

# Effect of HALS against photo-degradation of greenhouse PO film under severe sulfur fumigation



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# Introduction

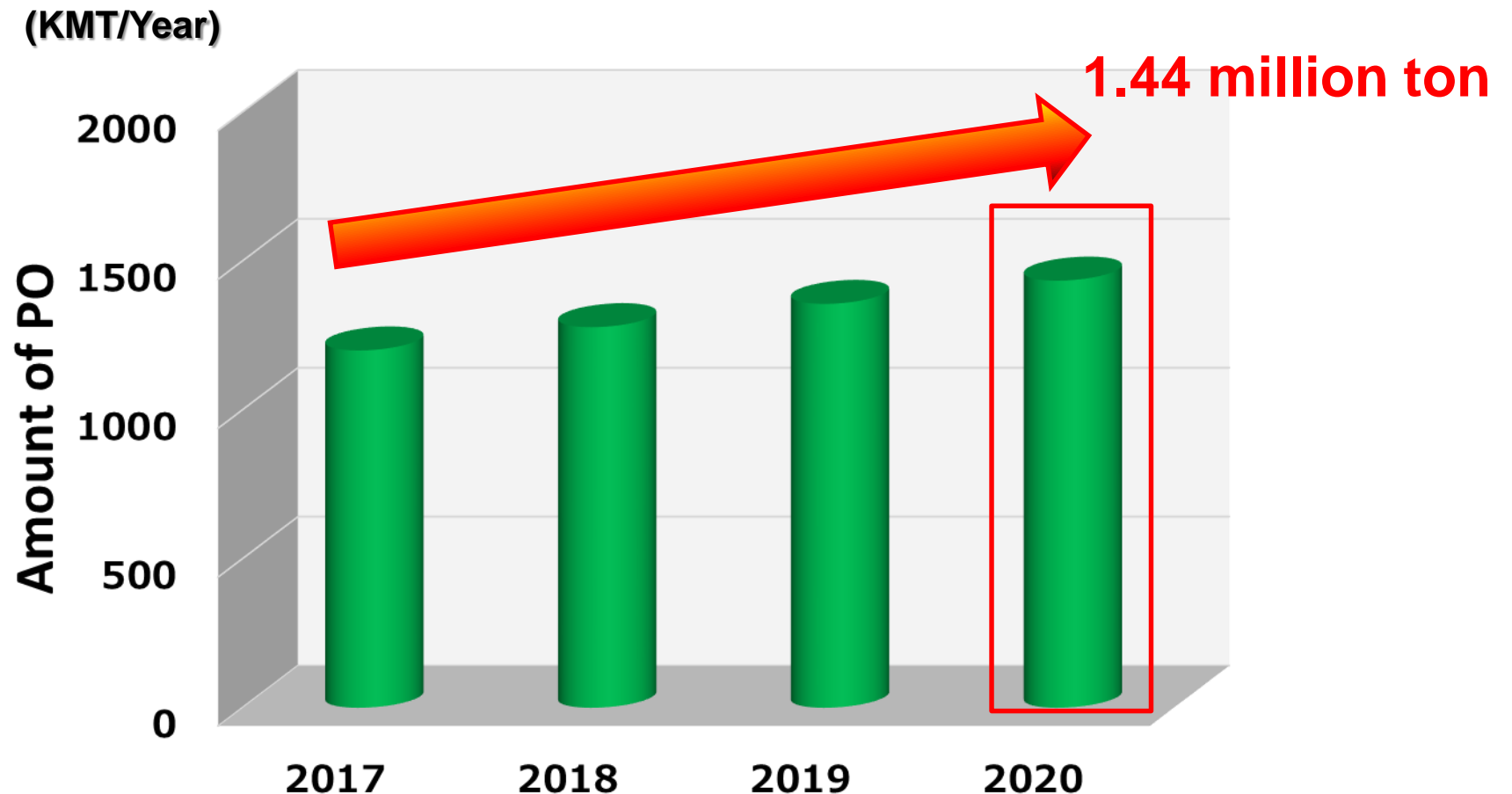
# Types of Agricultural film

| Applications  | Purpose   | Requirement   | Period [year] | Percentage [%]* |
|---|---|---|---------------|-----------------|
| <b>Greenhouse</b><br> | <ul style="list-style-type: none"> <li>External covering</li> </ul>   | <ul style="list-style-type: none"> <li>Long term weatherability</li> <li>Transparency</li> <li>Heat retention, etc</li> </ul> | 3 <           | 38              |
| <b>Mulch</b><br>      | <ul style="list-style-type: none"> <li>Ground covering</li> <li>Keeping ground temp.</li> <li>Weed suppression</li> </ul> | <ul style="list-style-type: none"> <li>Mid term weatherability</li> <li>Color is Black, Silver, Green, etc</li> </ul>         | 1~3           | 37              |
| <b>Silage</b><br>    | <ul style="list-style-type: none"> <li>Wrapping preservation of grass</li> </ul>  | <ul style="list-style-type: none"> <li>Disposable</li> <li>Adhesion during storage</li> </ul>                                 | < 1           | 25              |

\*Agricultural Films Market by Applications & Polymers –Global Trends & Forecasts to 2017

Long term weatherability is required for greenhouse application, so the suitable light stabilizer system must to be used.

# Global demand of PO for greenhouse



\*Agricultural Films Market by Applications & Polymers –Global Trends & Forecasts to 2017

Demand of PO compounds for greenhouse has been continuously increasing.

# Trend of Greenhouse Film

- ✓ Because greenhouse films are exposed to sunlight for a long period of time, high weatherability is very important.
- ✓ HALS is essential to give long-term weatherability for agricultural film.

