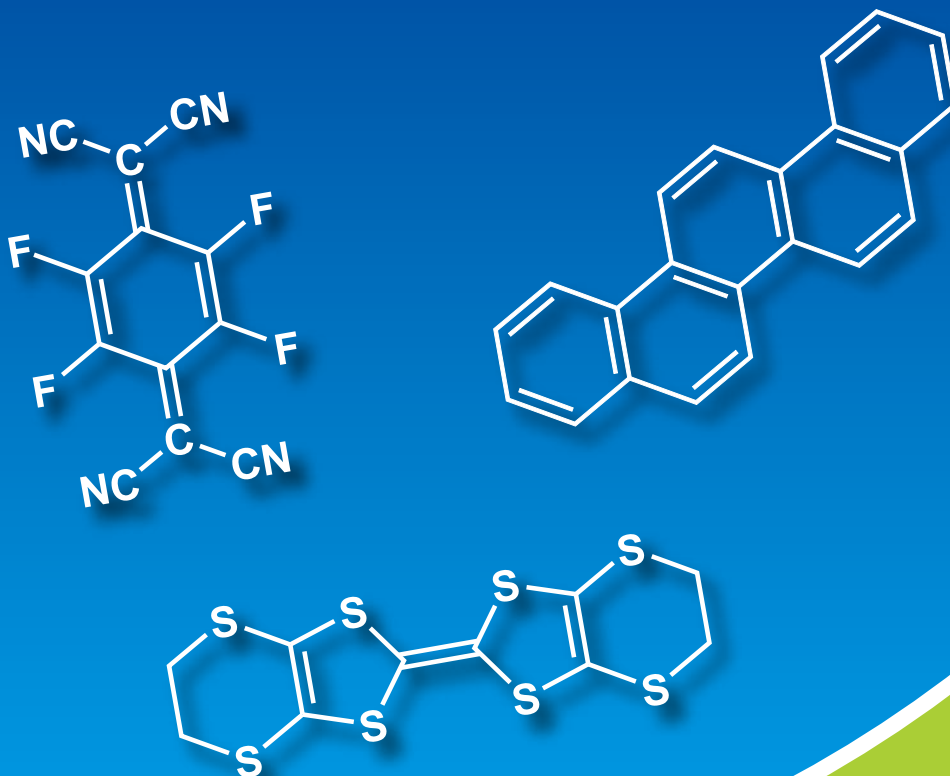


# Molecular Conductors



Acceptor Molecules

Donor Molecules

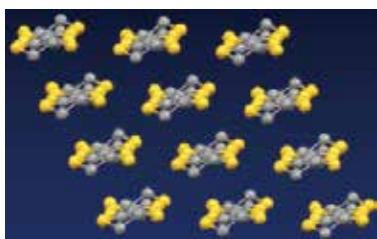
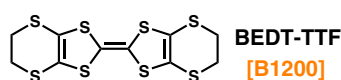
Electrocrystallization Supporting Electrolytes

Tetrathiafulvalene (TTF) Precursors

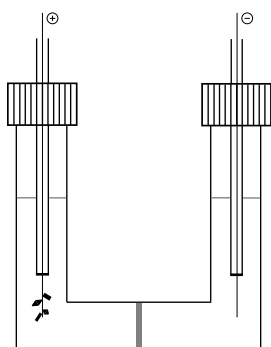
# Molecular Conductors

A molecular conductor is an electrical conductor based on a molecular component. A chemical modification of the molecule can control the electronic structure and physical properties. We can synthesize an opened-shell molecular conductor by chemical or electrochemical doping of a carrier, although an organic molecule is usually an insulator with a closed-shell structure. The first example of an organic conductor was observed from a bromine-doped perylene.<sup>1)</sup> After this observation, a molecular conductor based on tetrathiafulvalene (TTF) was reported in the 1970s,<sup>2)</sup> and the first case of an organic molecular superconductor was observed from the organic salt of tetraselenafulvalene, (TMTSF)<sub>2</sub>X in the 1980s.<sup>3)</sup> These TTF and TMTSF salts form a one-dimensional or pseudo one-dimensional molecular arrangement. On the other hand, bis(ethylenedithio) tetrathiafulvalene (BEDT-TTF) favors forming a two-dimensional molecular arrangement, which is a relatively stable molecular metal toward temperature.<sup>4-6)</sup>

