

Gas-free Phenolic Resin For Friction Materials

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Introduction

Requirements for Frictions

1. Low noise
2. Low wear
3. Heat resistance
4. Excellent moldability

Requirements for Environmental Issue

1. Low toxicity
2. Minimal waste
3. Clean work place
4. Low energy

Modified Resins

Reduction of Manufacturing Cost

Method of Reducing Manufacturing Cost

To Reduce Manufacturing Cost

To Reduce Price of Raw Material

To Reduce Price of Phenolic Resin

To Reduce Process

To Reduce Molding Time

To Reduce Post-Curing Time

To Use Fast Cure Resin

To Increase Molding Temperature

Gas-Free Resin

Resin Properties of Phenolic Resin

Property	PR-EPN-12T	PR-54953
Type	Gas-Free	Conventional
Gel Time (150°C, sec)	56	46
Flow (125°C, mm)	19	20
Hexamine Content (%)	0	11

➤ **Hexamine content of PR-EPN-12T is 0%.**

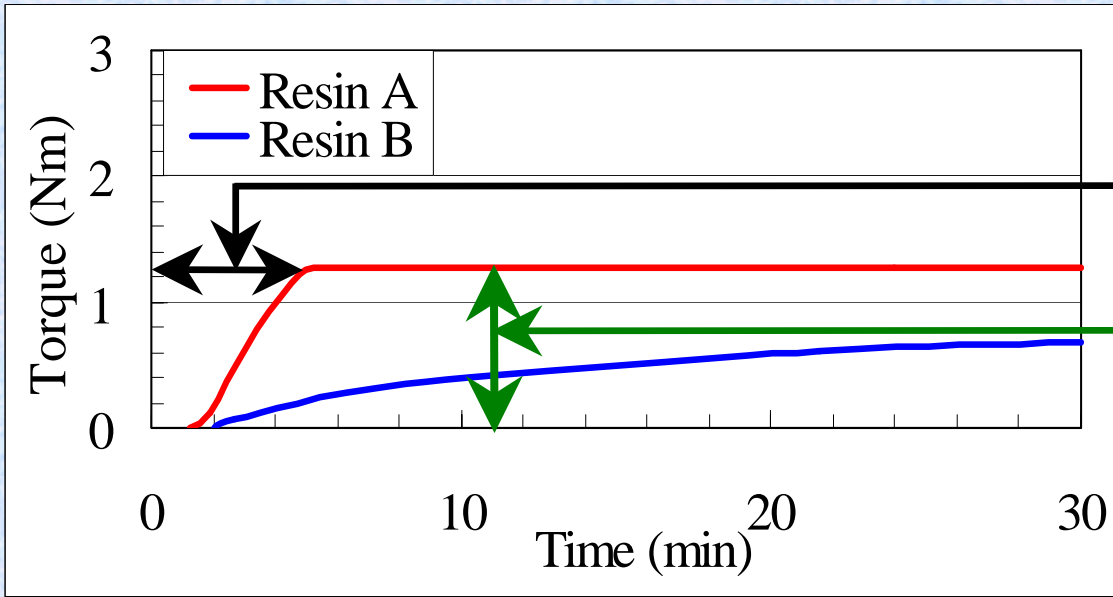
Curing Properties (Equipment)