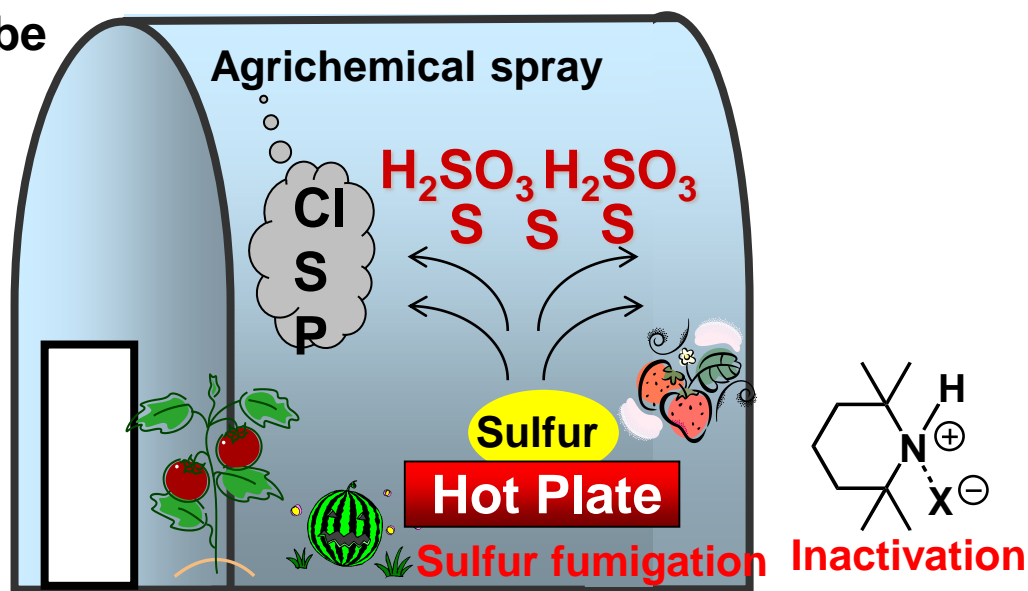


## However

- ✓ Pesticide, Sulfur etc... are used for preventing damage to crops from disease and harmful insects. Especially sulfur fumigation is increasing, S content: 2,000 → 3~4,000ppm in agricultural film
- ✓ On the other hand, HALS can be inactivated by sulfur and pesticide due to acid-base reaction.



- ✓ Low basicity HALS should be necessary for long-term use of greenhouse.



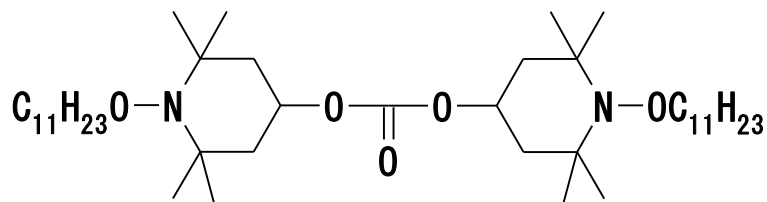
# **Newly developed light stabilizer**

# Identification of light stabilizers

## LS-2: 50% Active Component LDPE MB

- ✓ Main component : LS-1 (ADK STAB LA-81)
- ✓ Pellet Form

### LS-1 (ADK STAB LA-81)

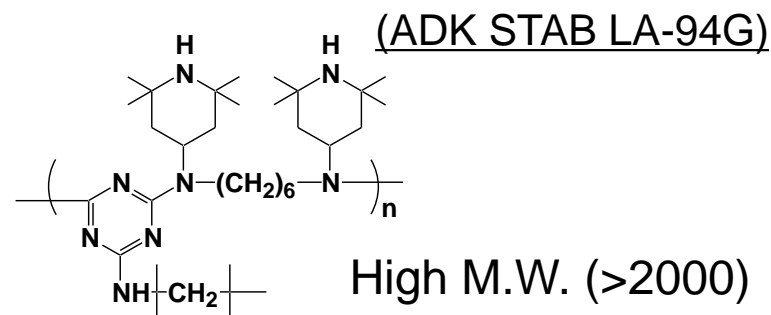


**NO-Alkyl type HALS**

### LS-3

NO-Alkyl type HALS  
(commercially available)

### Conventional LS



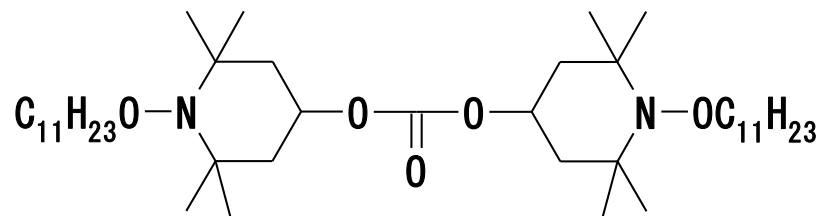


# Characteristics of LS-1

## ➤ Features

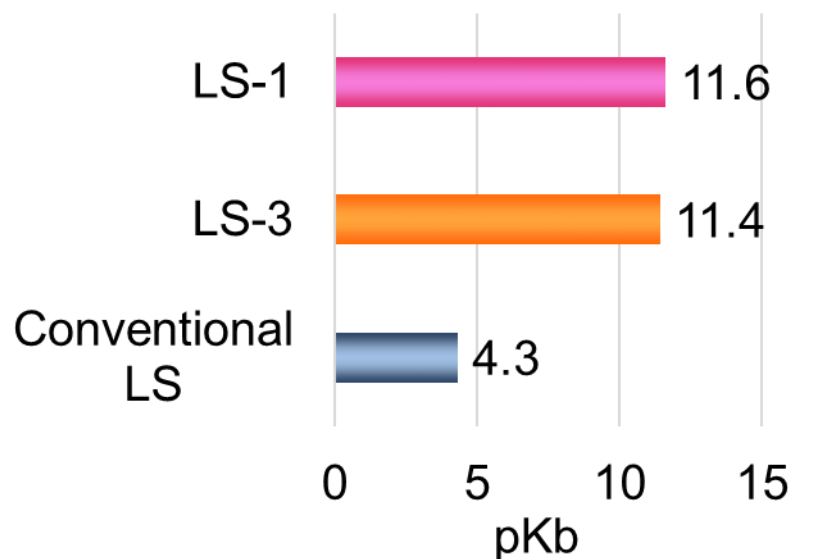
Low basicity

Low polarity (good compatibility with polyolefins)