Conducting salts of TTF derivatives can be normally obtained by an electrochemical oxidation (electrocrystallization).<sup>7)</sup> These TTF derivatives can function as donor molecules with a hole carrier. Metal dithiolene complexes (M(dmit)<sub>2</sub>), 7,7,8,8-Tetracyanoquinodimethane (TCNQ) and fullerene (C<sub>60</sub>) are acceptor molecules with an electron carrier. An M(dmit)<sub>2</sub> salt produced the first example of an acceptor-based organic superconductor.<sup>8)</sup> Chemical modifications of the M(dmit)<sub>2</sub> salt produced plenty of those organic superconductors by changing the central metal atom and counter cation.<sup>9)</sup>



Molecular arrangement of BEDT-TTF salt ( $\beta$ -form)



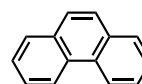
Electrocrystallization

Several alkali-doped nanocarbon and nanographene compounds have shown superconductivity. It is well known that rubidium- and cesium-doped fullerenes have demonstrated superconductivity at more than 30 K.<sup>10)</sup> Recently, superconductivity of Cs<sub>3</sub>C<sub>60</sub> at 38 K was reported.<sup>11)</sup> Although the molecular conductors synthesized from TTF and M(dmit)<sub>2</sub> exhibit low-dimensional molecular arrangements, these fullerene salts can form three-dimensionality.<sup>12)</sup> Kubozono *et al.* reported that an alkali-doped picene demonstrated superconductivity at 18 K.<sup>13)</sup> This result indicates that one can observe superconductivity from a planar nanocarbon material as well. In addition to the picene-based superconductor, an alkali-doped phenanthrene ( $T_c = 5$  K),<sup>14)</sup> alkali-doped coronene ( $T_c = 15$  K),<sup>15)</sup> and alkali-doped 1,2:8,9-dibenzopentacene ( $T_c = 33$  K)<sup>16)</sup> have also shown superconductivity.

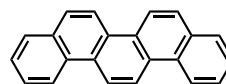
## Superconducting materials by alkali metal doping



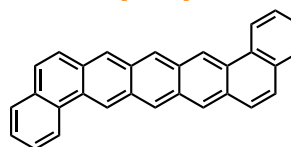
**C<sub>60</sub>**  
[B1660][B1641]



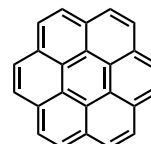
**Phenanthrene**  
[P0079]



**Picene**  
[P2207]



**1,2:8,9-Dibenzopentacene**  
[D1311]



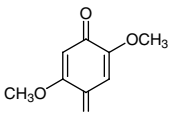
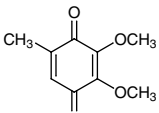
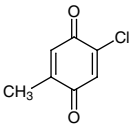
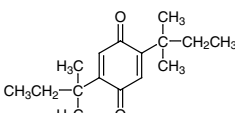
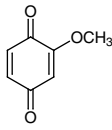
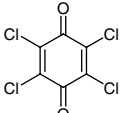
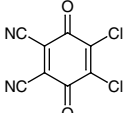
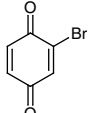
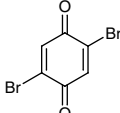
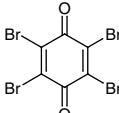
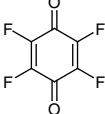
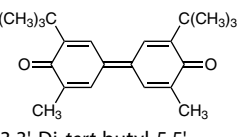
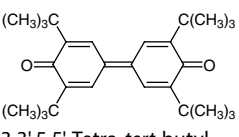
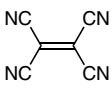
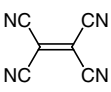
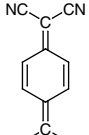
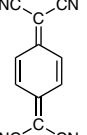
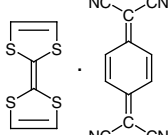
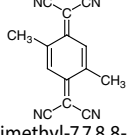
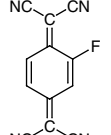
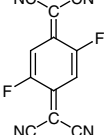
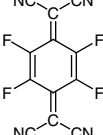
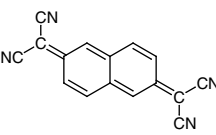
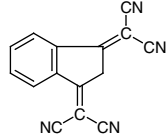
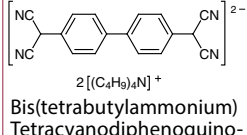
**Coronene**  
[C0386][C1961]

