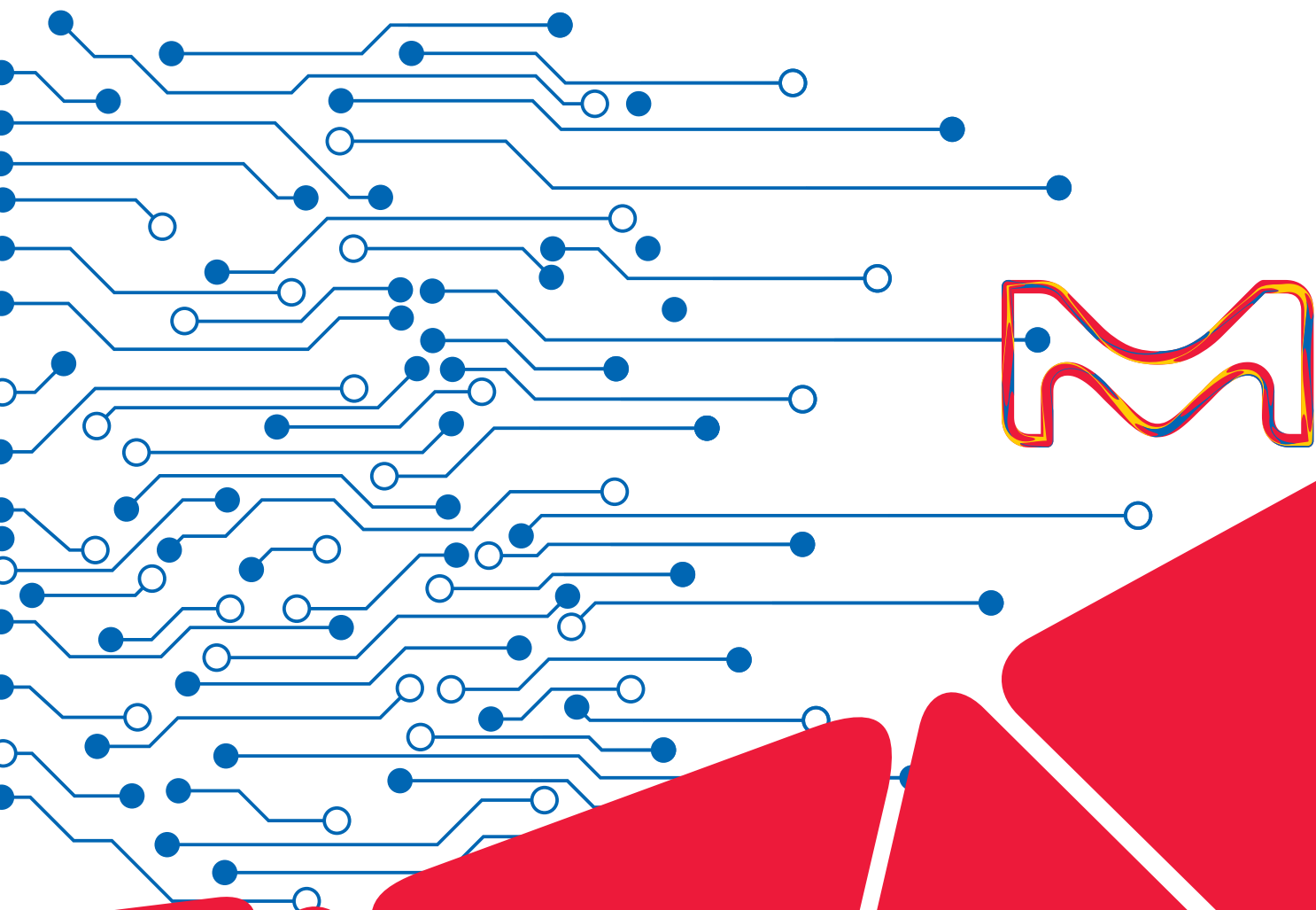


Electronic INKS

For sustainable printed electronics



MilliporeSigma is
the U.S. and Canada
Life Science business
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Sigma-Aldrich®
Lab & Production Materials

