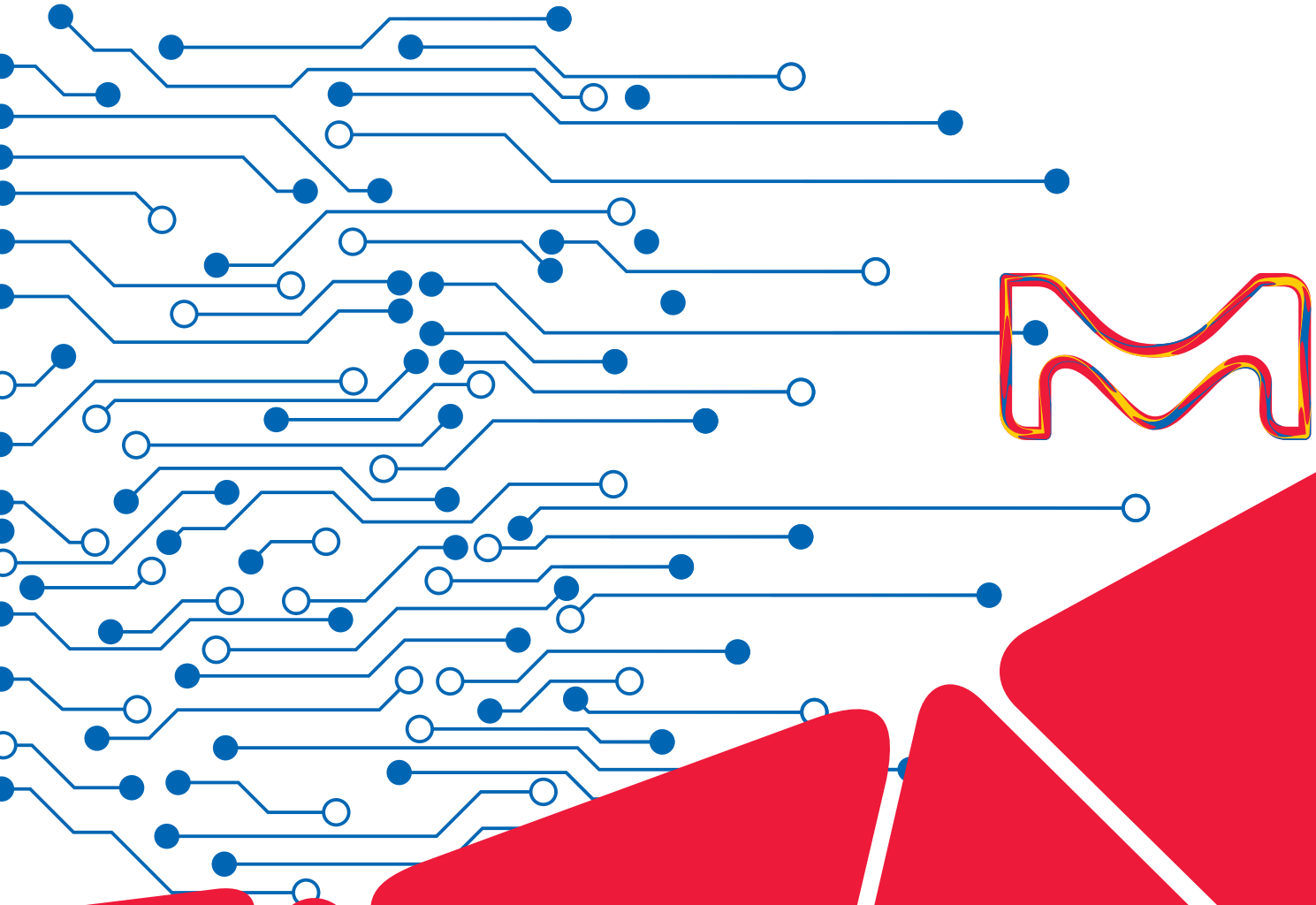
Electronic Inks

For sustainable printed electronics



The Life Science business of Merck operates as MilliporeSigma in the U.S. and Canada.