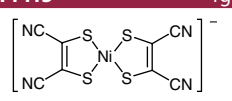
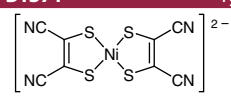
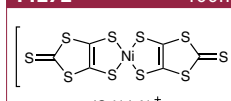
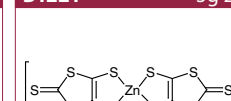
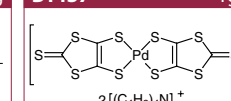
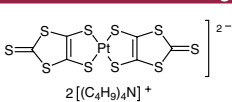
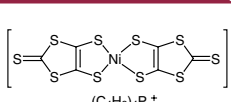
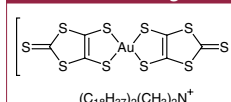
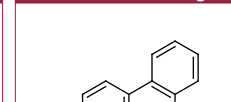
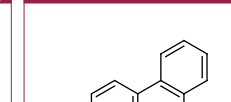
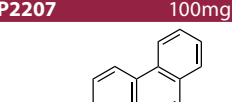
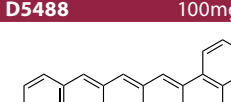
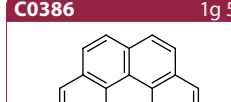
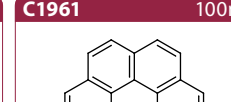

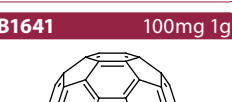
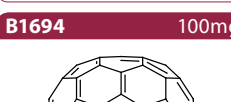
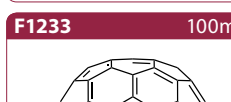


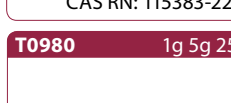

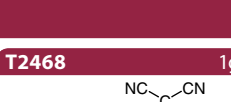
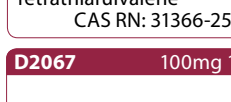
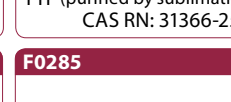
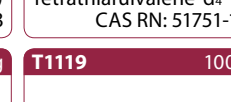
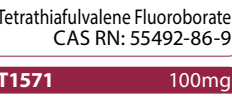
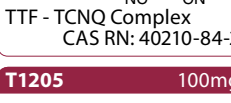
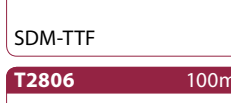
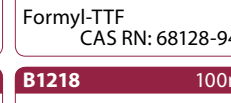
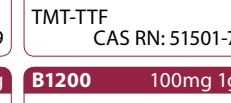

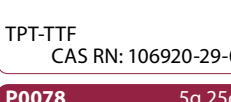
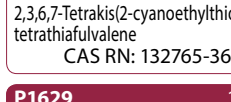


