

ELECTRONIC CHEMICALS



ABOUT HERAEUS

A globally leading technology group, Heraeus is headquartered in Hanau, Germany. Founded in 1851, it is a family-owned portfolio company which traces its roots back to a pharmacy opened by the family in 1660. Today, Heraeus combines businesses in the environmental, energy, electronics, health, mobility and industrial applications sectors.

In the 2018 financial year, Heraeus generated revenues of €20.3 billion with approximately 15,000 employees in 40 countries. Heraeus is one of the top 10 family-owned companies in Germany and holds a leading position in its global markets.

With technical expertise, a commitment to excellence, a focus on innovation and entrepreneurial leadership, we are constantly striving to improve our performance. We create high-quality solutions for our clients and strengthen their long-term competitiveness by combining unique material expertise with leadership in technology.

About Heraeus Epurio LLC

Heraeus Epurio LLC is an award-winning specialty chemicals producer that develops Photo-Acid Generators (PAGs), Polymers, Monomers, and Crosslinkers for the **semiconductor, display, electronic and aerospace industries**.

We are experts in producing materials with **low trace metals**, while also having extensive experience in synthesizing a wide variety of organic compounds.

We provide **quality turnkey service** and are known in our industry as the reliable partner in development, from molecule to multi-tonne scale, to after-sales and technical support.

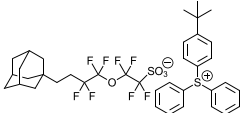
PHOTO ACID GENERATORS

Heraeus Deep UV PAG

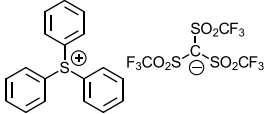
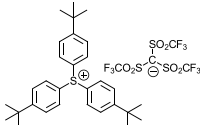
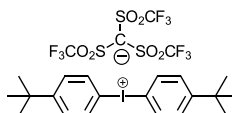
Based on 30 years of experience in producing electronic-grade photoactive materials as Daychem Laboratories in Dayton (OH), **Heraeus** has put together selected chromophores together with vintage acids to create different classes of unique products for critical layer resists in highest resolution.

Most of these products are available in Ultra-Pure (UP) quality with purity above 99.5% and content of all 26 metals below 10 ppb. This makes even conventional chemistry available for new frontiers in resist resolution.

Heraeus Ionic PAG Strong bulky acid

Product Name	Chemical Structure	Properties	Features
PA-253		Strong acid generation m.p. 128~9°C High solubility (>20% in PGMEA)	ArF

Heraeus Ionic PAG C1 acid

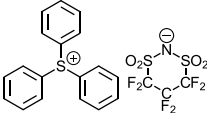
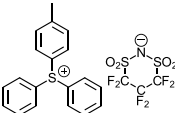
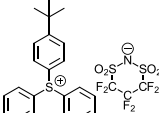
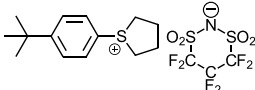
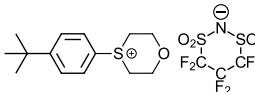
Product Name	Chemical Structure	Properties	Features
* TPS-C1		Strong acid(C1) generation m.p. 76~78°C	Deep UV
TTBPS-C1		Strong acid(C1) generation m.p. 164~165°C	Deep UV
DTBPIO-C1		Strong acid(C1) generation m.p. 104~105°C	Deep UV

* Regular product

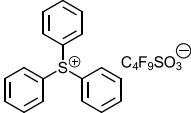
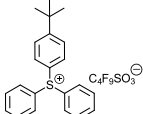
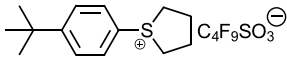
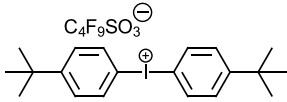
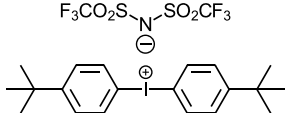
Ionic PAG

Ionic PAG

Heraeus Ionic PAG – N3 acid

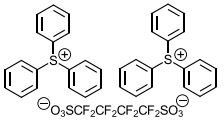
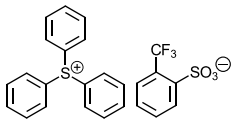
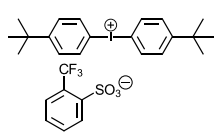
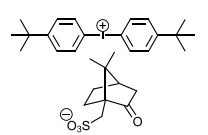

Product Name	Chemical Structure	Properties	Features
* TPS-N3		Strong acid(N3) generation m.p. 104~105°C	Deep UV
TDPS-N3		Strong acid(N3) generation m.p. 83~85°C	Deep UV
TBDPS-N3		Strong acid(N3) generation m.p. 114~116°C	Deep UV
TBPTMS-N3		Strong acid(N3) generation m.p. 177~178°C	Deep UV
TBPTO-N3 (PA-289)		Strong acid(N3) generation m.p. >240°C	Deep UV

