Vision 2025 for Additives

– New Technology for Polypropylene –

Dr. Naoshi Kawamoto
Head of Polymer Additives R&D
ADEKA Corporation
Approx.

68 million MT

Even just as conventional antioxidants...

over 100,000 MT
A History of Polypropylene and Additives

Polymer additives development together with PP development

- Nucleating/Clarifying agent ↓
  - UVA
- Antioxidant ↓
  - HALS

Innovation with passage of time


- Ziegler–Natta Catalyst ↑
- Supported Ziegler–Natta catalyst ↑
- Bulk polymerization process ↑
- Gas–Phase polymerization process ↑
- Metalloocene Catalyst ↑
- Post-Metallocene Catalyst ↑
Innovation of Polymer Additives by ADEKA

- NA-11: Nucleating agent
- NA-21: Clarifier
- NA-71
- NA-05
- NA-27: New benchmark N.A.

1970
1980
1990
2000
2010

- LA-11: Nucleating agent
- LA-27: New benchmark N.A.
- LA-57: HALS
- LA-52
- LA-402XP
- LA-68
- LA-63P
- LA-F70
- LA-81: NO-Alkyl HALS
- FP-2000 series: Flame retardant
ADEKA Additives – For All Kinds of Polymers

**Antioxidant**
- Phenolic
- Phosphate
- Thioether

**Light Stabilizers**
- UV Absorber
- HALS

**Metal Deactivators**
- Metal deactivator
- Additives for filled polymer

**Nucleating Agents**
- Nucleator
- Clarifier

**PVC Stabilizers**
- Ca–Zn
- Ba–Zn

**Flame Retardant**
- Phosphate ester type
- Intumescent type

**Plasticizers**
- Epoxy type
- Polymeric type
- Trimellitate type
- Specialty for Rubber
Production Process Innovation

- Catalyst
- Donor
- Polymerization
- Extruder & Additivation
- Molding

Added before pelletizing/molding
No progress for almost 60 years!

Now Adeka introduces Paradigm-Shift in Additives Addition into Polymerization Reactor In-Situ Technology
Addition of Polymer Additives into Polymerization stage

This In-situ technology promises extreme-dispersion of polymer additives into polymer matrix, resulting in maximizing the performance of polymer additives!

ADEKA’s newly developed “In-situ technology” allows direct addition into catalyst/polymerization stage without any drawbacks like catalyst deactivation, operation issue of plant...
Benefits of In-situ Technology

✓ Cost & Material Saving (Additives cost)
   Additives: over $700,000/y (In-situ stabilization, 250kt plant)

✓ Realize ultimate properties that never achieved by current technology
   Extending application range of PP
   Promises weight reduction, resulting in improving fuel efficiency

✓ Environmentally friendly
✓ Minimize the toxicological issue
   (due to low phenol content)

All-plastic made automobile
In-situ Stabilization

- Direct addition of Antioxidants into the polymerization reactor

![Chemical structure of T-1215A]

T-1215A
In-situ antioxidant
In-situ Stabilization for Polypropylene

Stabilizer T-1215A (50 ppm) + α (150 ppm)

Compounding
AO-60 500 ppm + 2112 500 ppm

Stability during Processing

\[
\begin{array}{c|ccccc}
\text{Multiple extrusions} & 0 & 1st & 2nd & 3rd & 4th & 5th \\
\hline
M_w (PP) & \text{Compounding} & \text{In-situ} & \text{Compounding} & \text{In-situ} & \text{Compounding} & \text{In-situ} \\
\hline
500k & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
450k & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
400k & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
350k & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
300k & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
\hline
\end{array}
\]

\text{In-situ reactor stabilized PP shows excellent stabilization performance, similar to traditional system but with lower loading level.}

\text{Compounding NO}_x \text{ discoloration}

\text{After exposure}

\text{Initial}

Multiple extrusion by Laboplastmill having twin-screw with 230 °C. All formulations include 500 ppm of CaSt via compounding.
In-situ Nucleation

- Direct addition of Nucleating agent/Clarifier into the polymerization reactor

In-situ nucleator/clarifier precursor

T-186
**In-situ Nucleation for Polypropylene – Lower Dosage**

**In-situ: T-186 (200ppm)**  
In combination with Na source

**Compounding: NA-11 (1000ppm)**

In-situ nucleation demonstrated an excellent nucleation ability (higher crystallization temperature) at a quite lower dosage, below 1/5 loading level of practical dosage of NA-11.
In-situ nucleation technology helps achieve higher crystallization temperature of over 134 °C, which could not be achieved by current technology.
Ultimate Nucleating Ability

Over 2500 MPa could be achieved by in-situ Nucleation.

→ Replace engineering plastics, GF/talc filled PP without weight increase.

Flexural modulus (MPa)

- PP with H-NA*
- PP with L-NA*
- PP with 5% Talc
- PP with 10% Talc
- PP with 15% Talc
- PP Without NA

Density

*H-NA: Sodium 2,2’-Methylenebis-(4,6-di-tert-butyl-phenyl) phosphate
*L-NA: Sodium Benzoate
Well regulated Crystallites

Current nucleation technology

In-situ nucleation

In-situ nucleation enables nuclei generation at higher temperature, and thus crystal-growth process proceeds with higher mobility of polymer chains, resulting in regulating the crystallite, that is, lamellar crystals with fewer defects are formed. As a results, the final product shows ultimate physical and mechanical properties.

T–186 with suitable ion source instead of Na acts as In-situ Clarifier.
General Conclusion

Innovative In-situ technology including both stabilization and nucleation/clarifiers opens new era of PP production technology, and leads to paradigm shift in polymer additives industry.

We ADEKA shall innovate continuously, and we act and advance together with you to realize the Vison 2025 via additives technology.
Thank you very much for listening...

Next year, we ADEKA will celebrate 100 years anniversary. Continuous history of over century is an invaluable sign of trusted partner for all stake holder.