

1 ESLEAM™ 221P

ESLEAM™ 221P is the acidic dispersant with low molecular weight. It is suitable for dispersing metal powders ($< 1\mu\text{m}$), that shows prevention of aggregation and viscosity reduction in the dispersing system.

2 Features

- ◆ Shows excellent dispersing property for metals, **especially for Nickel**, prevents metal powders from aggregation and lowers viscosity in dispersing system.
- ◆ **High active content (100%)**, it does not contain impurities such as alkali metals.
- ◆ Shows **excellent solubility** in various solvents except for water.
- ◆ Shows **good thermal decomposition property**. It decomposes at 500°C in Nitrogen atmosphere.

3 Properties

| Item | Value or Property |
|--|---------------------|
| Active content(%) | 100 |
| Appearance(25°C) | Yellow liquid |
| Nature of Liquid | Acidity |
| Viscosity($\text{mPa}\cdot\text{s}, 25^{\circ}\text{C}$) | Approximately 1,700 |

* Representative values, not values of standard.

4 Solubility

| Solvent | Solubility |
|-----------|------------|
| Water | × |
| Acetone | △ |
| Ethanol | ○ |
| Terpineol | ○ |
| Hexane | ○ |
| Toluene | ○ |

* ○:soluble △:emulsification ×:insoluble
(5wt% Solution, at 25°C)

5 Additive amount

The additive amount of ESLEAM™ 221P is normally from 1 to 5wt% (for powder weight). As the optimal additive amount strongly depends on particle size or surface area of powder. We recommend some tests using different amount of the product to determine the optimal additive amount.

6 Regulatory information

| Country | Status |
|------------|---------|
| CSCI (JP) | On list |
| TSCA (US) | On list |
| IECSC (CN) | On list |
| ECL (KR) | On list |
| ECN (TW) | On list |

Please ask us regarding the registration status of REACH for each product

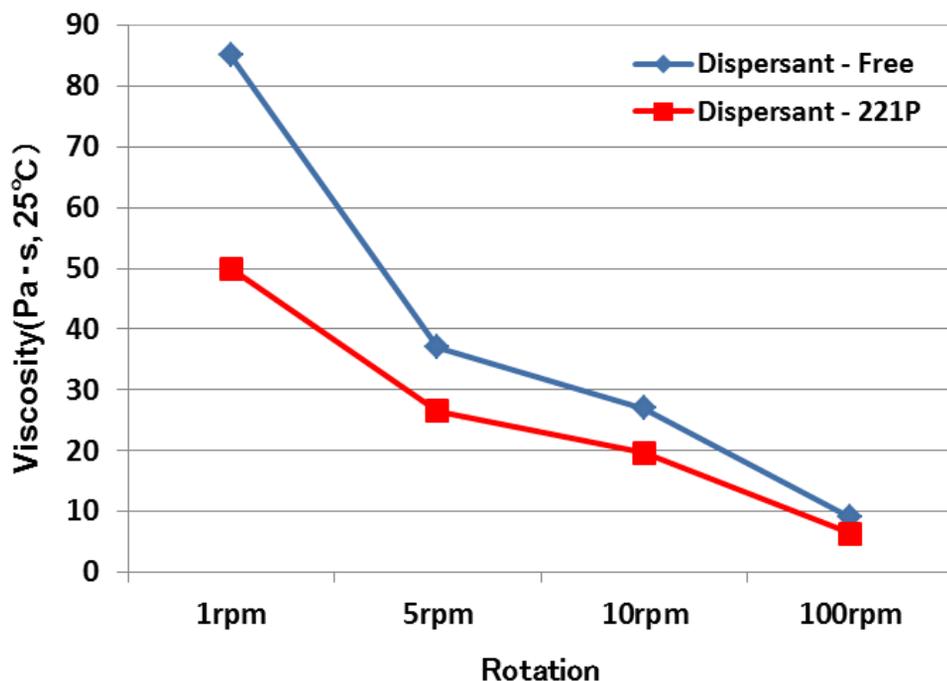
7 Evaluation of Nickel Paste

ONi Paste formulation

| | Product name /Chemical name | Concentration (wt%) | Remarks |
|-------------------------------|---------------------------------|------------------------|---|
| Dispersant | ESLEAM™ 221P | 1.0 | 2wt% for amount of Ni and additive |
| Metal Powder | Nickel | 46.0 | — |
| Additive | Barium Titanate (BT-01) | 4.6 | 10wt% for amount of Ni |
| Resin (Binder Conc.; 8wt%) | Vehicle | 28.8 | 2.3wt% as binder conc. (Ethyl Cellulose) |
| Solvent | Dihydroterpineol Acetate (DHTA) | Balance | — |