Heraeus Ionic PAG – Nf acid

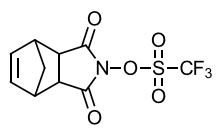
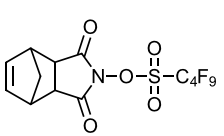
Product Name	Chemical Structure	Properties	Features
TPS-Nf		Low diffusion strong acid(nonafluoric acid) generation m.p. 84~88°C	Deep UV
* TBDPS-Nf (PA-271)		Low diffusion strong acid(nonafluoric acid) generation m.p. 131~137°C	Deep UV
TBPTMS-Nf (PA-282)		Low diffusion strong acid(nonafluoric acid) generation m.p. 174~176°C	Deep UV
DTBPIO-Nf (PA-233)		Low diffusion strong acid(nonafluoric acid) generation m.p. 175~177°C	Deep UV
DTBPIO-N1		Strong acid(N1) generation m.p. 153~155°C	Deep UV

* Regular product

Heraeus Ionic PAG – other acids

Product Name	Chemical Structure	Properties	Features
BTSPFBDS		Strong acid (perfluorobutane disulfonic acid) generation m.p. 157~159°C	Deep UV
TPS-TFMBS		Weak acid (o-trifluoromethylbenzenesulfonic acid) generation m.p. 156~157°C	Deep UV
DTBPIO-TFMBS		Weak acid (o-trifluoromethylbenzenesulfonic acid) generation	Deep UV
DTBPIO-CS		Weak acid (camphorsulfonic acid) generation m.p. 215~217°C	Deep UV
DTBPIO-PFBDS		Strong acid (perfluorobutane disulfonic acid) generation m.p. 175~176°C	Deep UV

Heraeus Non-ionic DUV PAG

Product Name	Chemical Structure	Properties	Features	Remarks
* MDT		White powder Strong acid (triflic acid) generation m.p. 88~89°C	Deep UV	
PA-229		White powder Low diffusion strong acid (nonaflc acid) generation m.p. 54~56°C	Deep UV	

* Regular product

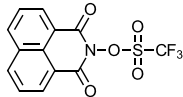
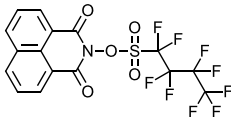
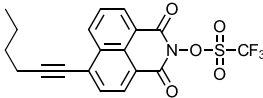
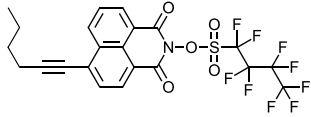
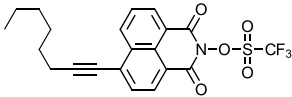
NON-ionic PAG

HERAEUS I-LINE AND BROADBAND PAG

Following the growing market demand for highly sensitive, high solubility i-line PAG for various chemical amplified resist applications, **Heraeus** developed a set of i-line, broadband and even g-line products.

Purity is according to the proven electronic grade quality of **Heraeus**, and most of the PAGs are scaled up cost-effectively in production to deliver up to tons quantity per year, making them also attractive for cutting-edge devices for memory chips, advanced packaging and display resists.

Heraeus Standard i-line PAGs

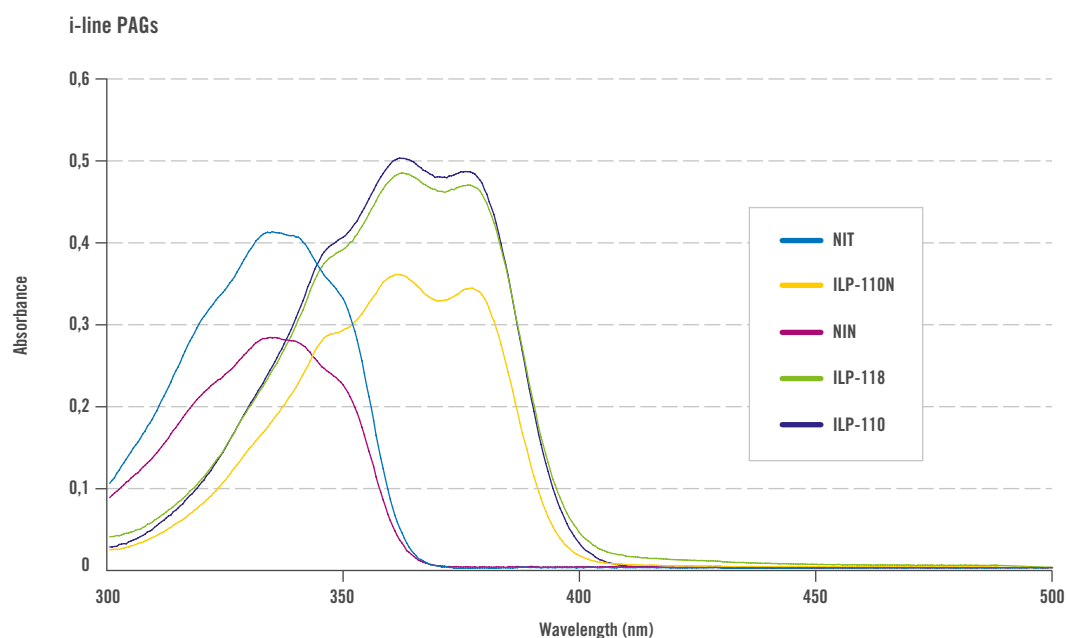
Product Name	Chemical Structure	Properties	Features
* NIT		White powder Strong acid (triflic acid) generation m.p. 210~214°C	i-line
* NIN		White crystalline powder. Low diffusion Strong acid (nonaflic acid) generation m.p. 148.5~149.5°C	i-line
ILP-110		Light-yellow powder Strong acid (triflic acid) generation m.p. 113~114°C	i-line
* ILP-110N		Low diffusion strong acid (nonaflic acid) generation m.p. 122~124°C	i-line
ILP-118		Light-yellow powder Strong acid (triflic acid) generation m.p. 66~68°C	i-line