Sigma-Aldrich®

Lab & Production Materials

Maximize Performance with Our Electronic Inks

While minimizing your environmental footprint with printable materials

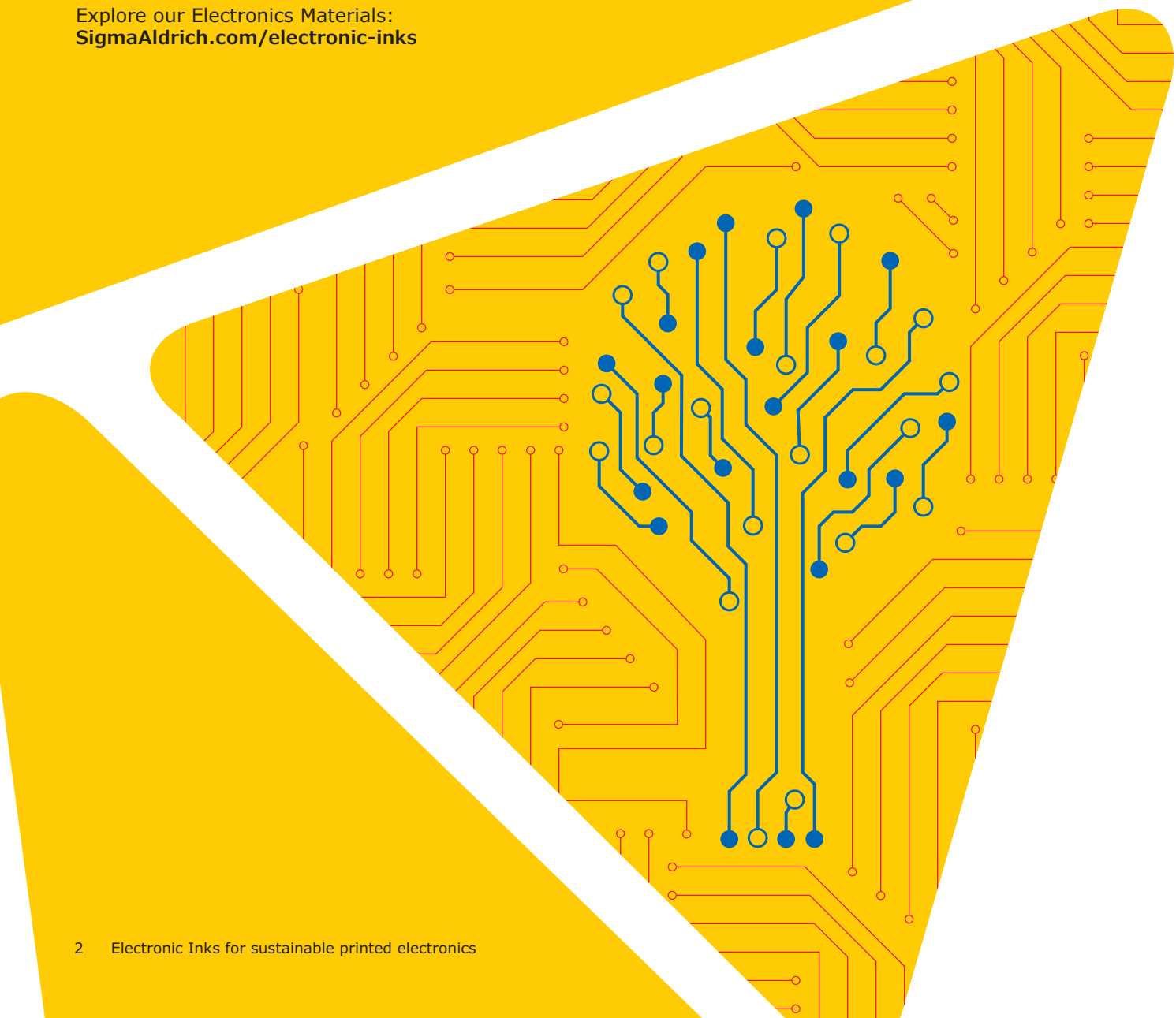
The development of organic-based electronic materials has garnered great interest in flexible electronics applications due to their energy efficiency, small size, low cost, and sustainability. Our portfolio of 'greener' inks provides incomparable performance and economic efficiency with a lower environmental impact.

We offer a wide range of electronic inks for all your applications and technologies:

- Conductive inks
- Semiconductive inks
- Dielectric inks

To complement those, we also have cleaning solutions for your printed electronic inks.

Explore our Electronics Materials:
SigmaAldrich.com/electronic-inks

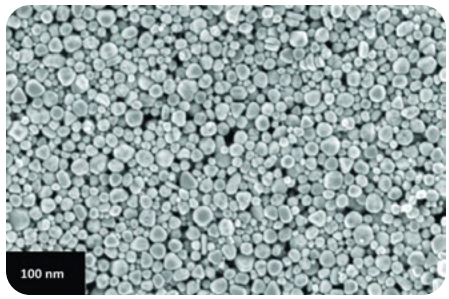


Conductive Inks

We offer a wide range of conductive inks with various viscosities and particle sizes available, encompassing

- Metal nano- and micro- particle inks
- Conducting polymer inks
- Carbon nanomaterial inks

For more information on our conductive inks, visit **SigmaAldrich.com/conductiveink**

