1 and 4 litre leak-proof bottles (Nalgene™ Wide-Mouth Lab Quality HDPE Bottles)
- IBC containers > 250 litre

Minimum Order Quantity

Minimum order quantity of Graphinks is 50 mL.

Health & Safety

A Material Safety Data Sheets (SDS) is available to provide both workers and emergency personnel with the proper procedures for handling or working with GRAPHINKS. This SDS includes information such as physical data (form and colour, boiling point, etc.), handling and storage recommendations, first aid measures and ecological information. The Safety Data Sheet is provided with any order and should be observed.

Scientific Publications

Info on formulation, inkjet and screen printing and applications of our Graphinks can be found on p52-61 of:

"Production and processing of graphene and related materials," 2D Materials, 7, 022001 **(2020)**

Info on processing, formulation and printing of our Graphink 2/CMC:

"Microfluidization of Graphite and Formulation of Graphene-Based Conductive Inks," ACS Nano, 11, 2742–2755 **(2017)**

Application of our Graphink 2/CMC in RFID applications:

"Screen-printed and spray coated graphene-based RFID transponders," 2D Materials, 7, 015019 **(2020)**