* Regular product



i-line

UV spectra of i-line PAGs



* Sample concentration: 0.001% in PGMEA or ACN

Heraeus i, g, h-line PAGs

Product Name	Chemical Structure	Properties	Features
ILP-113		Yellow powder Strong acid (triflic acid) generation m.p. 125~126°C	i, h-line broadband
* HTPG-104S		White powder Strong acid (HCl) generation m.p. 143~145°C	i-line
PA-223		Orange powder Strong acid (triflic acid) generation m.p. 146~147°C	i, h, g-line broadband

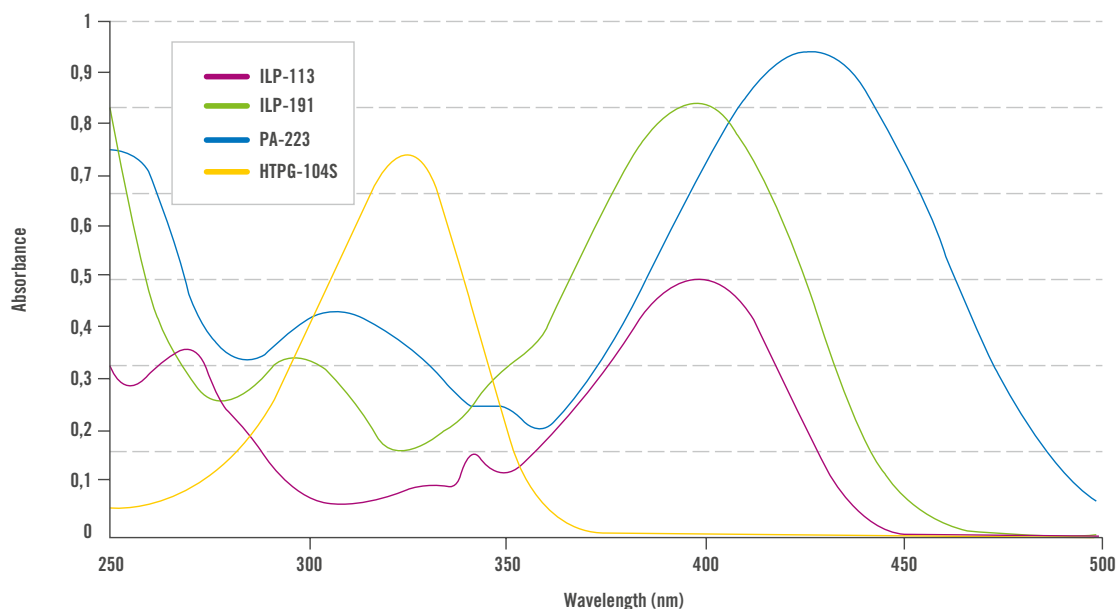