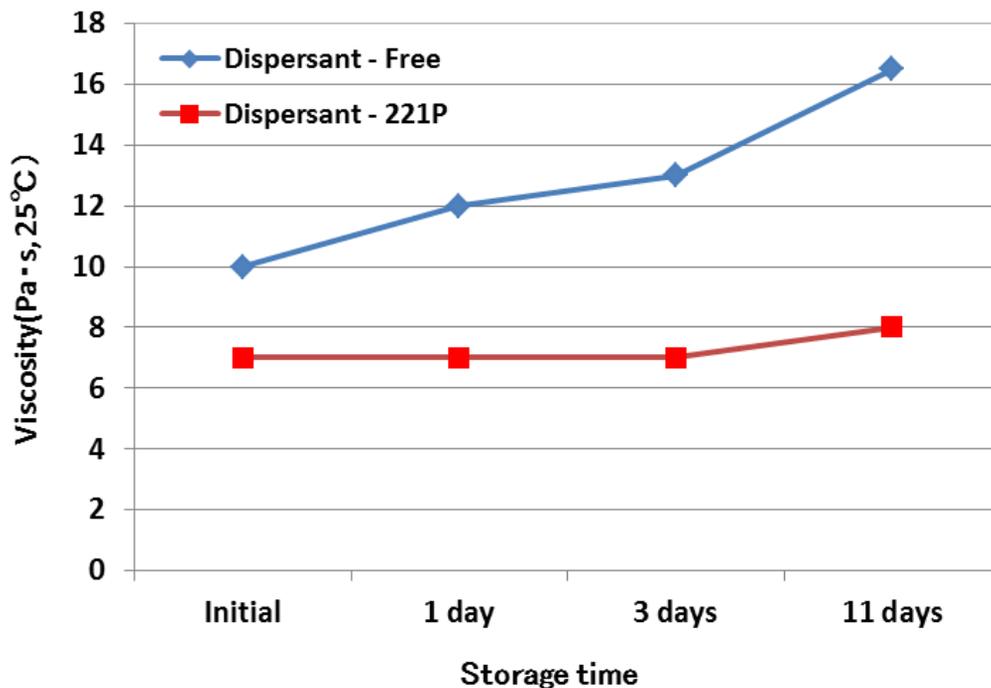
○The Effect of Viscosity Reduction in Nickel Paste

| Dispersant | Viscosity(Pa·s) | | | | Viscosity Ratio (10rpm/100rpm) |
|------------------------------------|-----------------|------|-------|--------|-----------------------------------|
| | 1rpm | 5rpm | 10rpm | 100rpm | |
| Dispersant Free | 85.0 | 37.0 | 27.0 | 9.0 | 2.9 |
| ESLEAM™ 221P (2wt% for pigment) | 50.0 | 26.5 | 19.6 | 6.4 | 3.1 |



ESLEAM™ 221P gives moderate thixotropy and viscosity reduction

○The Stability of Viscosity in Nickel Paste



ESLEAM™ 221P stabilizes the viscosity

○The Stability of Homogeneity in Nickel Paste (after 24 hours)



Dispersant Free



Separation



ESLEAM™ 221P
(1.2 wt%)



Consistent



ESLEAM™ 221P
(2.0 wt%)

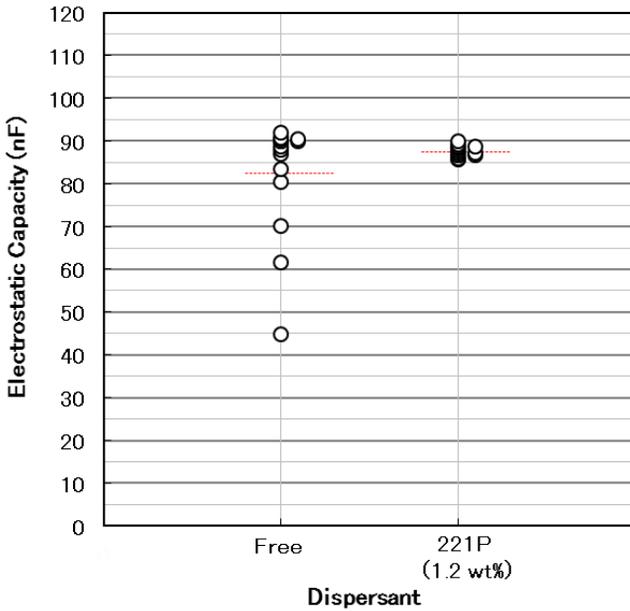


Consistent

ESLEAM™ 221P shows excellent dispersion stability

8 Evaluation for MLCC (Multi-Layer Ceramic Capacitors)

○ Electrostatic Capacity for MLCC



【Composition of Ni Paste】

| Run | Dispersant | Ni Concentration |
|-----|-----------------------|------------------|
| 1 | Dispersant Free | 36.8 wt% |
| 2 | 221P (1.2 wt% for Ni) | 37.0 wt% |

【Characteristics of MLCC】

| Run | Ni Deposition Amount | Electrostatic Capacity (Ave.) | Variability (Ave./3σ) |
|-----|------------------------|-------------------------------|-----------------------|
| 1 | 3.4 mg/cm ² | 82.5nF | 49.1% |
| 2 | 3.5 mg/cm ² | 87.5nF | 4.5% |