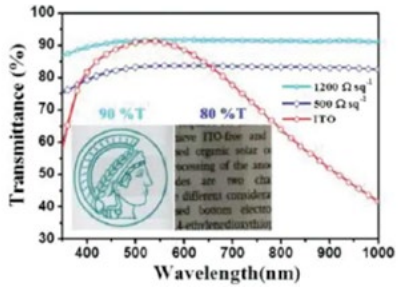


Metal Inks

Name	Concentration	Electrical Properties	Cat. No.
Silver ink, LIFT printable	75 wt. % Silver content	Resistivity (4PP): After laser sintering* ≤ 8 μΩ·cm (≤ 5 bulk) for LIFT printed line (~1-2 μm thick) on plastic substrate	**907669**
Silver nanoparticle ink	30 wt. % dispersion in ethylene glycol	≤20 μΩ-cm (after sintering at 200 °C, 2h) ≤45 μΩ-cm (after sintering at 120 °C, 2h) ≤7 μΩ-cm (after sintering at 240 °C, 4h)	**798738**
	50 wt. % dispersion in tripropylene glycol mono methyl ether	≤20 μΩ-cm (after sintering at 200 °C, 2h) ≤7 μΩ-cm (after sintering at 240 °C, 4h)	**796042**
Silver nano ink, aerosol printable	50 wt. % Silver content	1.8 mΩ/sq, per 25 μm after curing at 150 °C, 1h on glass 1.2 mΩ/sq, per 25 μm after curing at 200 °C, 1h on glass 3 mΩ/sq, per 25 μm after curing at 100 °C, 1h on glass 2.3 mΩ/sq, per 25 μm after curing at 120 °C, 1h on glass	**923559**
Silver nano ink, screen printable, photonically curable	55 ± 5 wt. % Silver content	15.6 mΩ/sq, per 25 μm after curing at 150 °C, 5 min on glass 7.5 mΩ/sq, per 25 μm after curing at 200 °C, 5 min on glass 75 mΩ/sq, per 25 μm after curing at 120 °C, 1h on glass	**923575**
Silver nanoparticles ink for screen printing	55 ± 5 % loading (Nanoparticles loading)	–	**901090**
Conductive nanosilver ink for inkjet printing	18-20%W/W Silver content	–	**907022**
SunTronic® silver nanoparticle ink for inkjet printing	Solid content: 40%	Volume Resistivity: 5-30 8 μΩ·cm	**901971**
Silver nanoparticles ink for inkjet printing	20 ± 1 % loading (Nanoparticles loading)	Resistivity: 1.5 mΩ/sq, per 25 μm (by digital printing using DIMATIX DMP 2800-Cartridge 10 pL, oven curing at 150 °C for 30 min.)	**901083**
Silver nanoparticles ink for spray printing	20 ± 1 % loading (Nanoparticles loading)	Resistivity: 2 mΩ/sq, per 25 μm (coated on PET arcophane AO STS 100 μm using normandy coating, thermal curing at 150 °C for 30 min)	**901089**
SunTronic® conductive silver ink for screen printing	Solid content: 82-85%	Sheet resistivity: <0.010 Ω/sq/mil (150°C/10 min) Volume resistivity: <2.5x10-5 Ω.cm (150°C/30 min)	**901879**
Silver Nanoparticle Pneumatic Aerosol Jet® Ink	63-67 wt. % Silver content (by ash)	Conductivity: ≥1 x 105 Scm-1	**900191**
Silver nano ink, aerosol jet printable	60 wt. % Silver content	–	**908460**
Conductive silver printing ink	Solid content: 75-85%	Volume resistivity: 9-10 μΩ-cm	**791881**
	Solid basis: 75-85%	Volume resistivity: 5-6 μΩ-cm	**791873**
Flexible conductive silver paste for screen printing	Solid content: 44-46%	Volume resistivity: 925 μΩ-cm at 60 °C 527 μΩ-cm at 130 °C	**901769**
Silver/silver chloride (60/40) paste for screen printing		Sheet resistivity: <100 miliohms per square (20 micron thick printed on alumina substrate)	**901773**
Silver, dispersion, for printing on plastic films	30-35 wt. % in triethylene glycol monomethyl ether	spec. resistivity 11 μΩ-cm	**736465**
Silver, dispersion, for printing on polyimide films	50-60 wt. % in tetradecane	spec. resistivity ~ 2.7 μΩ-cm	**736503**
Silver, dispersion, for printing on ITO and glass	50–60 wt. % in tetradecane	spec. resistivity ~ 2.2 μΩ-cm	**736511**
	30–35 wt. % in triethylene glycol monoethyl ether	spec. resistivity ~ 2 μΩ-cm	**736481**
Silver, dispersion	30–35 wt. % in triethylene glycol monomethyl ether	–	**736473**

Metal Inks

Name	Concentration	Electrical Properties	Cat. No.
Silver, conductive paste	≥75%	1–3 x 10–5 Ω-cm (conductive paste) 1.59 µΩ-cm at 20 °C	**735825**
Platinum paste, screen printable	–	–	**791512**
Nano silver inkjet ink, photonically curable, low resistivity	20 ± 1 wt. % Silver content	16.5 2 mΩ/sq, per 25 µm after curing at 150 °C, 5 min on glass 13.5 2 mΩ/sq, per 25 µm after curing at 200 °C, 5 min on glass	**923567**