LS-1

## Basicity of LS-1 and other HALS



\*using pH meter in MeOH

## Solubility of HALS

| HALS            | Heptane | Methanol |
|-----------------|---------|----------|
| LS-1            | >50     | 0.1      |
| LS-3            | 1.4     | 0.3      |
| conventional LS | 4.2     | 0.1      |

(g/100g-solvent)

LS-1 is expected to have an excellent compatibility with polyolefin

# Advanced light stabilizer technology in Greenhouse film application

# Evaluation Condition

## Formulation

- LLDPE (MFR=2.0) : 100
- Phenolic AO-1 (0.05%) / Phosphite P-1 (0.10%) / Ca-St (0.05%)

**Light stabilizer (1.0 or 2.0%(LS-2))**

## Processing condition of blown film

- Single screw extrusion  
φ20mm L/D=25
- Temperature : 190 °C
- Ring die  
diameter : 25mm, slit width : 0.8 mm
- Film thickness : 40~50 μm
- Fold width : 80~90 mm
- Winding speed : 4.5~5.0 m/min

## Evaluation condition

### Sulfur fumigation condition

- **Condition A (Severe)**
- **Condition B (Medium)**

**Accelerated weathering test**  
**ISO 4892-2 (Xenon-Weather-O-Meter)**

- **Radiation : 60 W/m<sup>2</sup>**
- **WL region : 300-400 nm**
- **BPT : BST65 °C with water spray**

# Initial color after processing

## Photograph of film after processing

LS: 1phr



w/o LS

LS-1

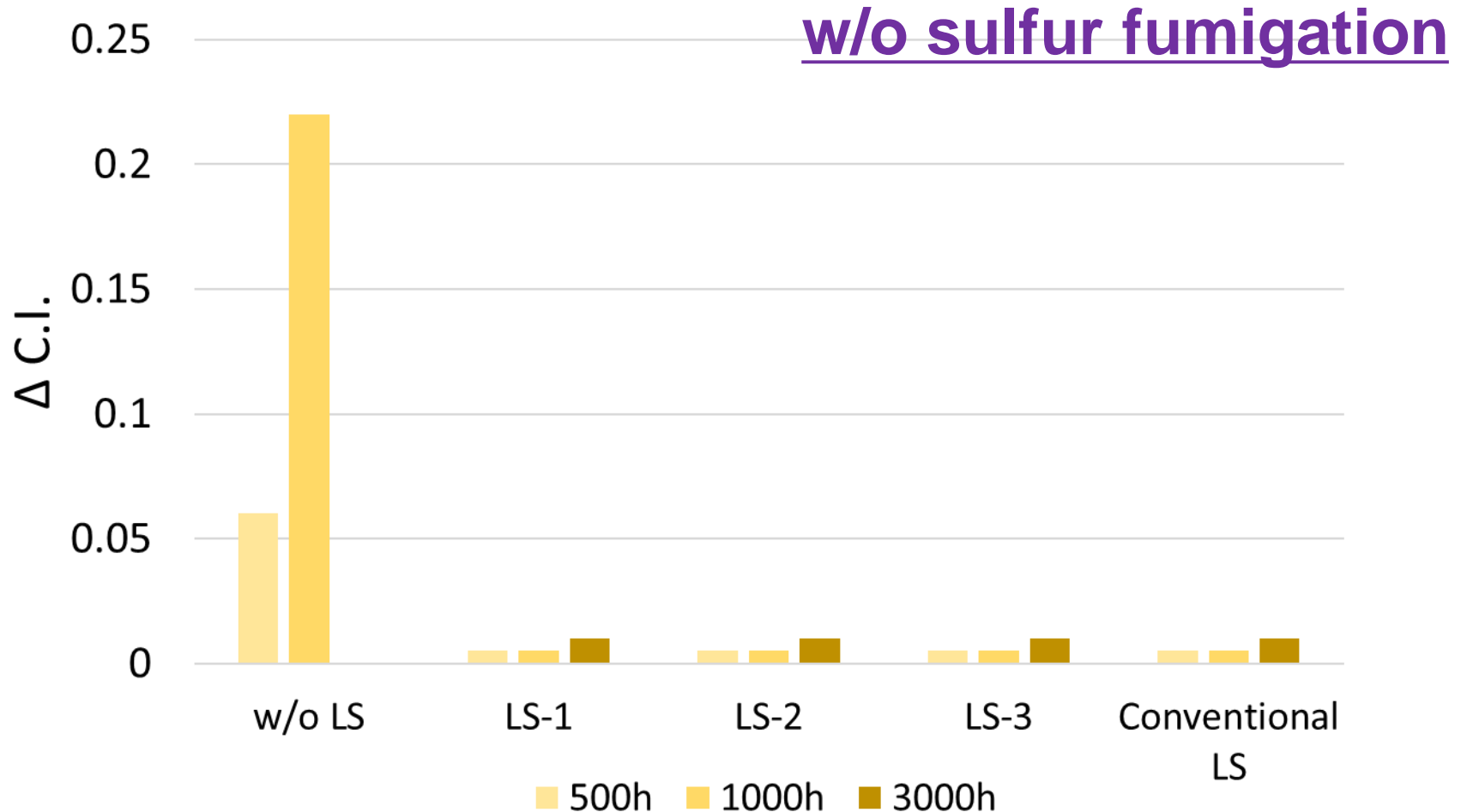
LS-2

LS-3

Conventional LS

LS-2 has no negative influence on the initial color of film

# Weatherability – $\Delta$ Carbonyl Index-



LS-2 showed equal weatherability as other LS in case of no sulfur fumigation

# Optimization of sulfur fumigation condition

## Sulfur fumigation treatment

PO film was exposed to sulfur fumed by heating of sulfur on the hot plate in a box.