* Regular product

PAG

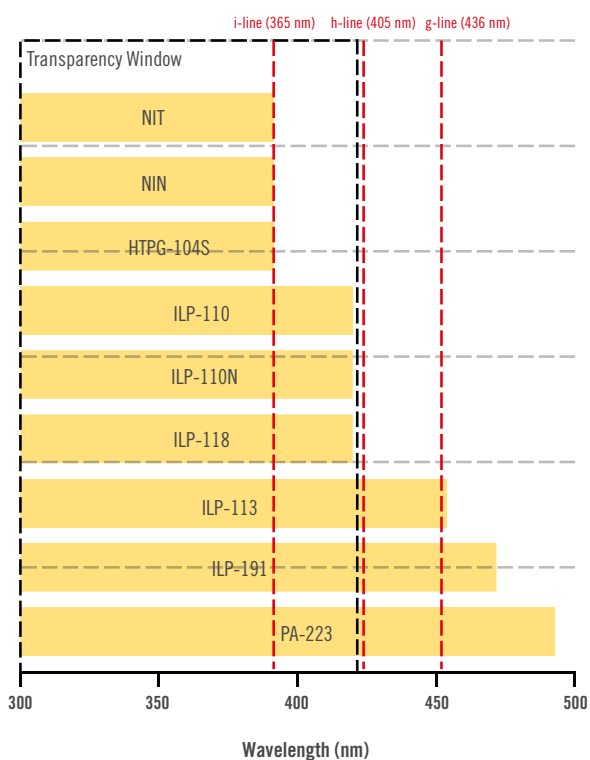
PAG

UV spectra for i, g, h-line PAGs

I, g, h-Line PAGs

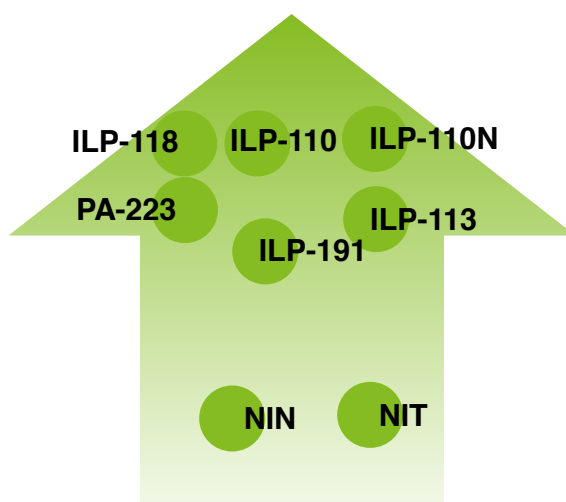


UV absorption



Formulation and relative i-Line sensitivity

More Sensitive



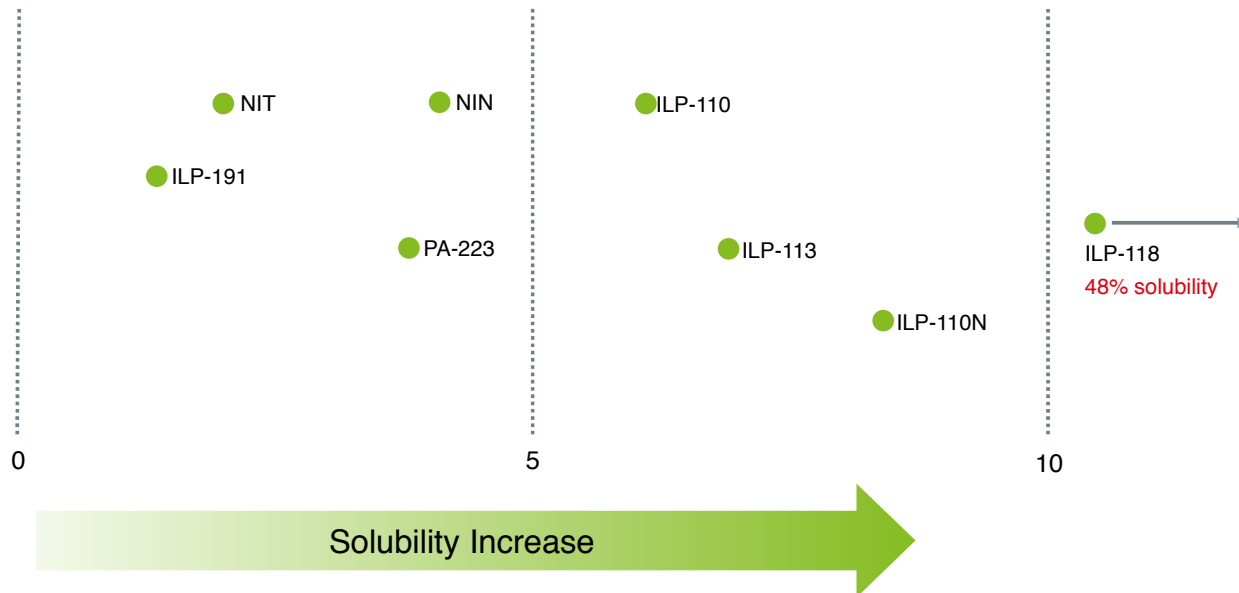
Less Sensitive

Each resist has the same molar equivalent of PAG

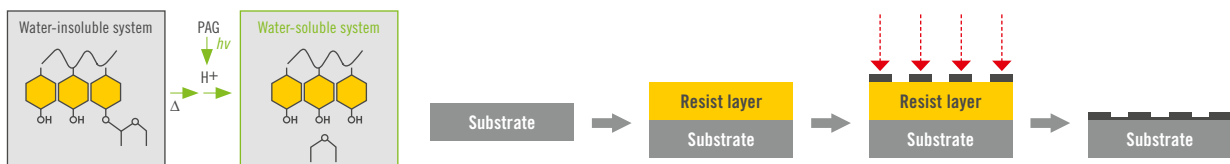
Resist consists of 30%-protected PHS, PAG, and TEA as quencher in PGMEA