ESLEAM™ 221P reduces variability in electrostatic capacity

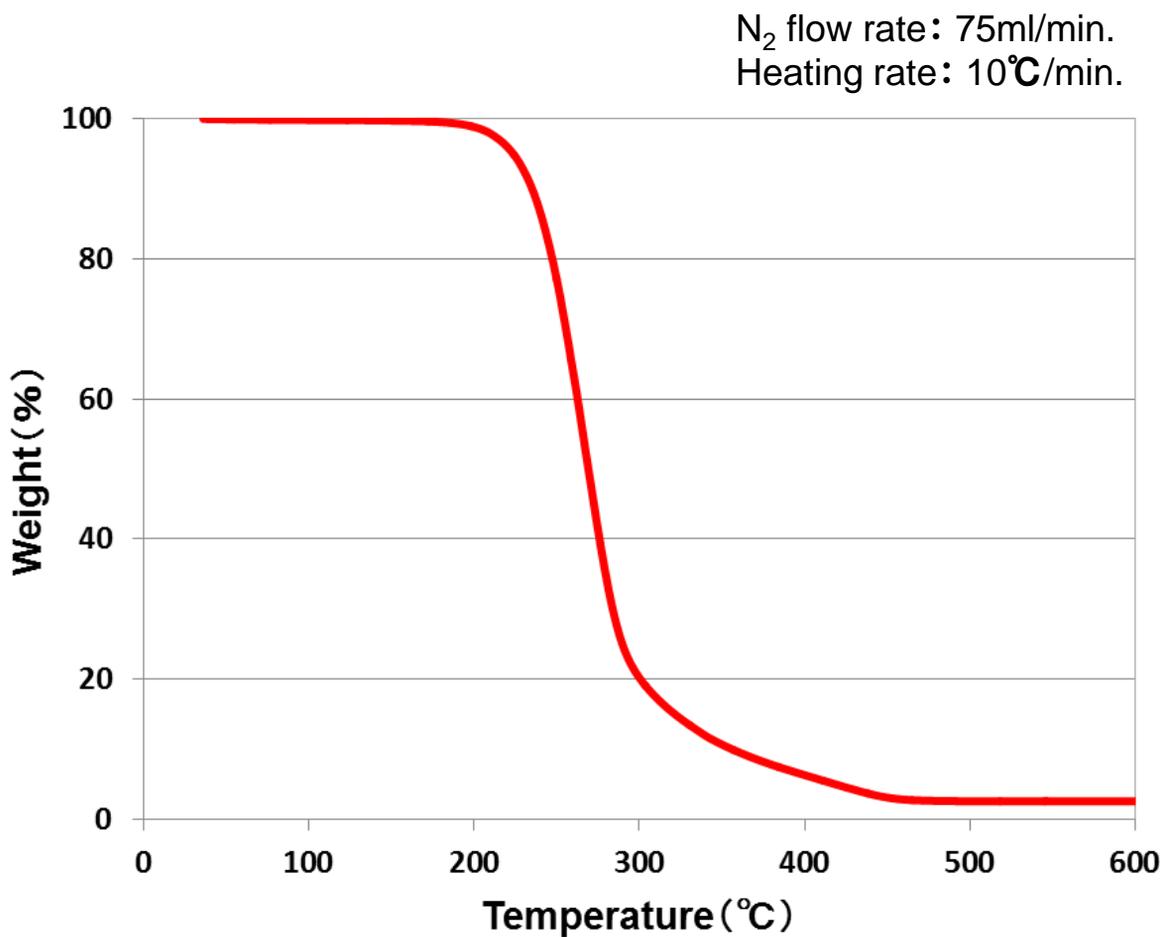
○ Cross Section Image of MLCC

| Dispersant in Ni Paste | Cross Section Image (1) 10μm | Cross Section Image (2) 10μm |
|--|---------------------------------|---------------------------------|
| Dispersant Free (Ni Deposition Amount : 0.34mg/cm ²) | | |
| 221P / 1.2 wt% (Ni Deposition Amount : 0.35mg/cm ²) | | |
| 221P / 2.0 wt% (Ni Deposition Amount : 0.34mg/cm ²) | | |

ESLEAM™ 221P gives excellent continuity in nickel electrode layers

9**Thermal decomposition properties**

ESLEAM™ 221P shows **good thermal decomposition property**.
It decomposes at 500°C in Nitrogen atmosphere.



10 Caution on handling

For more detail, please refer to Safety Data Sheet (SDS).

11 Other Information

This leaflet has been published based on the best effort in NOF CORPORATION's research, however, the evaluation result mentioned in this leaflet can not be assured. And it is necessary to handle this material carefully since all chemicals may have unknown hazardous properties. Please arrange the safe condition of use in the responsibility of each user. And if this material is used in the specific condition, please prepare for the safety measure which is suitable for the application, then use this material.

Please refer to our sales representative for any other questions.



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