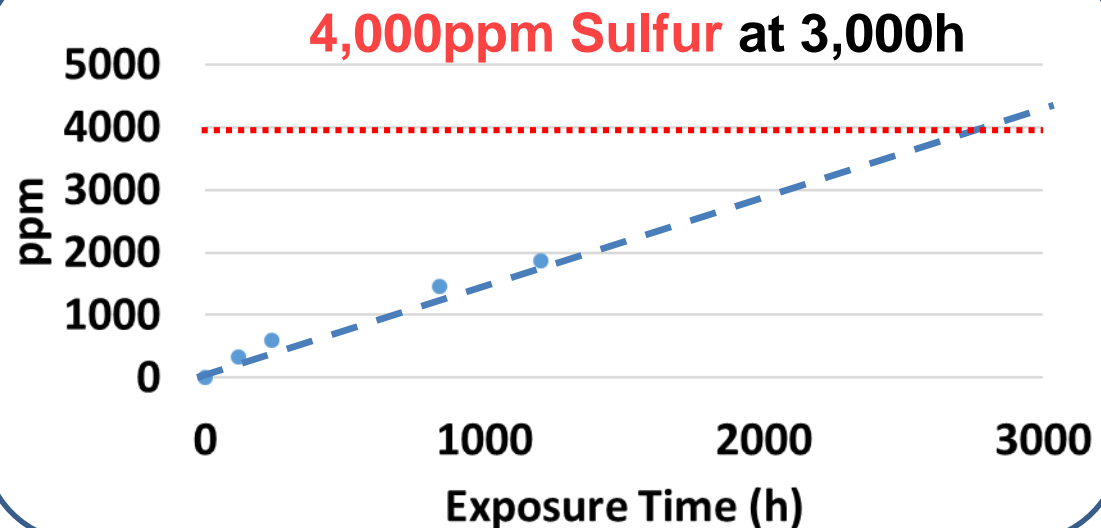
PO film was put under weathering test.

## Sulfur fumigation treatment model



## Sulfur fumigation condition

- Amount of sulfur : 5.0 g
- Heat condition : 160 °C, 4 h
- Sulfur fumigation cycle :  
Once every **120h** of exposure