SOLUBILITY

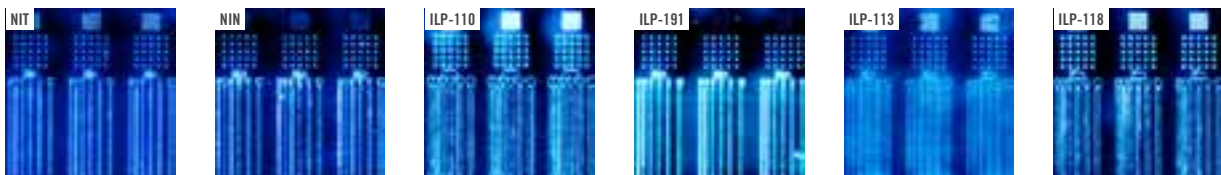
Solubility in PGMEA, %(w/w, RT)



Patterning test: Positive tone chemical amplified resist



Patterning test results



Coating Thickness

~1μm by spin coating /
SOB condition: 110oC, 60sec

Exposure

10sec (1sec + about 7.0 mJ) /
Light source: LED i-line / No PEB

Development

2.38% TMAH, 23oC, 60sec

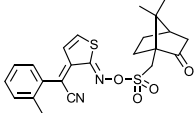
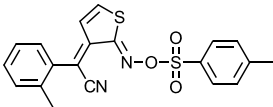
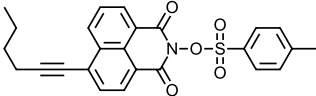
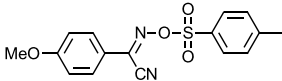
PATTERNING

Heraeus Weak Acid PAGs

According to the market demand of weak acids for sensitive resin systems, Heraeus offers proven sensitive chromophore and weak-acid combinations as cost-effective alternatives to existing systems.

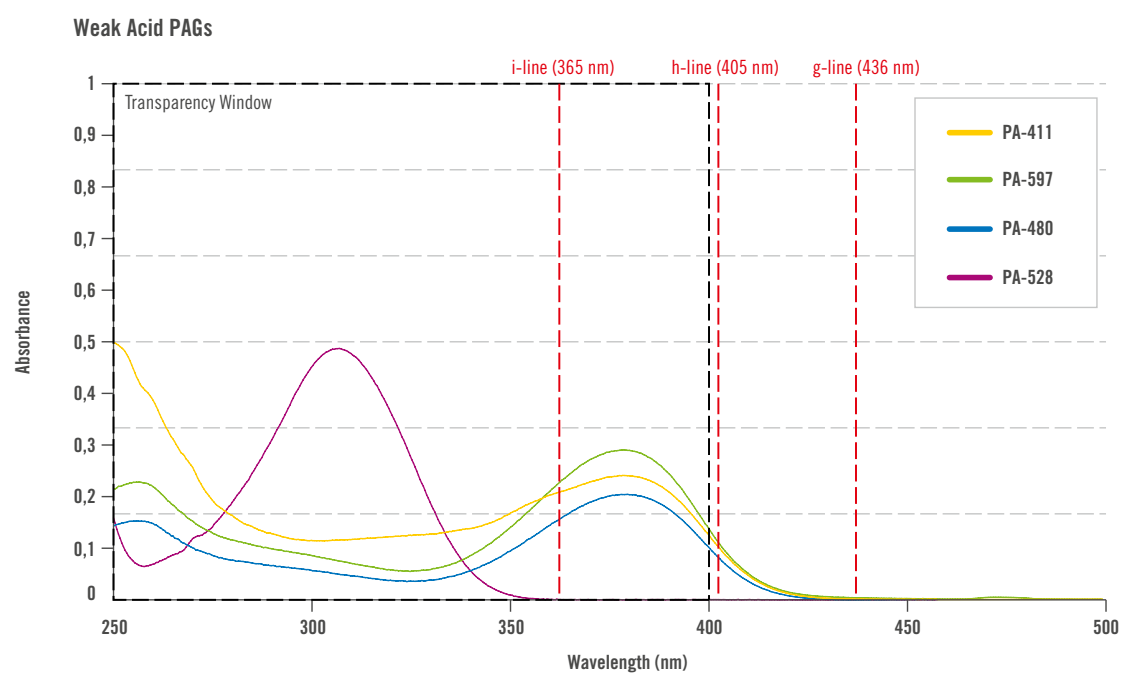
Highest purity and quality consistency is a given also for this product range.