Polymeric Inks

Name	Decription	Electrical Properties	Cat. No.
Graphene/PEDOT:PSS hybrid ink	dispersion in DMF	500 Ω/sq, 20 nm film: 80% transmittance	**900442**
Molybdenum trioxide/PEDOT:PSS ink	viscosity 3 cP	–	**901047**
Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate)	dry re-dispersible pellets	–	**768618**
	dry re-dispersible pellets, high conductivity	–	**900208**
	1.3 wt % dispersion in H_2O, conductive grade	1 S/cm	**483095**
	2.8 wt % dispersion in H_2O, low-conductivity grade	~1E–5 S/cm	**560596**
	0.8% in H_2O, conductive inkjet ink	110 Ω/sq	**739316**
	1.1% in H_2O, neutral pH, high-conductivity grade	<100 Ω/sq, >70% visible light transmission (40 µm wet)	**739324**
	1.1% in H_2O, surfactant-free, high-conductivity grade	<100 Ω/sq, <80% visible light transmission (40 µm wet)	**739332**
	5.0 wt. %, conductive screen printable ink	≤130 Ω/sq	**768650**
	0.54% in H_2O, high-conductivity grade	<200 Ω/sq, >90% visible light transmission (40 µm wet)	**739340**
	0.5–1 wt. % (PEDOT: PSS in water), high-conductivity grade	<200 Ω/sq (coating : 40µ wet, drying: 6 min 130C)	**900181**
	1.0 wt. % in H_2O, high-conductivity grade	50–120 Ω/sq	**768642**
	3.0–4.0% in H_2O, high-conductivity grade	>200 S/cm	**655201**
Polypyrrole	conductivity 10–50 S/cm (pressed pellet)	10–50 S/cm (pressed pellet)	**577030**
	doped, 5 wt % dispersion in H_2O, conductivity >0.005 S/cm (dried cast film)	>0.005 S/cm (dried cast film)	**482552**
	doped, conductivity 30 S/cm (bulk), extent of labeling: 20 wt. % loading, composite with carbon black	30 S/cm (bulk)	**530573**
	undoped, extent of labeling: ~20 wt. % loading, composite with carbon black	~8.5 S/cm	**577065**
	doped, conductivity 0.5–1.5 S/cm (pressed pellet, typical), extent of labeling: ~5 wt. % loading, coated on titanium dioxide	–	**578177**
	High surface area conducting polypyrrole	–	**912573**
Polypyrrole-block-poly(caprolactone)	0.3–0.7 wt. % (dispersion in nitromethane), contains p-toluenesulfonate as dopant	10–40 S/cm (bulk); 10,000–50,000 Ohms/sq	**735817**

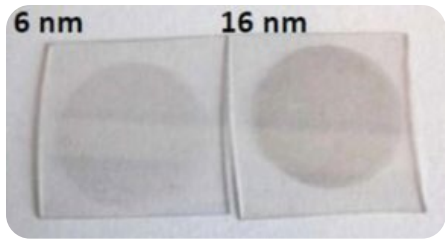
Carbon Nanomaterial Inks

Carbon nanomaterials combine a number of desirable features amenable to a wide range of printed electronics applications.

We offer a wide range of carbon nanomaterial inks, enabling solution processability towards

- Sensors and actuators
- Energy harvesting and storage
- Lighting devices

For more information on our carbon nanomaterial inks, visit **SigmaAldrich.com/graphene**



Graphene Inks

Name	Concentration	Electrical properties	Cat. No.
Graphene dispersion	1 mg/mL (electrochemically exfoliated graphene) in DMF	–	**900450**
Graphene dispersion	≥0.2 mg/mL (electrochemically exfoliated graphene) in DMF	–	**900448**
Graphene ink	2.4 wt. % (solid (graphene and ethyl cellulose) in cyclohexanone/terpineol)	resistivity: 0.003–0.008 Ω-cm (thermally annealed 250 °C for 30 minutes, film thickness >100 nm)	**793663**
Graphene ink	2.2–3.4 wt. % (solid (graphene and ethyl cellulose) in cyclohexanone/terpineol)	resistivity: 0.003–0.008 Ω-cm, thermally annealed 300 °C for 30 minutes, film thickness >100 nm	**900695**
Graphene ink for spin/spray coating photonically annealable	1.8–3.0 wt. % solids	resistivity: 0.003–0.005 Ω-cm, sample prepared by spin-coating at 2000 rpm/30 s for 5 coats, followed by thermal annealing at 300 °C in air for 30 minutes	**900960**
Graphene ink in water	~0.1 wt. % solids in water	sheet resistance: 4k Ω/sq, 80 nm thickness	**808288**
Graphene ink in water	10 wt. % solids in water	sheet resistance: 10 Ω/sq, at 25 µm thickness	**808261**