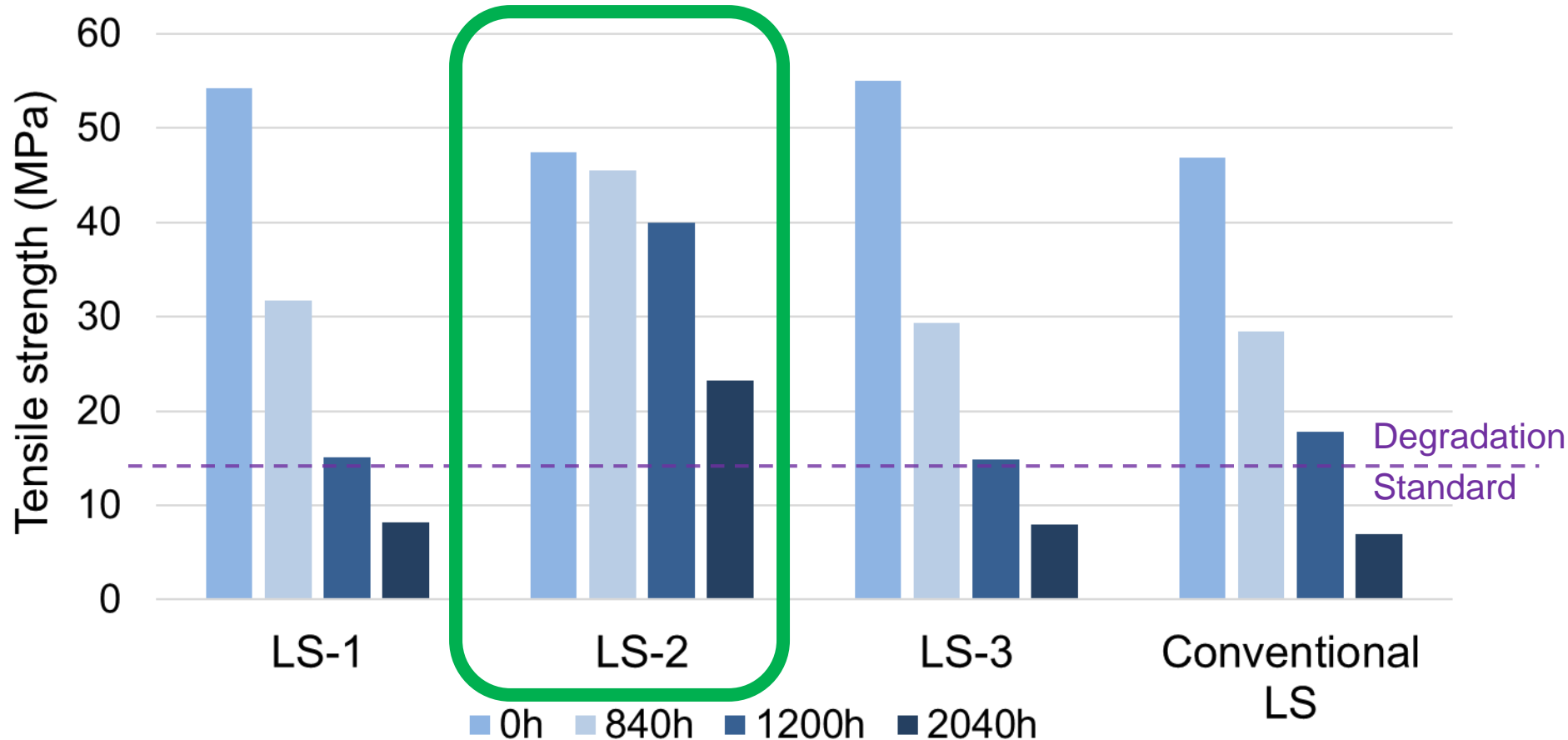
# Testing equipment for tensile test



**SHIMADZU AG-Xplus**  
**Speed:500mm/min**

# Weatherability ~Tensile strength~

With severe sulfur fumigation

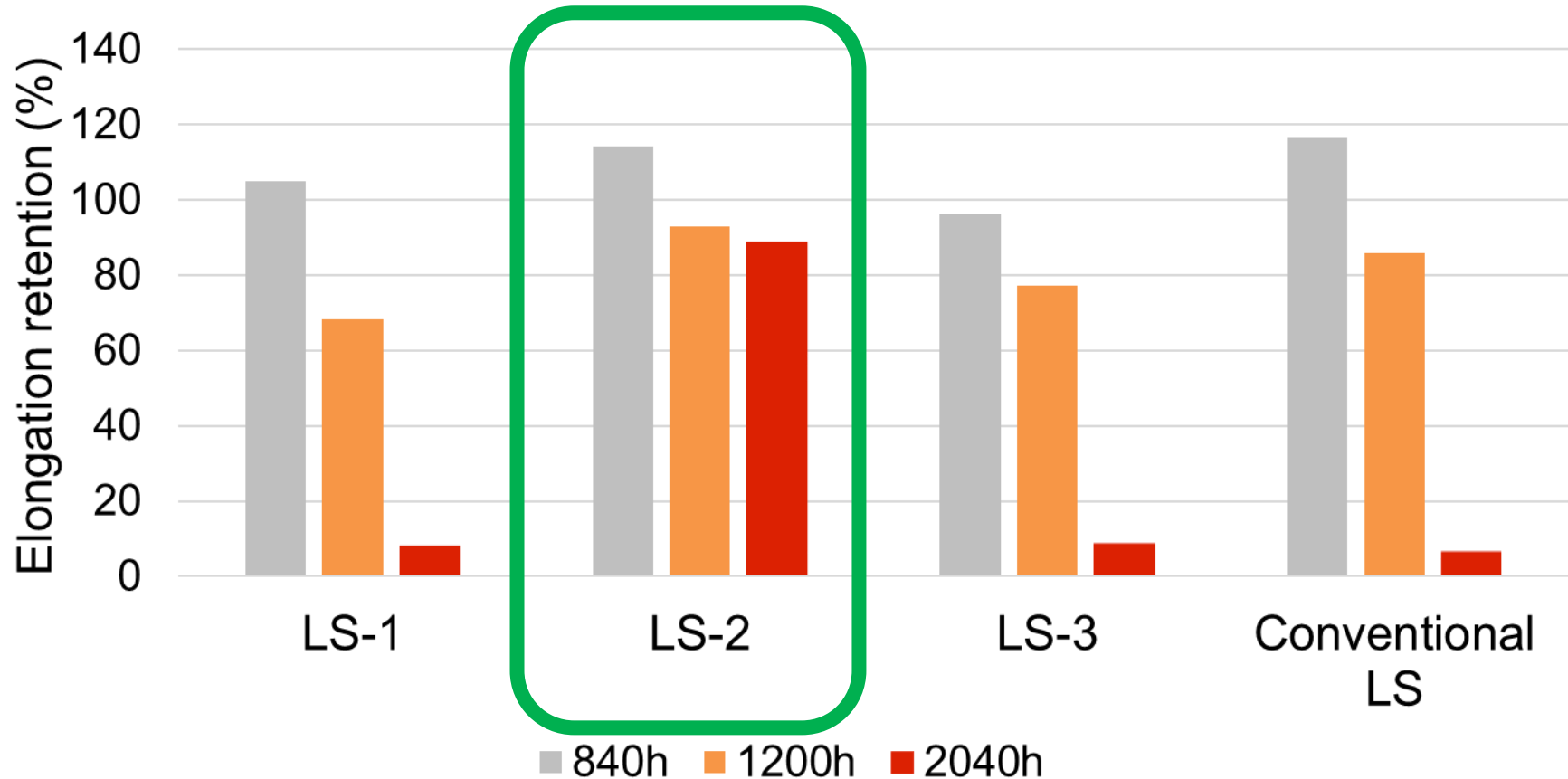


LS-2 showed the best weatherability among other LS from tensile strength point of view under severe sulfur fumigation condition



# Weatherability ~Elongation retention~

With severe sulfur fumigation



LS-2 showed the best weatherability among other LS from tensile elongation point of view under severe sulfur fumigation condition

# Summary-1

Sulfur fumigation condition...

With the following condition, 4,000ppm sulfur content at 3,000 hours exposure were achieved to simulate severe condition

- Amount of sulfur : 5.0 g
- Heat condition : 160 °C, 4 hours
- Sulfur fumigation cycle : Every 120 hours of exposure

Advanced Light Stabilizer, **LS-2** could provide...