Heraeus Non-Ionic weak acid PAGs

Product Name	Chemical Structure	Properties	Features
PA-480		Yellow powder Weak acid (sulfonic acid) generation m.p. 143~145°C	i, h, g-line
PA-411		Yellow powder Weak acid (tosylic acid) generation m.p. 136~139°C	i, h, g-line
PA-298		Yellow powder Weak acid (sulfonic acid) generation m.p. 93~95°C	i, h, g-line
PA-528		White powder Weak acid (tosylic acid) generation m.p. 134°C	i-line



UV spectra for weak acid PAGs



* Sample concentration: 0.001% in PGMEA or ACN

HERAEUS CROSSLINKERS

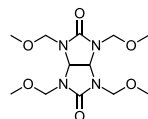

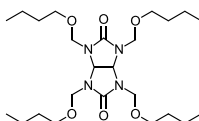

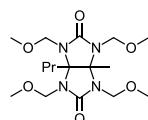

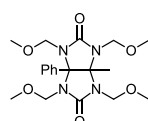

Heraeus has a long tradition of manufacturing glycoluril-based crosslinkers in highest purity for semicon resists. This is why processes have been developed and scaled up to reduce or remove contaminations of formaldehyde and methylene chloride.

Today the low-metal contamination and the methylene chloride-free (MCF) products from

Heraeus define the new standard in the semicon industry. Various chemical modifications have significantly lowered the sublimation tendency.

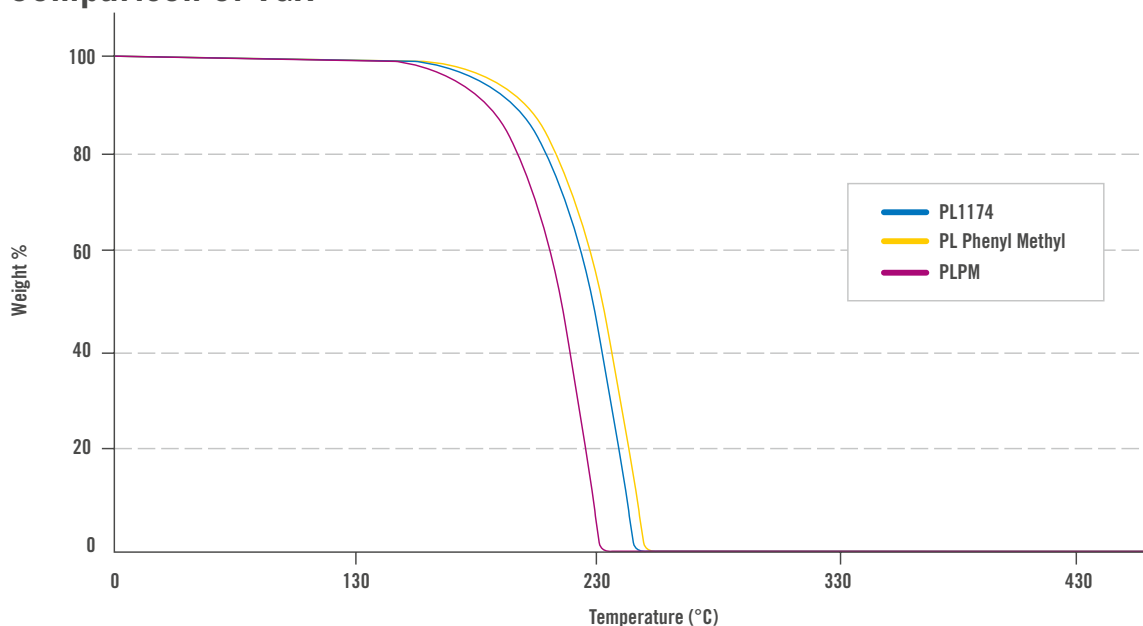
Furthermore, Heraeus developed certified methylene chloride-free versions of crosslinkers to comply with international regulations against hazardous, halogenated materials, and to provide safe and environmentally-friendly products.