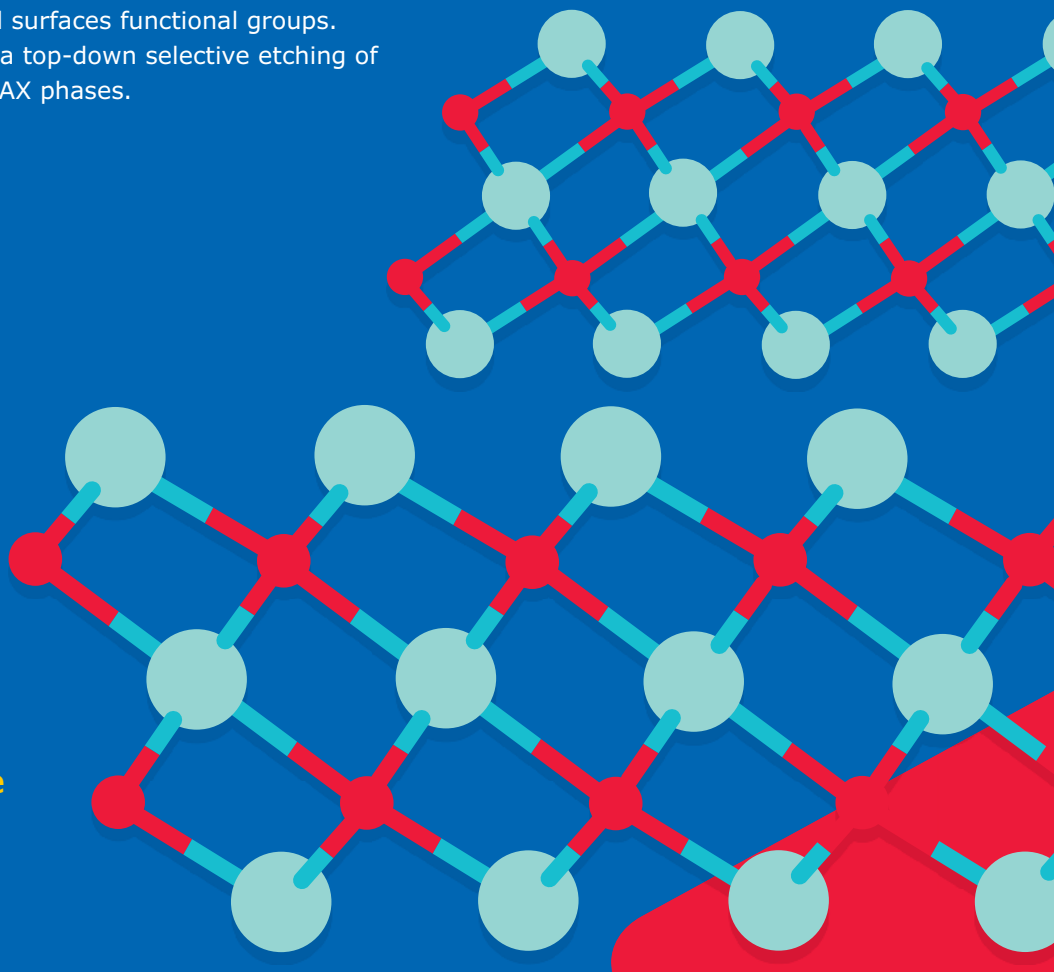
Graphene Oxide-based Materials

Name	Form	Description	Cat. No.
Graphene oxide	paste, non-exfoliated	≥3% C (by gravimetric analysis combined with EA)	**900704**
	4mg/mL dispersion in H_2O	monolayer content (measured in 0.5mg/mL): >95%	**777676**
	2 mg/mL dispersion in H_2O	avg. no. of layers 1	**763705**
	dispersion in 0.05 M HEPES buffer	pH stabilized, pH 7.5	**901940**
	1 mg/mL dispersion in H_2O	avg. no. of layers 15–20	**794341**
Graphene oxide nanocolloids	2 mg/mL dispersion in H_2O	–	**795534**
Graphene oxide, alkylamine functionalized	2.0 mg/mL dispersion in toluene	–	**809055**
Graphene oxide, alkylamine functionalized	1 mg/mL, dispersion in H_2O	–	**791520**
Reduced Graphene oxide	10 mg/mL dispersion in H_2O	stabilized with poly(sodium 4-styrenesulfonate)	**900197**
Mn3O4/reduced graphene oxide nanocomposite	10 mg/mL dispersion in acetone	Thickness: 0.5–1 nm, reduced graphene oxide Loading Density: 30%–70% (Mn3O4 nanocrystal) by TEM Resistance: < 103 Ω/sq (reduced graphene oxide)	**803812**
PtCo/reduced graphene oxide nanocomposite	10 mg/mL dispersion in acetone	Thickness: 1–10 nm, graphene Loading Density: 10%– 50% (PtCo nanocrystal) by TEM Resistance: <103 Ω/sq (graphene)	**803901**

From MAX Phase to MXene

MXene is a promising new family of 2D nanomaterials, consisting of conductive 2D carbides, nitrides, and carbonitrides.