- Better initial color stability
- No negative influence on transparency
- No issue on weatherability with no sulfur condition
- **The best weatherability** under severe sulfur condition

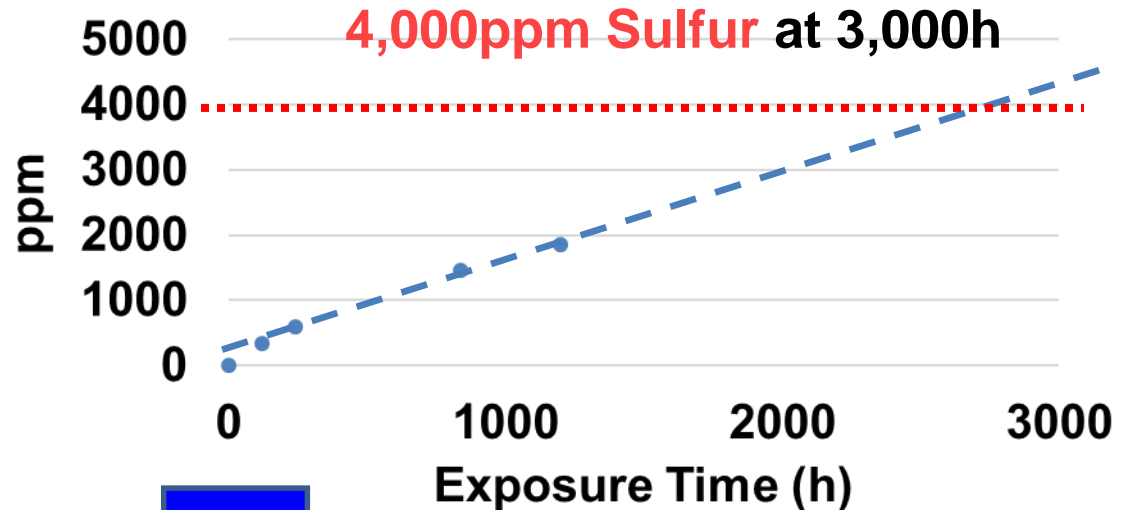
# Medium sulfur fumigation condition

## Severe

### Sulfur fumigation conditions

- Amount of sulfur : 5.0 g
- Heat condition : 160 °C, 4 h
- Sulfur fumigation cycle :