## References

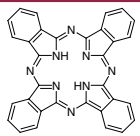
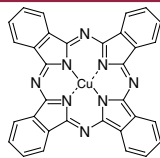
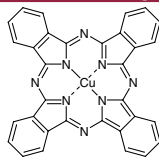
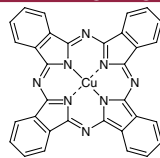
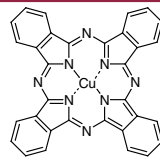
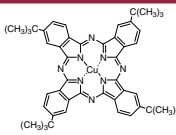
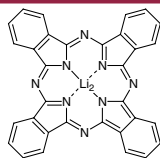
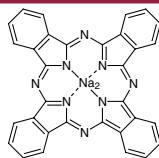
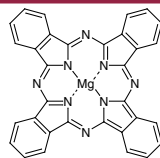
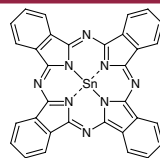
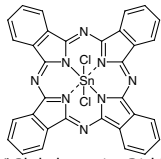
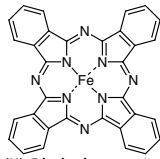
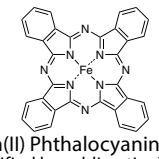
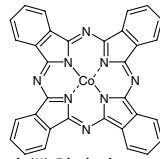
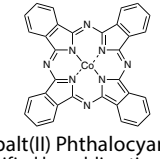
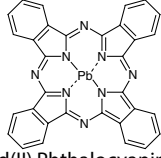
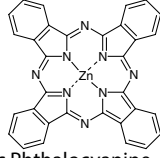
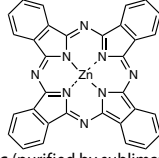
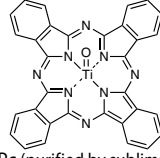
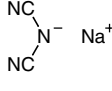
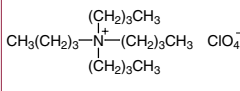
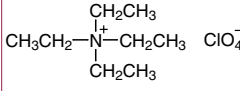
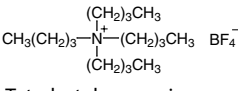
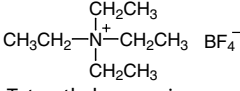
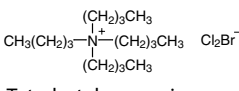
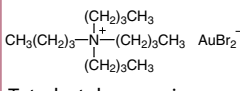
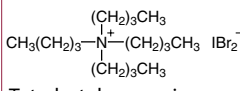
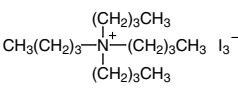
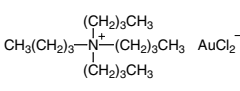
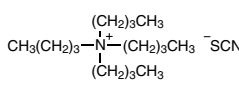
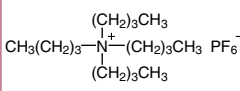
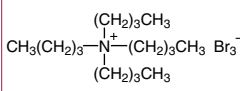
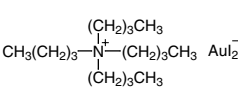
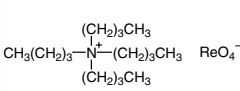
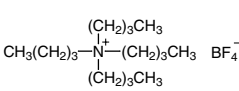
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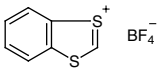
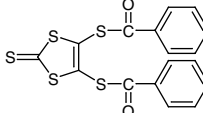
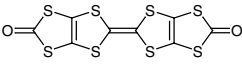
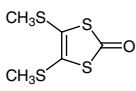
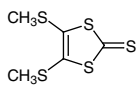
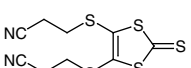
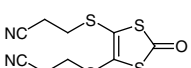
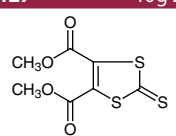

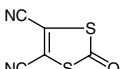
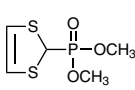
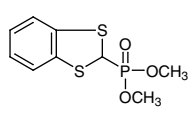
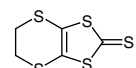
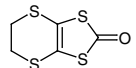
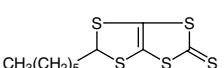
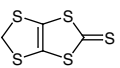
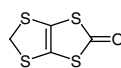
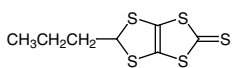
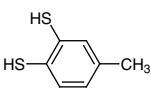
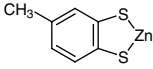
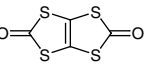
## Acceptor Molecules