First described by Professor Yury Gogotsi from Drexel University in 2011, MXenes combine both metallic conductivity and hydrophilic nature, due to their hydroxyl or oxygen terminated surfaces functional groups. They typically can be synthesized via top-down selective etching of their layered precursor materials, MAX phases.



MXene offers:

- High solution processability
- High conductivity
- High surface area
- High electrochemical activity

MXene are widely reported in applications such as:

- Conductive electronic devices
- Energy storage devices
- Sensors and biosensors
- Multifunctional composites
- Water purification
- Catalyst

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The life science business of Merck operates as MilliporeSigma in the U.S. and Canada.

Sigma-Aldrich®
Lab & Production Materials

Semiconductor Inks

Our wide range of semiconductive inks at various viscosities and particle size encompasses:

- Semiconductive inorganic inks
- Semiconductive organic inks

For more information on our conductive inks, visit **SigmaAldrich.com/conductiveink**

Semiconductive Inorganic Inks

Name	Concentration	Description	Cat. No.
Boron nitride	0.1–0.5 mg/mL in H_2O	particle size: ≤500 nm	**900710**
	20 mg/mL in H_2O	nanoplatelet	**900417**
Hexagonal boron nitride ink	Solid content = 20–40%	200–450 cP (shear viscosity at 1000 s-1, 25 °C) for blade coating	**901349**
Hexagonal boron nitride ink	Solid content = 4.4–6.4%	6–15 cP (shear viscosity at 1000 s-1, 25 °C) for inkjet printing	**901410**
Molybdenum disulfide	0.1–0.5 mg/mL in H_2O	particle size: ≤500 nm	**900724**
Molybdenum disulfide ink	Solid content = 3.0–3.85%	4–11 mPa.s (shear viscoisty at 1000 s-1, 25 °C) for inkjet printing	**901187**
Molybdenum disulfide ink	Solid Content = 1.5–2.5%	2–4 mPa.s for spin/spray coating	**901867**
Molybdenum disulfide suspension	1 mg/mL in H_2O	50–1000 nm thickness < 3 layers	**901797**
Molybdenum disulfide suspension	5 mg/mL in H_2O	50–1000 nm thickness < 3 layers	**902012**
Molybdenum oxide nanoparticle ink	Solid content = 2.3–2.7wt% crystalline MoO3 in ethanol	1–3 cP	**900151**
Zinc oxide ink for inkjet printing	>=0.9 % loading (Nanoparticles loading)	–	**901091**

Hole Transport Organic Materials (p-type)

Name	Orbital energy	mP	solubility	Purity / Mw	Cat. No.
4,4′-Bis(N-carbazolyl)-1,1′-biphenyl	HOMO 6 eV LUMO 2.9 eV	281–285 °C	–	97%	**660124**
4,4′-Bis(N-carbazolyl)-1,1′-biphenyl	HOMO 6 eV LUMO 2.9 eV	277.9 °C (typical, DSC)	–	sublimed grade, 99.9% trace metals basis	**699195**
N,N′-Bis(3-methylphenyl)-N,N′-diphenylbenzidine, 99%	HOMO 5.5 eV LUMO 2.3 eV	175–177 °C (lit.)	–	99%	**443263**
N,N′-Diphenyl-N,N′-bis-[4-(phenyl-m-tolylamino) phenyl]biphenyl-4,4′-diamine	–		–	95%	**900968**
J51	HOMO -5.29 eV LUMO -3.3 eV	> 200 °C (> 392 °F)	organic solvents: chlorobenzene dichlorobenzene limited solubility in $CHCl_3$	Mw 40,000–80,000 by GPC (PS standard)	**901058**
J61	HOMO -5.22 eV LUMO -3.21 eV	–	organic solvents: chlorobenzene dichlorobenzene limited solubility in $CHCl_3$	Mw 50,000–100,000 by GPC (PS standard)	**901045**
Me-4PACz	HOMO -5.74 eV LUMO -2.49 eV	–	THF	≥99%	**923184**
PBDB-T	HOMO -5.28 eV LUMO -3.48 eV	> 200 °C (> 392 °F)	chlorobenzene dichlorobenzene	Mw >50,000 by GPC (GPC standard: PS)	**901099**
PBDB-T1	HOMO -5.36 eV LUMO -3.43 eV	> 200 °C (> 392 °F)	hot o-dichlorobenzene	Mw 20,000–50,000 (GPC, PS standard)	**901097**

Hole Transport Organic Materials (p-type)