Once per **120h** exposure

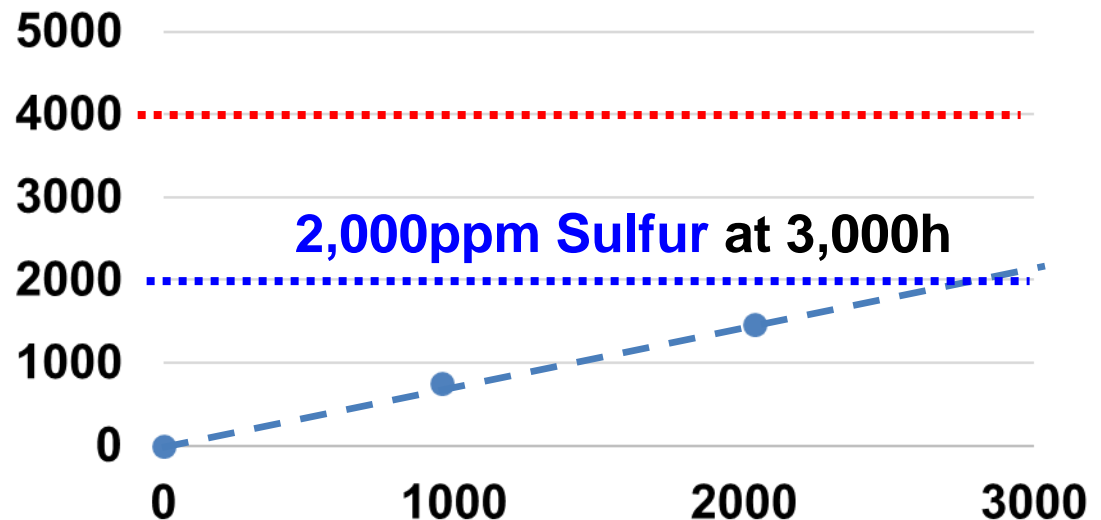


## Medium

### Sulfur fumigation conditions

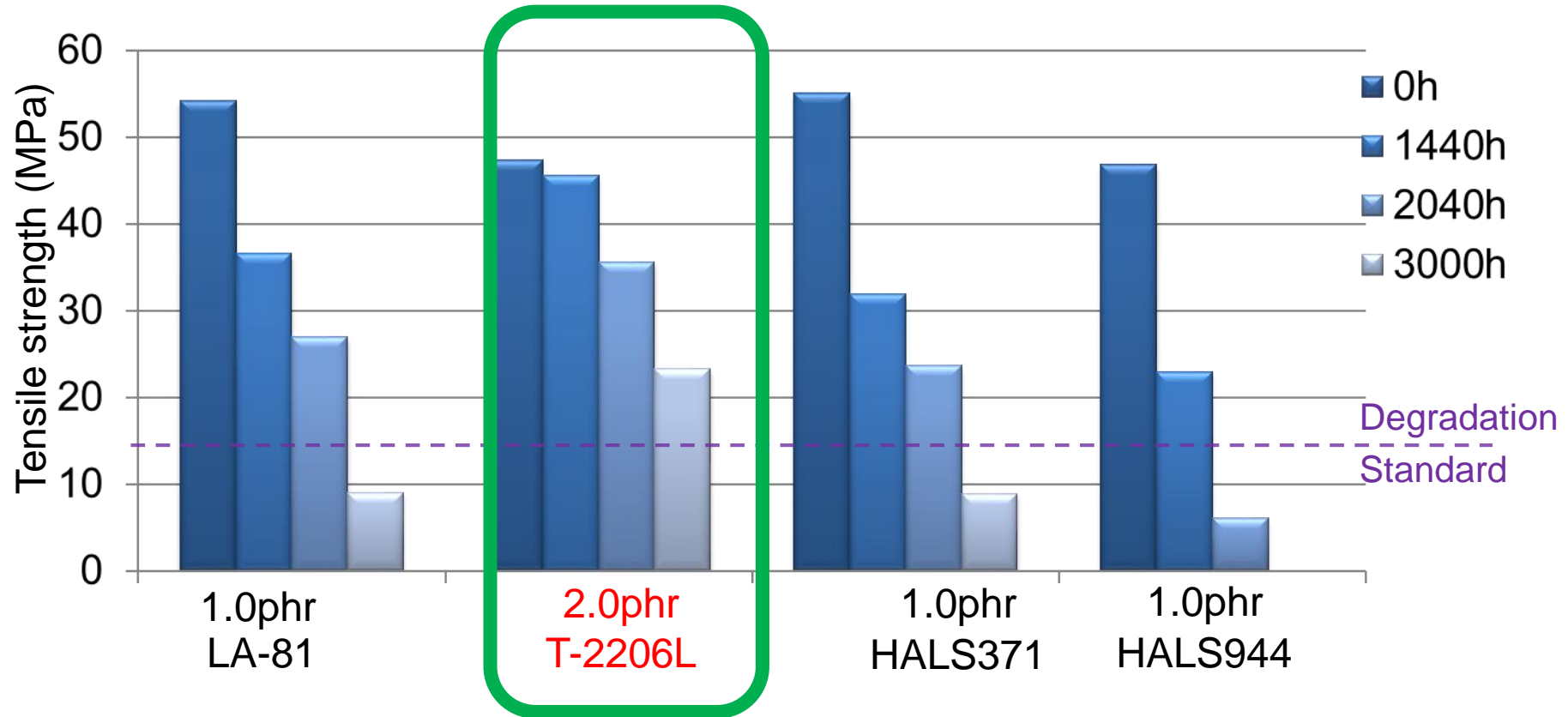
- Amount of sulfur : 5.0 g
- Heat condition : 160 °C, 4 h
- Sulfur fumigation cycle :