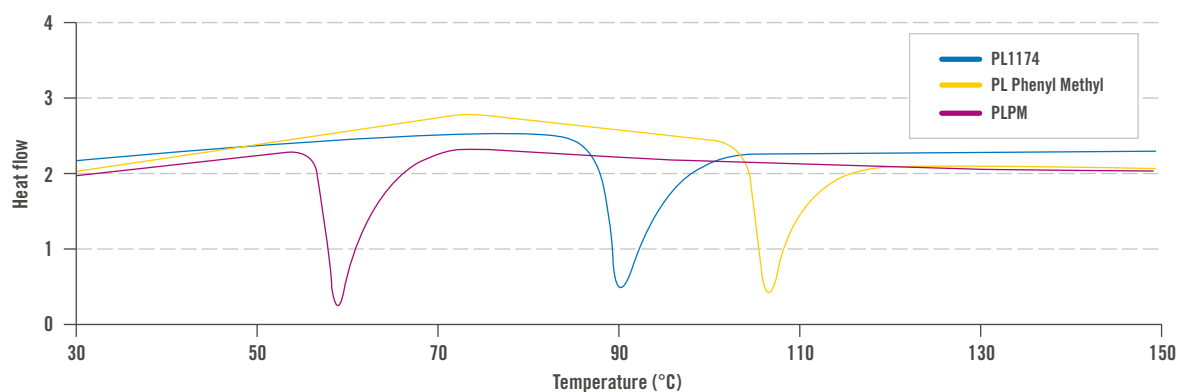
Product Name	Chemical Structure	Properties	Features
* PL-1174		White crystalline powder m.p. 107~113°C Available methylene chloride-free (MCF) and UP	
* TBGU		Colorless liquid Available methylene chloride-free (MCF) and UP	
* PLPM		White powder m.p. 87~89°C Available methylene chloride-free (MCF) and UP	
PL Phenyl Methyl		White powder m.p. 136~138°C Available methylene chloride-free (MCF) and UP	

* Regular product

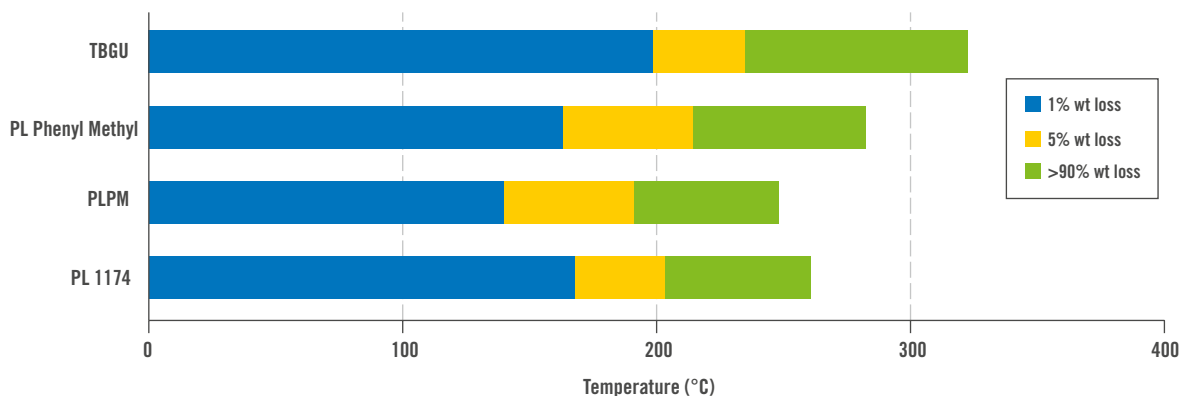
Comparison of TGA



Comparison of DSC



Decomposition temperatures



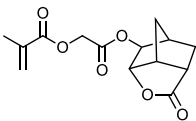
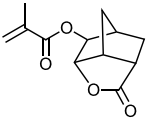
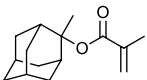
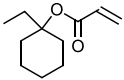
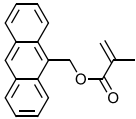
Solubility for crosslinkers

Solubility into 100 mL of	PLPM (-MCF)	PL Phenyl Methyl	PL1174	TBGU a
Water	7.7 g	<0.3 g	11.8 g	~6 g
Methanol	46 g	3.4 g	22.6 g	miscible
IPA	10 g	<2 g	<2 g	miscible
EL	25 g	<2 g	6 g	miscible
PGMEA	10 g	<2 g	<2 g	miscible
PGME	10 g	<2 g	<2 g	miscible

HERAEUS MONOMERS: ACRYLATE

Coming from long experience of critical layer polyacrylate-based resists, Heraeus developed and scaled up a number of monomers with sterically hindered groups.

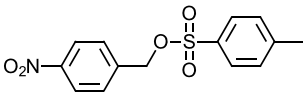
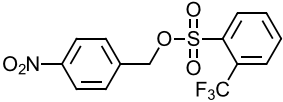
From UP grade for new critical layer developments to high-end memory and logic chips-related photo materials such as PR, BARC, and hardmask applications, where cost and volume availability are important factors, we offer the entire product range.

Product Name	Chemical Structure	Properties	Features
* MNLMA		White powder m.p. 74~77°C	Photorelated material for ArF
NMLA		White powder m.p. 101~102°C	Photorelated material for ArF
MAdMA		Colourless liquid	Photorelated material for ArF
ECHA		Colourless liquid	Photorelated material for ArF
9-AMM		Yellow powder m.p. 86~88°C	BARC Deep UV resist

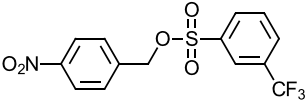
HERAEUS THERMAL ACID GENERATORS

With thicker film resist demands, more and more formulations contain thermal acid generators to enable final curing during post-baking.