<b>D2250</b> 5g 25g  2,5-Dimethoxy-1,4-benzoquinone CAS RN: 3117-03-1	<b>D1956</b> 1g 5g  Coenzyme Qo CAS RN: 605-94-7	<b>C1336</b> 5g  2-Chloro-5-methyl-1,4-benzoquinone CAS RN: 19832-87-2	<b>D2152</b> 5g  2,5-Di-tert-amylbenzoquinone CAS RN: 4584-63-8	<b>M1045</b> 1g 5g  Methoxybenzoquinone CAS RN: 2880-58-2
<b>T0061</b> 25g 500g  Chloranil CAS RN: 118-75-2	<b>D1070</b> 25g 250g  DDQ CAS RN: 84-58-2	<b>B1601</b> 1g 5g  2-Bromo-1,4-benzoquinone CAS RN: 3958-82-5	<b>D2249</b> 1g 5g  2,5-Dibromo-1,4-benzoquinone CAS RN: 1633-14-3	<b>T0617</b> 5g 25g  Bromanil CAS RN: 488-48-2
<b>T0790</b> 1g 5g  Fluoranil CAS RN: 527-21-9	<b>D4407</b> 1g  3,3'-Di-tert-butyl-5,5'-dimethyldiphenylquinone CAS RN: 2417-00-7	<b>T1503</b> 1g  3,3',5,5'-Tetra-tert-butyl-4,4'-diphenylquinone CAS RN: 2455-14-3	<b>T3264</b> 1g 5g  TCNE (purified by sublimation) CAS RN: 670-54-2	<b>T0077</b> 5g 25g  Tetracyanoethylene CAS RN: 670-54-2
<b>T0078</b> 5g 25g  TCNQ CAS RN: 1518-16-7	<b>T3034</b> 1g 5g  TCNQ (purified by sublimation) CAS RN: 1518-16-7	<b>T2468</b> 1g  TTF - TCNQ Complex CAS RN: 40210-84-2	<b>D2021</b> 100mg 500mg  2,5-Dimethyl-7,7,8,8-tetracyanoquinodimethane CAS RN: 1487-82-7	<b>F0509</b> 100mg  FTCNQ CAS RN: 69857-37-0
<b>D3200</b> 100mg  2,5-TCNQF <sub>2</sub> CAS RN: 73318-02-2	<b>T1131</b> 100mg 1g  F <sub>4</sub> TCNQ (purified by sublimation) CAS RN: 29261-33-4	<b>T1246</b> 100mg  TCNNO CAS RN: 6251-01-0	<b>B1416</b> 1g 5g  1,3-Bis(dicyanomethylidene)indan CAS RN: 38172-19-9	<b>B1466</b> 100mg  Bis(tetrabutylammonium) Tetracyanodiphenylquinodimethane CAS RN: 68271-98-7

