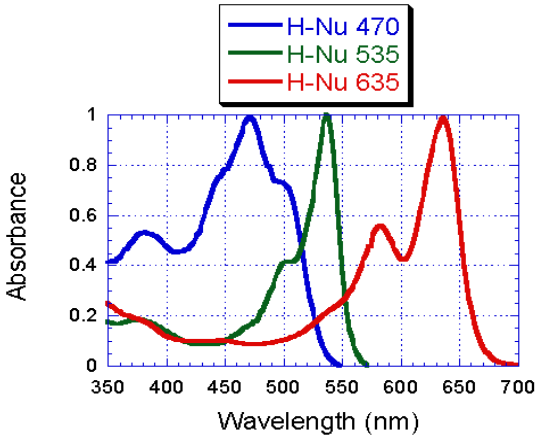
H-Nu 470 Visible/UV-Visible Light Photoinitiator

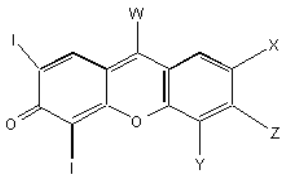
Name: 5,7-diiodo-3-butoxy-6-fluorone	**Formula: $C_{17}H_{14}I_2O_3$**
CAS # 161728-47-8	**Synonyms: DIBF, H-Nu 470**

General Information

- H-Nu Series of Fluorone dyes (**H-Nu 470, 535 and 635**) - photoinitiators with panchromatic absorbance throughout the UVA/visible spectrum (350-670 nm)
- **H-Nu 470, 535 and 635** - capable of curing a wide range of resins:
  Acrylates - free-radical mechanism
  Epoxides - cationic mechanism
- **H-Nu 470** - commercial photoinitiator, broad absorbance range of 350 nm to 530 nm (λmax=470 nm)
- Commercially available (LVE from the EPA), non-toxic (LD50>5000mg/kilo)
- **H-Nu 470** and its use is protected by U.S. Patents 5,451,343 and 5,395,862



H-Nu Photoinitiator Structures



Compound	W	X	Y	Z	ε	λmax (nm)
H-Nu 470	H	H	H	OBu	30200	470
H-Nu 535	H	I	I	OH	91200	535
H-Nu 635	CN	I	I	OH	80000	635

ε is the molar extinction coefficient. λmax (nm) is the peak maximum absorbance wavelength

Benefits of Use

- High absorptivity, low concentrations are needed (0.01-0.15 wt%)
- Capable of significant depth of cure in free radical formulations, > 1 inch
- Time and energy savings when one-pass thick cure can replace thin multi-layered coatings
- Cure through UV opaque, pigmented, or colored substrates (e.g. Kapton)
- Initiator bleaching: from bright orange to pale yellow/no residual color
- Bleaching/color change indicator of exposure/cure with UV/visible light

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Physical Properties

Appearance	Orange Powder
Molecular Weight	520 g/mol
Melting Point	>270 °C
Absorbance Maximum	470 nm
Molar Extinction Coefficient	30,200 (470 nm)

Photoinitiator Usage Recommendations

Complete dissolution of H-Nu Photoinitiators is required for best results:

- Dissolving H-Nu photoinitiators requires special care. Direct solubility of H-Nu 470 in resins can be difficult, predissolution of H-Nu photoinitiators in one of the following resins/solvents before adding resin is recommended

    - **Free Radical Only** -- **DMAA (N,N-Dimethylacrylamide)**
        - usage at 5-10 parts **DMAA** to 1 part **H-Nu 470**
    - **Cationic Only** – **GBL (γ – Butyrolactone**)
        - Usage at 5-10 parts **GBL** to 1 part **H-Nu 470**

    NOTE: **DMAA** is an excellent solvent for **H-Nu 470**, but it **cannot be used in cationic resins** as it inhibits cure.

- The presence of any undissolved orange particles is an indication of incomplete solubility. More heating or stirring may help with incorporation, or predissolution using **DMAA** or **GBL** as noted above is needed.

- Predissolving **H-Nu 470** in the appropriate material may allow for easier addition and faster usage. If not predissolving **H-Nu 470**, stirring/heating (65C is ok) at least 3 to 4 hours before using the formulation to ensure maximum solubility is recommended.

- H-Nu photoinitiator systems and materials that contain them are light sensitive and should be kept in the dark or in light proof bottles when not in use.