Name	Orbital energy	mP	solubility	Purity / Mw	Cat. No.
PBDTTT-C-T	HOMO -5.11 eV LUMO -3.25 eV	> 200 °C (> 392 °F)	chlorobenzene chloroform dichlorobenzene	Mw 80,000–150,000 (GPC, PS standard)	**901067**
PffBT4T-C9C13	HOMO -5.34 eV LUMO -3.69 eV	–	organic solvents: O-xylene (solubility limit: <18 mg/ml) 1,2,4-trimethylbenzene toluene chlorobenzene Di-chlorobenzene	Mw 35,000–100,000	**900980**
Poly(9,9-dioctylfluorenyl-2,7-diyl) end capped with dimethylphenyl	HOMO -5.3 eV LUMO -2.8 eV	–	chlorobenzene chloroform dichlorobenzene THF	Mw 50,000–150,000 by GPC	**923222**
Poly(9,9-dioctylfluorenyl-2,7-diyl)	HOMO -5.3 eV LUMO -2.8 eV	–	chlorobenzene chloroform dichlorobenzene THF	Mw 50,000–150,000 by GPC	**923214**
Poly(3-hexylthiophene-2,5-diyl)	HOMO 5 eV LUMO 3 eV	238 °C	–	average Mw 50,000–100,000	**445703**
Poly-TPD	HOMO -5.2 eV LUMO -2.4 eV	> 300 °C (> 572 °F)	–	Mw ≥20,000 g/mol	**907065**
PTAA	–	>400 °C	–	average Mn 7,000–10,000 (GPC)	**702471**
PTB7	HOMO -5.15 eV LUMO -3.31 eV	–	chlorobenzene chloroform dichlorobenzene	average Mw 80,000–200,000	**772410**
SHT-263 Solarpur®	HOMO -5.2 eV LUMO -2.3 eV	247 °C	–	≥99.9%	**902500**
SHT-263S Solarpur®	–	247 °C	–	99.90%	**916021**
Silicon Tetrabiphenyl MeOTAD	HOMO -5.34 eV LUMO -2.30 eV	–	–		**924385**
Spiro-MeOTAD	HOMO 5.2 eV	243–248 °C	–	99% (HPLC)	**792071**
2,4-spiro-OMeTAD, >=99% (HPLC)	HOMO -5.24 eV LUMO -2.08 eV	–	chloroform	≥99% (HPLC)	**923230**
Spiro-TTB	HOMO 5.2 eV LUMO 1.9 eV	–	THF	≥99% (HPLC)	**923192**
TFB	–	> 300 °C (> 572 °F)	–	average Mw >30,000 by GPC	**901101**
1,3,5-Tris(diphenylamino) benzene	–	252–256 °C	–	97%	**663247**

Electron Transport Organic Materials (n-type)

Name	Orbital energy	mP	Purity / Mw	Cat. No.
3TPYMB	–	–	≥98%, sublimed	**900953**
B3PYMPM	–	> 150 °C (> 302 °F)	≥99% sublimed	**900958**
Bathocuproine	HOMO 7 eV LUMO 3.5 eV	279–283 °C (lit.)	96%	**140910**
Bathocuproine	HOMO 7 eV LUMO 3.5 eV	279–283 °C (lit.); 285 °C (DSC)	sublimed grade, 99.99% trace metals basis	**699152**
BPy-TP2	–	334 °C (633 °F)	≥99% sublimed	**900939**
Liq	–	363–368 °C (685–694 °F)	>99.5% (sublimed, HPLC)	**900928**
TBPe	–		99% (sublimed, HPLC)	**900937**
PFN-Br	–	> 200 °C (> 392 °F)	Mw 30,000–50,000 by GPC	**906980**

Dielectric Polymers

Polymers are gaining prominence as dielectric materials, due to being lightweight, inexpensive, and easy to process and manufacture. Polymer dielectrics with both low and high dielectric constants have a wide range of applications in the electronics industry.

- A low dielectric constant makes the material suitable for electrical insulation applications.
- High dielectric constant polymer materials are employed as polarizable media and facilitating the propagation or reflection of electromagnetic waves within capacitor devices, in other devices such as piezoelectric transducers, dielectric amplifiers or rectifiers, and memory elements in semiconductor circuits.

For more information on our conductive inks, visit
SigmaAldrich.com/conductiveink

Dielectric Polymers

Name	Viscosity	Cat. No.
Polymer dielectric grey for screen printing	12.0–16.0 Pa.s (Haake RS1 C20/2° TiL at 230 sec-1 at 25 °C)	**902497**
SunTronic® UV curing jettable insulator for low-K dielectric applications	11–13 cP (at jetting temperature)	**901974**
Poly(4-vinylphenol), average Mw ~25,000	intrinsic viscosity parameters α=0.50, k=9.71 × 10−4	**436224**
Poly(4-vinylphenol-co-methyl methacrylate), average Mw 8.000–12,000 Da	solid	**474576**

Cleaning Solutions

We offer cleaning solutions to clean screen printing or inkjet printing, as well as bio-sourced acetone and IPA substitutes to clean your substrates.