<p><b>T1415</b> 1g</p>  <p>(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N<sup>+</sup> Tetrabutylammonium Bis(maleonitriledithiolato)- nickel(III) Complex CAS RN: 6251-01-0</p>	<p><b>B1371</b> 1g</p>  <p>2[(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N]<sup>+</sup> Bis(tetrabutylammonium) Bis(maleonitriledithiolato)- nickel(II) Complex CAS RN: 18958-57-1</p>	<p><b>T1272</b> 100mg</p>  <p>(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N<sup>+</sup> Tetrabutylammonium Bis(1,3-dithiole-2-thione-4,5- dithiolato)nickel(III) Complex CAS RN: 68401-88-7</p>	<p><b>B1221</b> 5g 25g</p>  <p>2[(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N]<sup>+</sup> BTBA-BDTD Zn Complex CAS RN: 68449-38-7</p>	<p><b>B1437</b> 1g 5g</p>  <p>2[(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N]<sup>+</sup> Bis(tetrabutylammonium) Bis(1,3-dithiole-2-thione- 4,5-dithiolato)palladium(II) CAS RN: 72688-90-5</p>
<p><b>B1438</b> 100mg</p>  <p>2[(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>N]<sup>+</sup> Bis(tetrabutylammonium) Bis(1,3-dithiole-2-thione- 4,5-dithiolato)platinum(II) CAS RN: 72688-91-6</p>	<p><b>T1416</b> 1g</p>  <p>(C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>P<sup>+</sup> Tetrabutylphosphonium Bis(1,3-dithiole-2-thione-4,5- dithiolato)nickel(III) Complex CAS RN: 105029-70-7</p>	<p><b>D2134</b> 100mg 500mg</p>  <p>(C<sub>18</sub>H<sub>37</sub>)<sub>2</sub>(CH<sub>3</sub>)<sub>2</sub>N<sup>+</sup> Dioctadecyldimethylammonium Bis(1,3-dithiole-2-thione- 4,5-dithiolato)aurate(III) CAS RN: 120141-26-6</p>	<p><b>P0079</b> 25g 500g</p>  <p>Phenanthrene CAS RN: 85-01-8</p>	<p><b>P0331</b> 1sample</p>  <p>Phenanthrene Zone Refined (number of passes:30) CAS RN: 85-01-8</p>
<p><b>P2207</b> 100mg</p>  <p>Picene (purified by sublimation) (&gt;99.9%) CAS RN: 213-46-7</p>	<p><b>D5488</b> 100mg</p>  <p>Dibenzo[a,h]pentacene CAS RN: 227-09-8</p>	<p><b>C0386</b> 1g 5g</p>  <p>Coronene CAS RN: 191-07-1</p>	<p><b>C1961</b> 100mg</p>  <p>Coronene (purified by sublimation) CAS RN: 191-07-1</p>	<p><b>B1660</b> 100mg 1g</p>  <p>Fullerene C<sub>60</sub> CAS RN: 99685-96-8</p>
<p><b>B1641</b> 100mg 1g</p>  <p>Fullerene C<sub>60</sub> (pure) CAS RN: 99685-96-8</p>	<p><b>B1694</b> 100mg</p>  <p>Fullerene C<sub>70</sub> CAS RN: 115383-22-7</p>	<p><b>F1233</b> 100mg</p>  <p>Fullerene C<sub>70</sub> [for organic electronics] CAS RN: 115383-22-7</p>	<div style="background-color: #800000; color: white; padding: 20px; text-align: center;"> <h2>Donor Molecules</h2> </div>	
<p><b>T0980</b> 1g 5g 25g</p>  <p>Tetrathiafulvalene CAS RN: 31366-25-3</p>	<p><b>T3380</b> 200mg 1g</p>  <p>TTF (purified by sublimation) CAS RN: 31366-25-3</p>	<p><b>T1377</b> 100mg</p>  <p>Tetrathiafulvalene-d<sub>4</sub> CAS RN: 51751-16-7</p>		
<p><b>T1282</b> 1g</p>  <p>Tetrathiafulvalene Fluoroborate CAS RN: 55492-86-9</p>	<p><b>T2468</b> 1g</p>  <p>TTF - TCNQ Complex CAS RN: 40210-84-2</p>	<p><b>D2067</b> 100mg 1g</p>  <p>SDM-TTF</p>	<p><b>F0285</b> 1g</p>  <p>Formyl-TTF CAS RN: 68128-94-9</p>	<p><b>T1119</b> 100mg</p>  <p>TMT-TTF CAS RN: 51501-77-0</p>
<p><b>T1571</b> 100mg</p>  <p>TET-TTF CAS RN: 104515-79-9</p>	<p><b>T1205</b> 100mg</p>  <p>TPT-TTF CAS RN: 106920-29-0</p>	<p><b>T2806</b> 100mg</p>  <p>2,3,6,7-Tetrakis(2-cyanoethylthio)- tetrathiafulvalene CAS RN: 132765-36-7</p>	<p><b>B1218</b> 100mg</p>  <p>BMDT-TTF CAS RN: 68550-20-9</p>	<p><b>B1200</b> 100mg 1g 5g</p>  <p>BEDT-TTF CAS RN: 66946-48-3</p>
<p><b>B1244</b> 100mg</p>  <p>B PDT-TTF CAS RN: 66946-49-4</p>	<p><b>P0078</b> 5g 25g</p>  <p>Perylene CAS RN: 198-55-0</p>	<p><b>P1629</b> 1g</p>  <p>Perylene (purified by sublimation) CAS RN: 198-55-0</p>	<p><b>T1221</b> 5g 25g</p>  <p>TDAE CAS RN: 996-70-3</p>	<p><b>P0355</b> 25g</p>  <p>Phthalocyanine CAS RN: 574-93-6</p>