Maximize Performance with Our Electronic Inks

While minimizing your environmental
footprint with printable materials

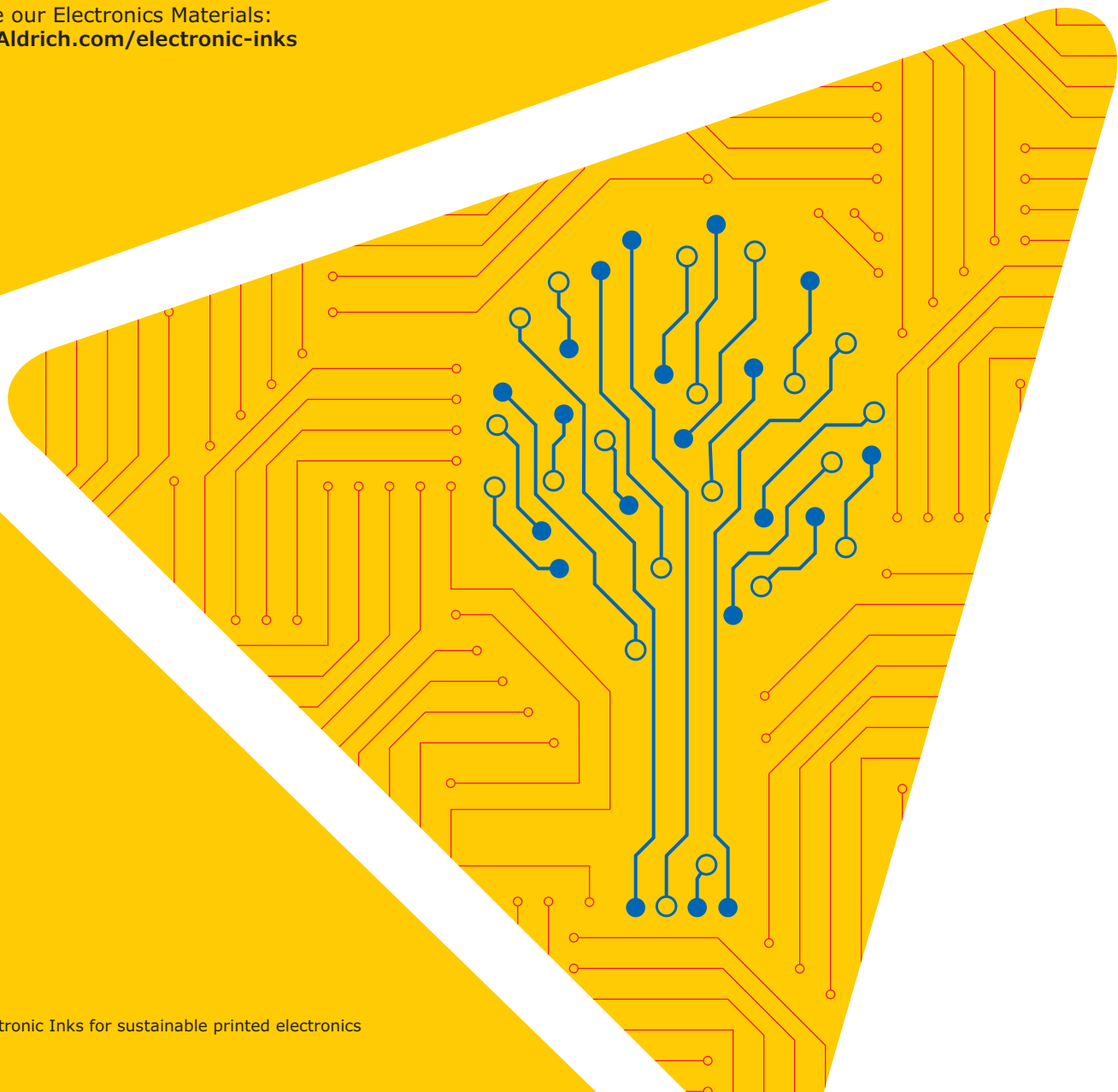
The development of organic-based electronic materials has garnered great interest in flexible electronics applications due to their energy efficiency, small size, low cost, and sustainability. Our portfolio of 'greener' inks provides incomparable performance and economic efficiency with a lower environmental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