- “Dimmed” light conditions or other form of light shielding for mixing and formulating when using H- Nu photointiators are recommended to prevent unwanted pre-polymerization.

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Photopolymerization Mechanisms

Acrylate Cure (Free-radical)

- Coinitiators are required – amine acrylates (**AA**) at 5 - 10 wt.% are recommended
- H-Nu 254 iodonium salt is recommended for acceleration if needed (may cause instability)
- When used in combination with common UV initiators and a typical Hg Arc curing device, cured coating properties are enhanced allowing the user to reduce the amount of UV initiator. Better cure depth is achieved:
  1) Moore, M., Lungu, V., Marino, T., *Radtech Report* **11**, *2*, (March/April) 1997;
  2) **US Patent 6,211,262** "Corrosion Resistant, Radiation Curable Coating", Mejiritski, A., Marino, T, Lungu, V., Martin, D., Neckers, D. C.)
- Recommended starting level of **H-Nu 470** - 0.05 - 0.15 wt.% based on total solids.
- Recommended starting concentrations:

Thin Cure (< 1 mm)

0.10 wt.% H-Nu 470	0.15 wt.% H-Nu 254 iodonium salt	5 wt.% Amine Acrylate (AA)

Thick Cure (1 mm or greater)

0.05 wt.% H-Nu 470	0.15 wt.% H-NU 254 iodonium salt	5-10 wt% AA
0.05 wt.% H-Nu 470	N/A	5-10 wt.% AA

Optimization may be necessary for each individual application

SGL's experimental coinitiator **Borate V** improves cure response over typical amine coinitiators and can be purchased separately.

Photoinitiator package (when added to a model acrylate formulation)	Reactivity (1-highest, 5-lowest)	Stability and storage
H-Nu 470 + H-NU 254 iodonium salt + Borate V	1	Needs refrigeration as it may polymerize in the dark at room T, can be used by mixing just prior to using.
H-Nu 470 + Sulfonium Hexafluroantimonate Salt + Borate V	2	Needs refrigeration as it may polymerize in the dark at room T, can use by mixing just prior to using.
H-Nu 470 + Borate V	3	Stable at room T, refrigeration recommended when not in use to prolong shelf life.
H-Nu 470 + H-NU 254 iodonium salt + Amine	4	May be unstable depending on resin used – use only as necessary
H-Nu 470 + Amine	5	Stable

- Typical formulations with **Borate V**:

0.05 - 0.1 wt.% H-Nu 470	N/A	0.50 wt.% Borate V
0.05 – 0.1 wt.% H-Nu 470	0.5 wt.% H-NU 254 iodonium salt	0.50 wt.% Borate V
0.05 – 0.1 wt.% H-Nu 470	1 wt.% Sulfonium Salt	0.50 wt.% Borate V

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It is best to dissolve Borate V directly into DMAA (2 parts DMAA to 1 part Borate V) before adding the resin as Borate V is difficult to dissolve in some resin systems.

Cationic Cure – Epoxides (including SU-8 photoresists*)

- **H-Nu 470** requires **H-Nu 254 Iodonium salt** to achieve cure in epoxide resins
- **Accelerator AN-910-E** can greatly enhance cure speed and sensitivity and is recommended
- **H-Nu 470** concentration range spans from 0.05 to 0.2 wt.%, with a good starting point at 0.10 wt.% based on solids
- Recommended starting concentrations:
  Standard:
  0.10 wt.% H-Nu 470 + 2.5 wt.% H-Nu 254 Iodonium Salt

  With Accelerator:
  0.10 wt.% H-Nu 470 + 0.1 wt.% AN-910-E + 2.5 wt.% H-Nu 254 Iodonium Salt
- Sulfonium salts will not work with **H-Nu 470** – you must use an iodonium salt
- Do not use **Amines** or **DMAA** solvent as they "poison" or quench the superacid formation, thus preventing cationic cure

***SU-8 w/470 References:** Y. Lin, P.R. Hermann, and K.Darmawikarta, *Appl. Phys. Lett*. **86**, *7*, 071117 (2005)
J.H. Moon, S.-M. Yang, D.J. Pine, and W.-S. Chang, *Appl. Phys. Lett*. **85**, *18*, 4184 (2004)
D. Rodriguez Ponce, K Lozano, et al. J. Polym. Sci.: Part B: Polym. Phys. **48**, 1, 47 (2010)

Product Safety and Handling

Please read MSDS information before handling any products described in this brochure.

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