<p><b>P1795</b> 1g</p>  <p>Phthalocyanine (purified by sublimation) CAS RN: 574-93-6</p>	<p><b>P0655</b> 25g</p>  <p>Pigment Blue 15 CAS RN: 147-14-8</p>	<p><b>P1005</b> 25g 250g</p>  <p>CuPc (<math>\alpha</math>-form) CAS RN: 147-14-8</p>	<p><b>P1006</b> 25g 100g 500g</p>  <p>CuPc (<math>\beta</math>-form) CAS RN: 147-14-8</p>	<p><b>P1628</b> 1g</p>  <p>CuPc (purified by sublimation) CAS RN: 147-14-8</p>
<p><b>T1256</b> 100mg</p>  <p>Copper(II) 2,9,16,23-Tetra-tert-butylphthalocyanine CAS RN: 39001-64-4</p>	<p><b>P1049</b> 1g 5g</p>  <p>Dilithium Phthalocyanine CAS RN: 25510-41-2</p>	<p><b>P0973</b> 1g 5g</p>  <p>Disodium Phthalocyanine CAS RN: 25476-27-1</p>	<p><b>P1018</b> 1g</p>  <p>Magnesium(II) Phthalocyanine CAS RN: 1661-03-6</p>	<p><b>P1024</b> 1g 5g</p>  <p>Tin(II) Phthalocyanine (purified by sublimation) CAS RN: 15304-57-1</p>
<p><b>P0997</b> 1g</p>  <p>Tin(IV) Phthalocyanine Dichloride CAS RN: 18253-54-8</p>	<p><b>P0774</b> 5g 25g</p>  <p>Iron(II) Phthalocyanine CAS RN: 132-16-1</p>	<p><b>I0783</b> 200mg 1g</p>  <p>Iron(II) Phthalocyanine (purified by sublimation) CAS RN: 132-16-1</p>	<p><b>P0887</b> 5g 25g</p>  <p>Cobalt(III) Phthalocyanine CAS RN: 3317-67-7</p>	<p><b>C3252</b> 200mg</p>  <p>Cobalt(II) Phthalocyanine (purified by sublimation) CAS RN: 3317-67-7</p>
<p><b>P0766</b> 1g 25g</p>  <p>Lead(II) Phthalocyanine CAS RN: 15187-16-3</p>	<p><b>P0767</b> 1g 5g 25g</p>  <p>Zinc Phthalocyanine CAS RN: 14320-04-8</p>	<p><b>Z0037</b> 500mg</p>  <p>ZnPc (purified by sublimation) CAS RN: 14320-04-8</p>	<p><b>T2272</b> 200mg 1g</p>  <p>TiOPc (purified by sublimation) CAS RN: 26201-32-1</p>	<p><b>P0660</b> 25g</p> <p>Pigment Green 7 CAS RN: 1328-53-6</p>
<h2>Electrocrystallization Supporting Electrolytes</h2>				
<p><b>S0838</b> 25g 100g</p>  <p>Sodium Dicyanamide CAS RN: 1934-75-4</p>				
<p><b>T0836</b> 25g 100g 500g</p>  <p>Tetrabutylammonium Perchlorate CAS RN: 1923-70-2</p>				
<p><b>T0839</b> 25g</p>  <p>Tetraethylammonium Perchlorate CAS RN: 2567-83-1</p>				
<p><b>T0914</b> 25g 100g 500g</p>  <p>Tetrabutylammonium Tetrafluoroborate CAS RN: 429-42-5</p>	<p><b>T0983</b> 5g 25g</p>  <p>Tetraethylammonium Tetrafluoroborate CAS RN: 429-06-1</p>	<p><b>T1186</b> 25g</p>  <p>Tetrabutylammonium Dichlorobromide CAS RN: 13053-75-3</p>	<p><b>T1261</b> 1g</p>  <p>Tetrabutylammonium Dibromoaurate CAS RN: 50481-01-1</p>	<p><b>T1269</b> 1g 10g</p>  <p>Tetrabutylammonium Dibromiodide CAS RN: 15802-00-3</p>
<p><b>T1271</b> 5g 25g</p>  <p>Tetrabutylammonium Triiodide CAS RN: 13311-45-0</p>	<p><b>T1273</b> 100mg</p>  <p>Tetrabutylammonium Dichloroaurate CAS RN: 50480-99-4</p>	<p><b>T1278</b> 25g 250g</p>  <p>Tetrabutylammonium Thiocyanate CAS RN: 3674-54-2</p>	<p><b>T1279</b> 25g 250g</p>  <p>Tetrabutylammonium Hexafluorophosphate CAS RN: 3109-63-5</p>	<p><b>T1284</b> 25g 100g 500g</p>  <p>Tetrabutylammonium Tribromide CAS RN: 38932-80-8</p>
<p><b>T1357</b> 100mg 1g</p>  <p>Tetrabutylammonium Diodoaurate</p>	<p><b>T1803</b> 1g 5g</p>  <p>Tetrabutylammonium Perrhenate CAS RN: 16385-59-4</p>	<p><b>T2648</b> 25g</p>  <p>Tetrabutylammonium Tetrafluoroborate CAS RN: 429-42-5</p>		