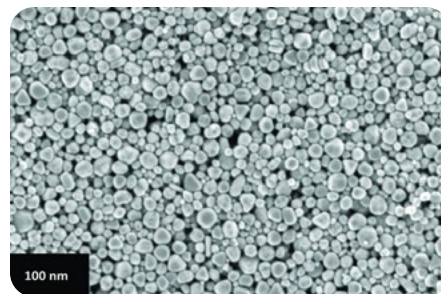


Conductive Inks

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* $\leq 8 \mu\Omega\cdot\text{cm}$ (≤ 5 bulk) for LIFT printed line ($\sim 1\text{-}2 \mu\text{m}$ thick) on plastic substrate	907669
Silver nanoparticle ink	30 wt. % dispersion in ethylene glycol	$\leq 20 \mu\Omega\cdot\text{cm}$ (after sintering at 200 °C, 2h) $\leq 45 \mu\Omega\cdot\text{cm}$ (after sintering at 120 °C, 2h) $\leq 7 \mu\Omega\cdot\text{cm}$ (after sintering at 240 °C, 4h)	798738
	50 wt. % dispersion in tripropylene glycol mono methyl ether	$\leq 20 \mu\Omega\cdot\text{cm}$ (after sintering at 200 °C, 2h) $\leq 7 \mu\Omega\cdot\text{cm}$ (after sintering at 240 °C, 4h)	796042
Silver nano ink, aerosol printable	50 wt. % Silver content	1.8 m Ω /sq, per 25 μm after curing at 150 °C, 1h on glass 1.2 m Ω /sq, per 25 μm after curing at 200 °C, 1h on glass 3 m Ω /sq, per 25 μm after curing at 100 °C, 1h on glass 2.3 m Ω /sq, per 25 μm after curing at 120 °C, 1h on glass	923559
Silver nano ink, screen printable, photonically curable	55 \pm 5 wt. % Silver content	15.6 m Ω /sq, per 25 μm after curing at 150 °C, 5 min on glass 7.5 m Ω /sq, per 25 μm after curing at 200 °C, 5 min on glass 75 m Ω /sq, per 25 μm after curing at 120 °C, 1h on glass	923575
Silver nanoparticles ink for screen printing	55 \pm 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 $\mu\Omega\cdot\text{cm}$	901971
Silver nanoparticles ink for inkjet printing	20 \pm 1 % loading (Nanoparticles loading)	Resistivity: 1.5 m Ω /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 \pm 1 % loading (Nanoparticles loading)	Resistivity: 2 m Ω /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 $\Omega\cdot\text{cm}$ (150°C/30 min)	901879
Silver Nanoparticle Pneumatic Aerosol Jet® Ink	63-67 wt. % Silver content (by ash)	Conductivity: $\geq 1 \times 10^5 \text{ Scm}^{-1}$	900191
Silver nano ink, aerosol jet printable	60 wt. % Silver content	-	908460
Conductive silver printing ink	Solid content: 75-85%	Volume resistivity: 9-10 $\mu\Omega\cdot\text{cm}$	791881
	Solid basis: 75-85%	Volume resistivity: 5-6 $\mu\Omega\cdot\text{cm}$	791873
Flexible conductive silver paste for screen printing	Solid content: 44-46%	Volume resistivity: 925 $\mu\Omega\cdot\text{cm}$ at 60 °C 527 $\mu\Omega\cdot\text{cm}$ 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 $\mu\Omega\cdot\text{cm}$	736465
Silver, dispersion, for printing on polyimide films	50-60 wt. % in tetradecane	spec. resistivity $\sim 2.7 \mu\Omega\cdot\text{cm}$	736503
Silver, dispersion, for printing on ITO and glass	50-60 wt. % in tetradecane	spec. resistivity $\sim 2.2 \mu\Omega\cdot\text{cm}$	736511
	30-35 wt. % in triethylene glycol monoethyl ether	spec. resistivity $\sim 2 \mu\Omega\cdot\text{cm}$	736481
Silver, dispersion	30-35 wt. % in triethylene glycol monomethyl ether	-	736473

Metal Inks

Name	Concentration	Electrical Properties	Cat. No.
Silver, conductive paste	≥75%	$1-3 \times 10^{-5} \Omega\text{-cm}$ (conductive paste) $1.59 \mu\Omega\text{-cm}$ at 20 °C	735825
Platinum paste, screen printable	-	-	791512
Nano silver inkjet ink, photonicallly 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

Accelerate your RESEARCH

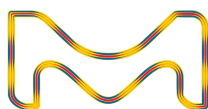
Graphene and Carbon Nanomaterials

We strive to be the first to bring the latest graphene products to market to help accelerate your research.