Once per **360h** exposure



# Weatherability ~Tensile strength~

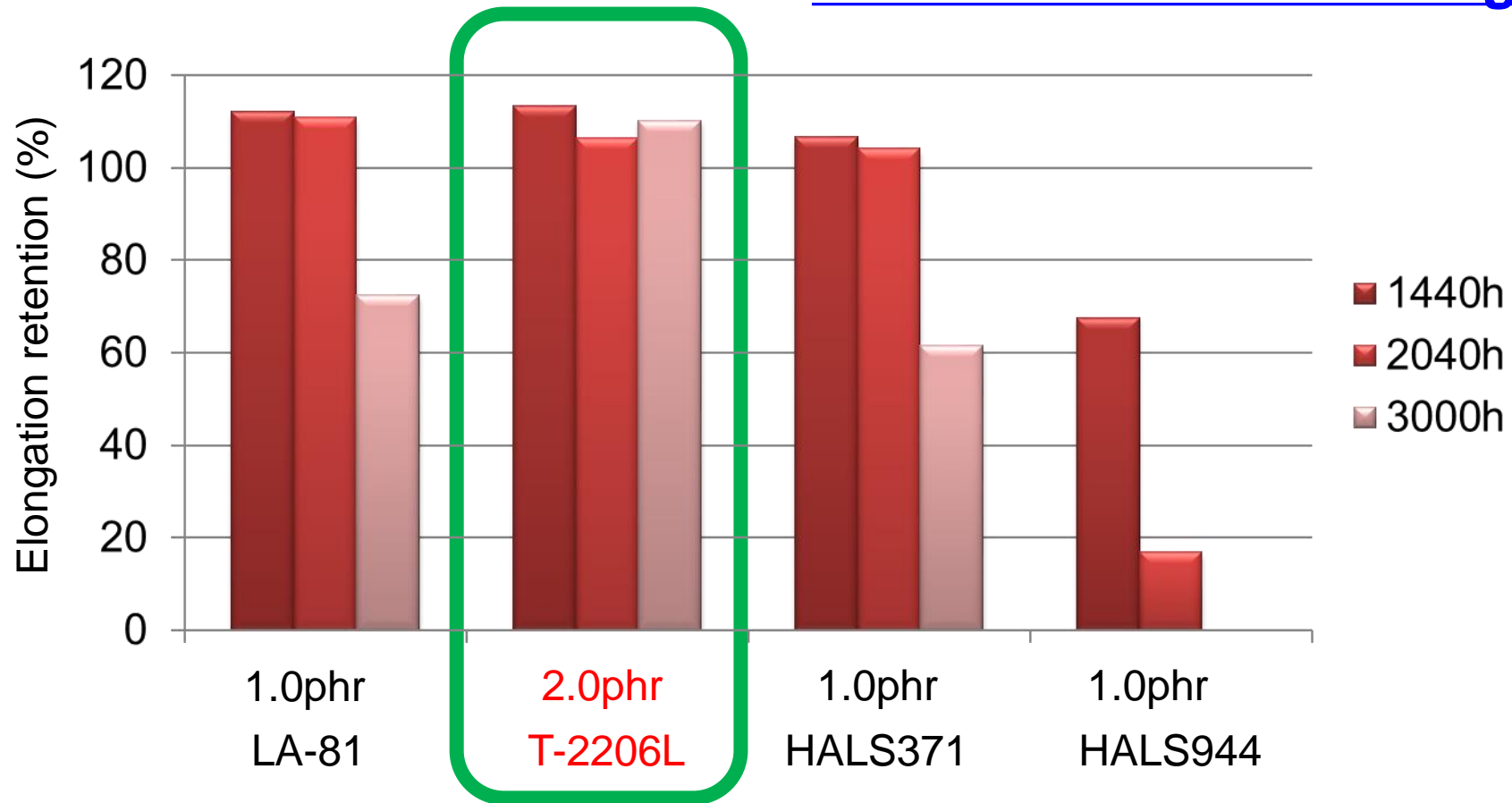
With medium sulfur fumigation



LS-2 showed the best weatherability among other LS from tensile strength point of view under medium sulfur fumigation condition as well

# Weatherability ~Elongation retention~

With medium sulfur fumigation



LS-2 showed same weatherability as LS-1 and LS-3 from tensile elongation point of view under medium sulfur fumigation condition

# Summary-2

Sulfur fumigation condition...

With the following condition, 4,000ppm sulfur content at 2,000 hours exposure were achieved to simulate medium condition

- Amount of sulfur: 5.0 g
- Heat condition: 160 degree C, 4 hours
- Sulfur fumigation cycle: Every 360 hours exposure

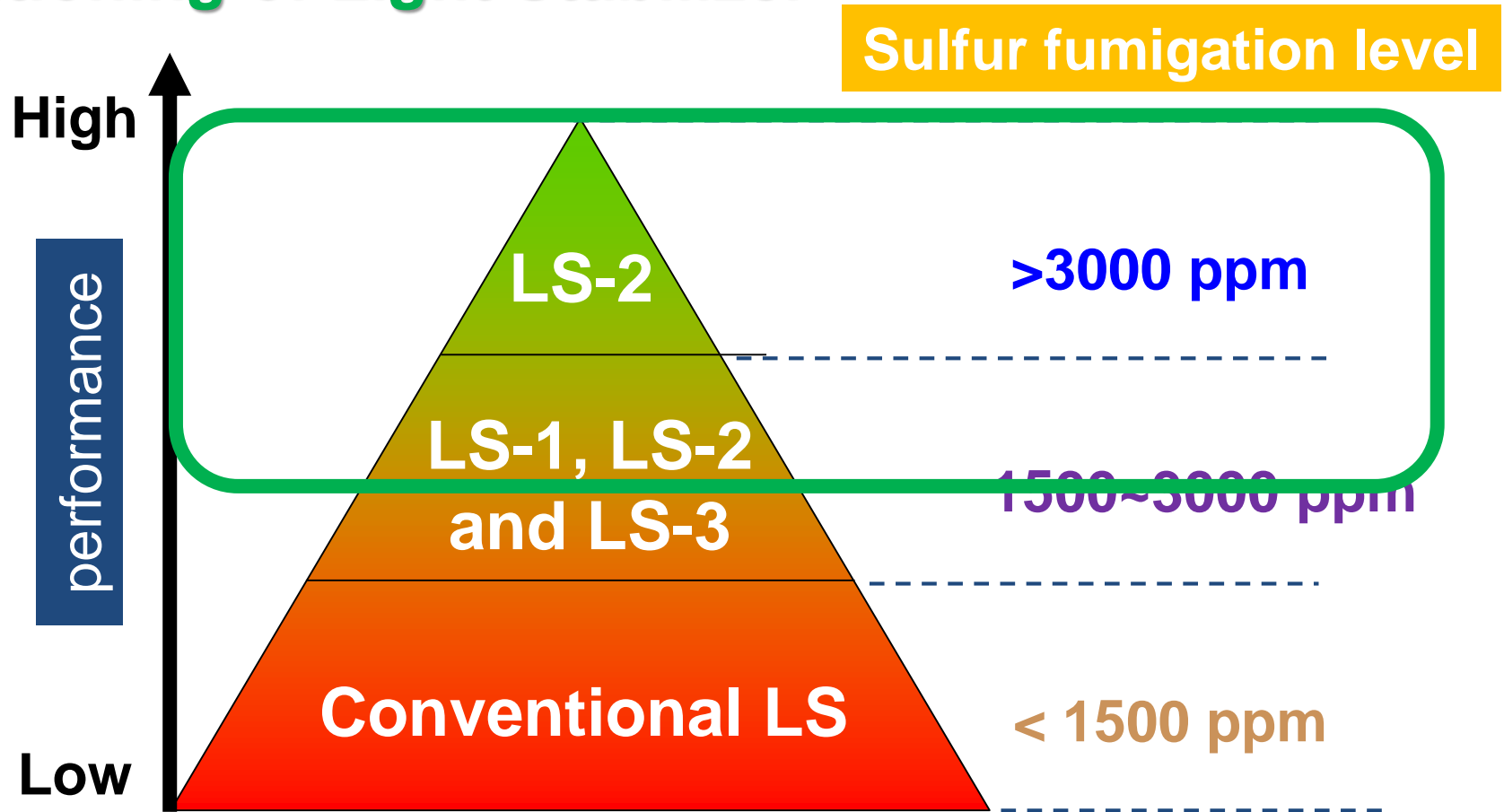
Advanced Light Stabilizer, **LS-2** could provide...

- **The best weatherability** under medium sulfur condition as well.

# Conclusion

# Conclusion

## Positioning of Light Stabilizer



LS-2 is the most suitable light stabilizer under high sulfur fumigation condition.



Thank you for your attention !