# Tetrathiafulvalene (TTF) Precursors

		<b>B1151</b> 5g  1,3-Benzodithiolium Tetrafluoroborate CAS RN: 57842-27-0	<b>B1199</b> 1g 5g  4,5-Bis(benzoylthio)- 1,3-dithiole-2-thione CAS RN: 68494-08-6	<b>B1272</b> 1g  Bis(carbonyldithio) tetrathiafulvalene CAS RN: 64394-47-4
<b>B1777</b> 1g  4,5-Bis(methylthio)- 1,3-dithiol-2-one CAS RN: 61485-46-9	<b>B1778</b> 1g  4,5-Bis(methylthio)- 1,3-dithiole-2-thione CAS RN: 49638-64-4	<b>B2228</b> 1g  4,5-Bis(2-cyanoethylthio)- 1,3-dithiole-2-thione CAS RN: 132765-35-6	<b>B2233</b> 1g  4,5-Bis(2-cyanoethylthio)- 1,3-dithiol-2-one CAS RN: 158871-28-4	<b>D2127</b> 10g 25g  Dimethyl 1,3-Dithiole- 2-thione-4,5-dicarboxylate CAS RN: 7396-41-0
<b>D2133</b> 1g 5g  1,3-Dithiole-2-thione CAS RN: 930-35-8	<b>D3252</b> 1g  4,5-Dicyano-1,3-dithiol-2-one CAS RN: 934-31-6	<b>D3981</b> 1g 5g  Dimethyl 2-(1,3-Dithiole)- phosphonate CAS RN: 133113-76-5	<b>D3992</b> 1g  Dimethyl 1,3-Benzodithiol- 2-ylphosphonate CAS RN: 62217-35-0	<b>E0429</b> 1g 5g 25g  4,5-Ethylenedithio- 1,3-dithiole-2-thione CAS RN: 59089-89-3
<b>E0460</b> 1g 5g  4,5-Ethylenedithio- 1,3-dithiol-2-one CAS RN: 74962-29-1	<b>H1163</b> 1g  5-Hexyl-1,3-dithiole[4,5- <i>d</i> ]- [1,3]dithiole-2-thione CAS RN: 202126-51-0	<b>M1112</b> 1g  4,5-Methylenedithio- 1,3-dithiole-2-thione CAS RN: 70800-59-8	<b>M1154</b> 100mg  4,5-Methylenedithio- 1,3-dithiol-2-one CAS RN: 85720-62-3	<b>P1635</b> 250mg 1g  5-Propyl-1,3-dithiole[4,5- <i>d</i> ]- [1,3]dithiole-2-thione CAS RN: 202126-48-5
<b>T0266</b> 1g 5g 25g  Toluene-3,4-dithiol CAS RN: 496-74-2	<b>T0279</b> 1g 5g  Zinc Dithiol CAS RN: 29726-21-4	<b>T1132</b> 1g 5g 25g  1,3,4,6-Tetrathiapentalene- 2,5-dione CAS RN: 64394-45-2		

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