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- Graphene Nanocomposites
- Graphene Oxide and Reduced Graphene Oxide
- Carbon Nanotubes and Nanohorns
- Fullerenes

For a complete list visit:

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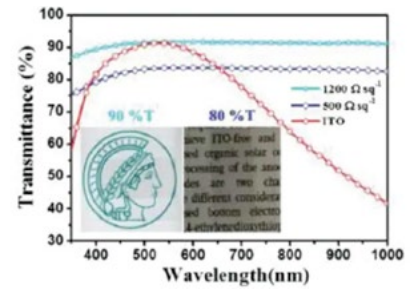
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Polymeric Inks

Name	Description	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 ₂ O, conductive grade	1 S/cm	483095
	2.8 wt % dispersion in H ₂ O, low-conductivity grade	~1E-5 S/cm	560596
	0.8% in H ₂ O, conductive inkjet ink	110 Ω /sq	739316
	1.1% in H ₂ O, neutral pH, high-conductivity grade	<100 Ω /sq, >70% visible light transmission (40 μ m wet)	739324
	1.1% in H ₂ O, surfactant-free, high-conductivity grade	<100 Ω /sq, <80% visible light transmission (40 μ m wet)	739332
	5.0 wt. %, conductive screen printable ink	\leq 130 Ω /sq	768650
	0.54% in H ₂ O, high-conductivity grade	<200 Ω /sq, >90% visible light transmission (40 μ m wet)	739340
	0.5-1 wt. % (PEDOT: PSS in water), high-conductivity grade	<200 Ω /sq (coating : 40 μ wet, drying: 6 min 130C)	900181
1.0 wt. % in H ₂ O, high-conductivity grade	50-120 Ω /sq	768642	
3.0-4.0% in H ₂ O, 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 ₂ O, 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

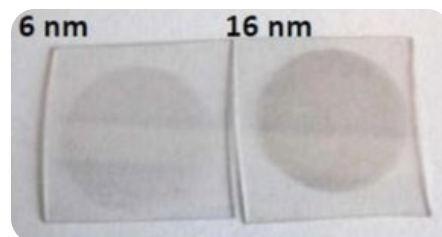
Carbon Nanomaterial Inks

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 photonicallly 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 ₂ O	monolayer content (measured in 0.5mg/mL): >95%	777676
	2 mg/mL dispersion in H ₂ O	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 ₂ O	avg. no. of layers 15–20	794341
Graphene oxide nanocolloids	2 mg/mL dispersion in H ₂ O	-	795534
Graphene oxide, alkylamine functionalized	2.0 mg/mL dispersion in toluene	-	809055
Graphene oxide, alkylamine functionalized	1 mg/mL, dispersion in H ₂ O	-	791520
Reduced Graphene oxide	10 mg/mL dispersion in H ₂ O	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

[SigmaAldrich.com/mxene](https://www.sigmaaldrich.com/mxene)



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Semiconductor Inks

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

- Semiconductive inorganic inks
- Semiconductive organic inks

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Semiconductive Inorganic Inks

Name	Concentration	Description	Cat. No.
Boron nitride	0.1–0.5 mg/mL in H ₂ O	particle size: ≤500 nm	900710
	20 mg/mL in H ₂ O	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 ₂ O	particle size: ≤500 nm	900724
Molybdenum disulfide ink	Solid content = 3.0–3.85%	4–11 mPa.s (shear viscosity 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 ₂ O	50–1000 nm thickness < 3 layers	901797
Molybdenum disulfide suspension	5 mg/mL in H ₂ O	50–1000 nm thickness < 3 layers	902012
Molybdenum oxide nanoparticle ink	Solid content = 2.3–2.7wt% crystalline MoO ₃ 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

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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.

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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 $a=0.50$, $k=9.71 \times 10^{-4}$	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

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**

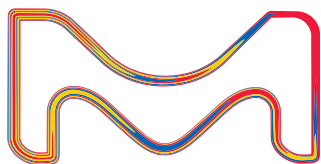
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- Insulating 2D nanomaterials
- Insulating oxide inks

- **Substrates**

- Indium Tin Oxide (ITO)
- Fluorine-doped Tin Oxide (FTO)
- Gold
- Graphene
- Silicon wafers
- Interdigitated substrates



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