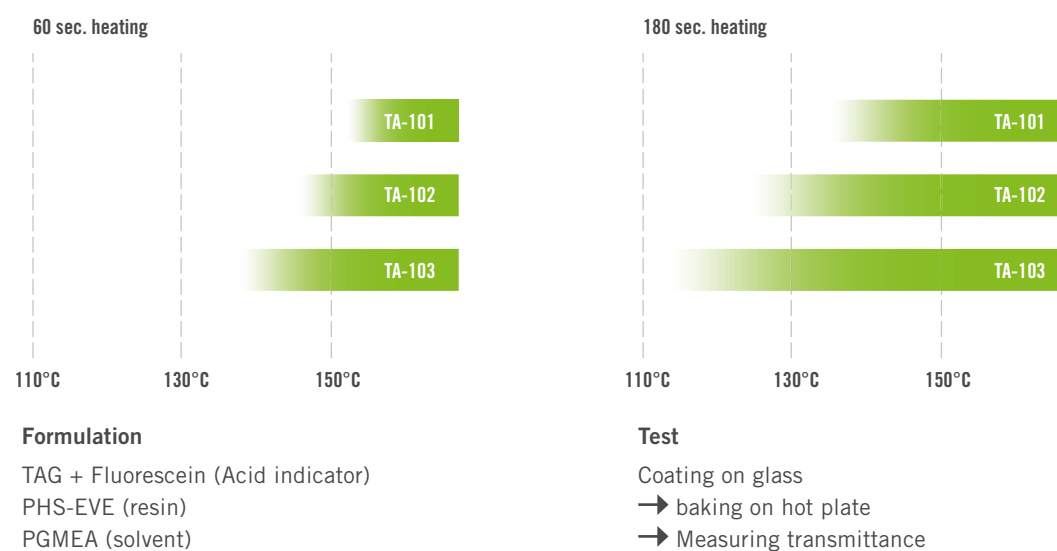
An IP-free set of products with different acid-releasing temperatures is available from Heraeus. Semiconductor-grade purity and effective costs are mandatory in the final application.

Product Name	Chemical Structure	Properties	Features
* TA-101		White powder 4.5% (w/w) in PGMEA m.p. 101~102°C	
TA-102		White powder 2.5% (w/w) in PGMEA m.p. 126~127°C	

* Regular product

Product Name	Chemical Structure	Properties	Features
TA-103		White powder 5% (w/w) in PGMEA m.p. 101~102°C	

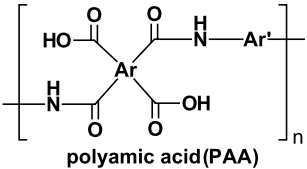
Acid generation – temperature by heating



HERAEUS POLYIMIDE PRECURSORS

Heraeus can toll manufacture Polyamic Acids and other PI precursors to suit your needs. We have the capacity to produce an output of 2 tons per day,

and can safely handle all major solvents, diamines, and dianhydrides.

Product Name	Chemical Structure	Properties	Features
* Polyamic acids (PAA) for Polyimides		High dielectric stability at high temperatures, chemically resistant and can be made colorless	Used as coatings in flex circuits, display, battery applications, photovoltaic and anywhere PI films are needed
PMR (Polymerizable Monomeric Reactants) Resins	Various diamine dianhydride mixtures	Used in temperatures over 350°C	Used in composites for high-temperature aerospace applications

* Regular product

+ Custom synthesis service

Heraeus provides all kinds of chemical compounds based on the customer's requirements, using our high-level synthesis technology and long experience in electronic materials. Rapid and smooth transition from g-scale to kg-scale is provided. Please get in touch with our sales team.

+ Purification technology

High-end photoresist applications in semiconductors require super-low chemical impurity and metal ions content. Heraeus has begun producing ultra-purification-grade products for advanced semiconductor photoresists. Our new production facility, equipped with full clean room environment, will operate in 2021.

EN/01.2021/www.data-graphis.de



- **Headquarters:** Hanau, Germany
- **Production:** Dayton, Ohio, USA
- **Sales offices:**
 - Heraeus Materials Technology Taiwan Ltd., Taipei, Taiwan
 - Heraeus Shanghai, China
 - Heraeus Korea, Suwon, South Korea
 - Heraeus K.K., Tokyo, Japan
 - Heraeus Epurio LLC, Dayton, Ohio, USA

The data given here is correct for January 2021 and is subject to change.

hepn_customerservice@heraeus.com
heraeus-epurio.com