Cleaning Solutions

product name	Initial Boiling Point	evaporation rate	DOZn symbol	Cat. No.
Cleaning solution for Ag ink	37.5 °C (flash point)	–	–	**910643**
Cleaning solution for screen printing Ag ink	189.6 °C	–	–	**923540**
ElectroGreen™, acetone substitute for electronics, bio-sourced	160 °F	2.84	YES, bio-sourced	**929670**
ElectroGreen™, isopropyl alcohol substitute for electronics, bio-based	170 °F	1.2	YES, bio-sourced	**929654**

MERCK

FlexAbility!

Our wide range of printed electronic products, from inks to substrates, enable your creation to come alive. We offer printable inks at various viscosities and particle size, and flexible/rigid substrates with various sizes and thicknesses.

- **Conductive Inks**
  - Metal nano- and micro- particle inks
  - Conducting polymer inks
  - Carbon nanomaterial inks
- **Semiconductor Inks**
  - Inorganic metal oxide ink
  - Organic semiconductor inks
  - 2D nanomaterial inks
- **Dielectric Inks**
  - Organic insulating inks
  - Insulating 2D nanomaterials
  - Insulating oxide inks
- **Substrates**
  - Indium Tin Oxide (ITO)
  - Fluorine-doped Tin Oxide (FTO)
  - Gold
  - Graphene
  - Silicon wafers
  - Interdigitated substrates

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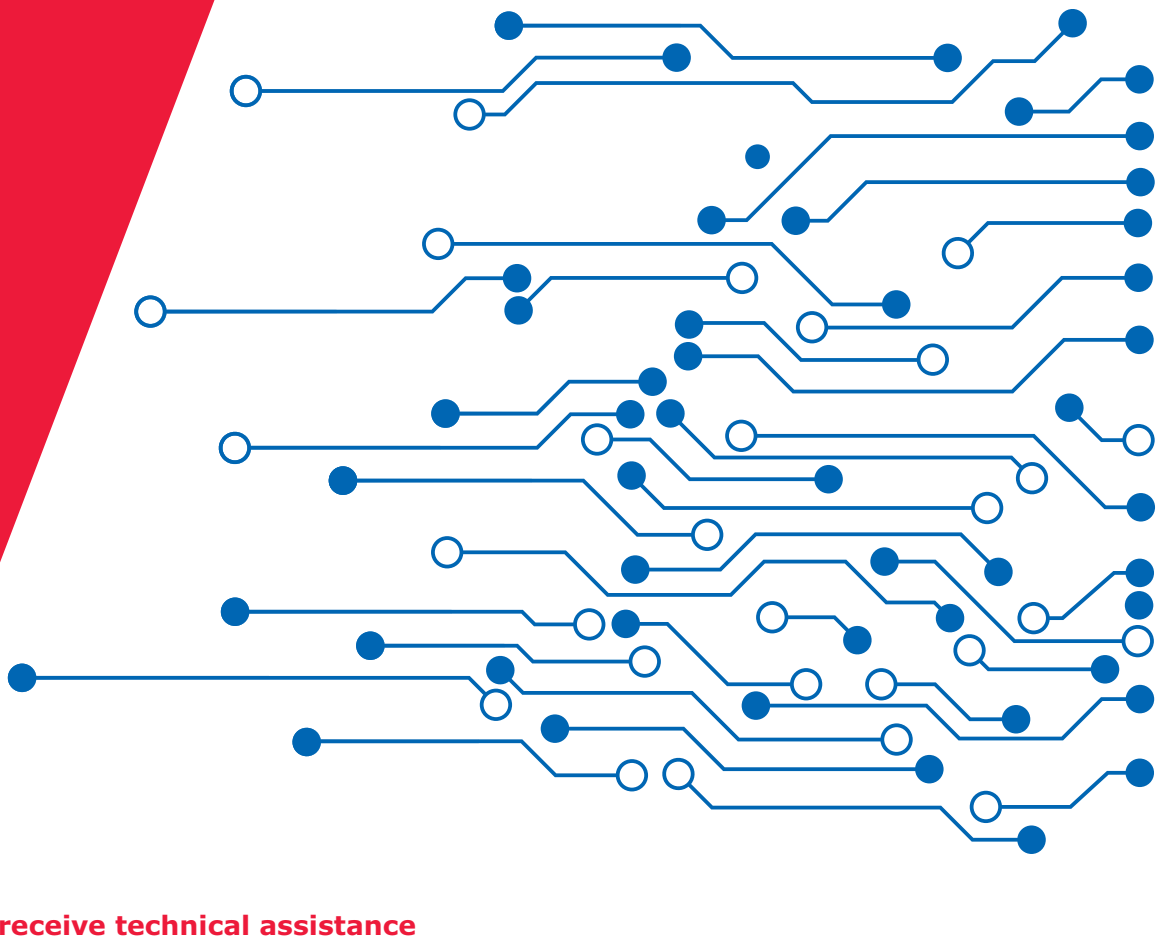

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