Torque Detector



Lower Molder

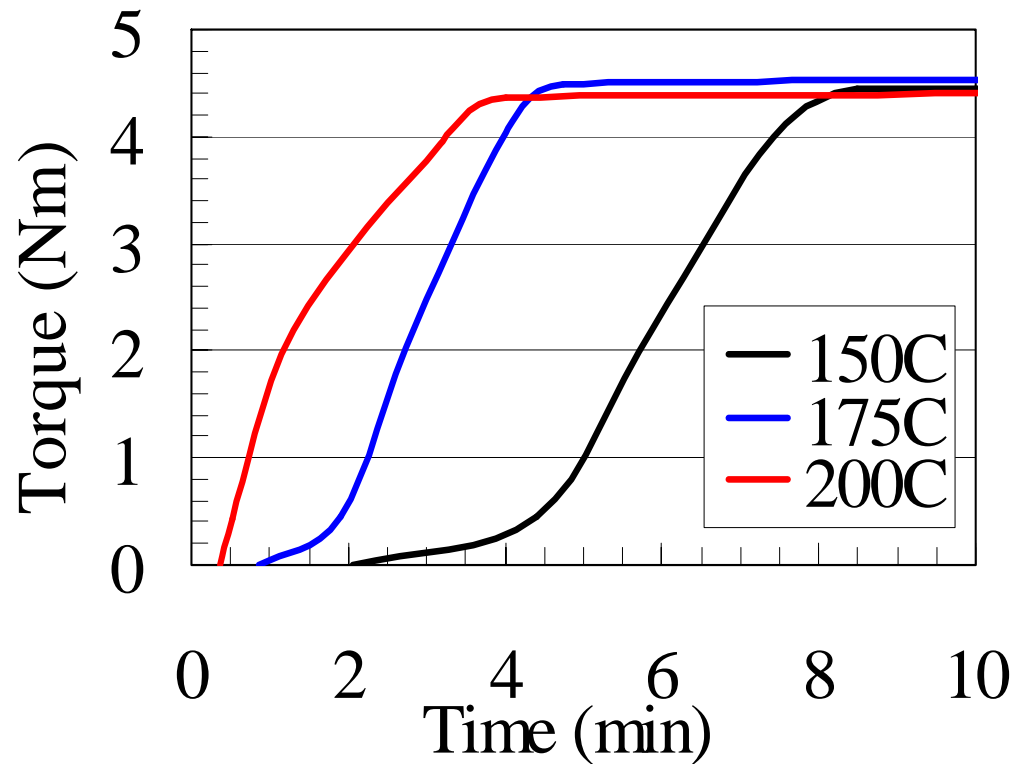


Curing Speed

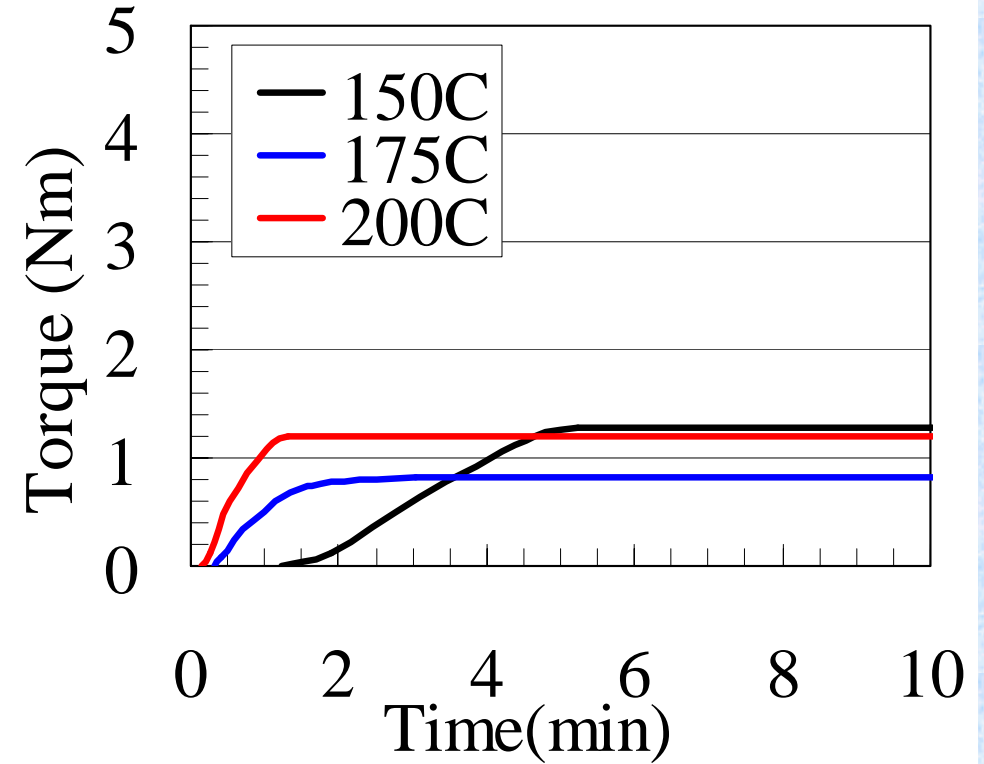
Degree of Cross-linking

Curing Properties (Result)

PR-EPN-12T



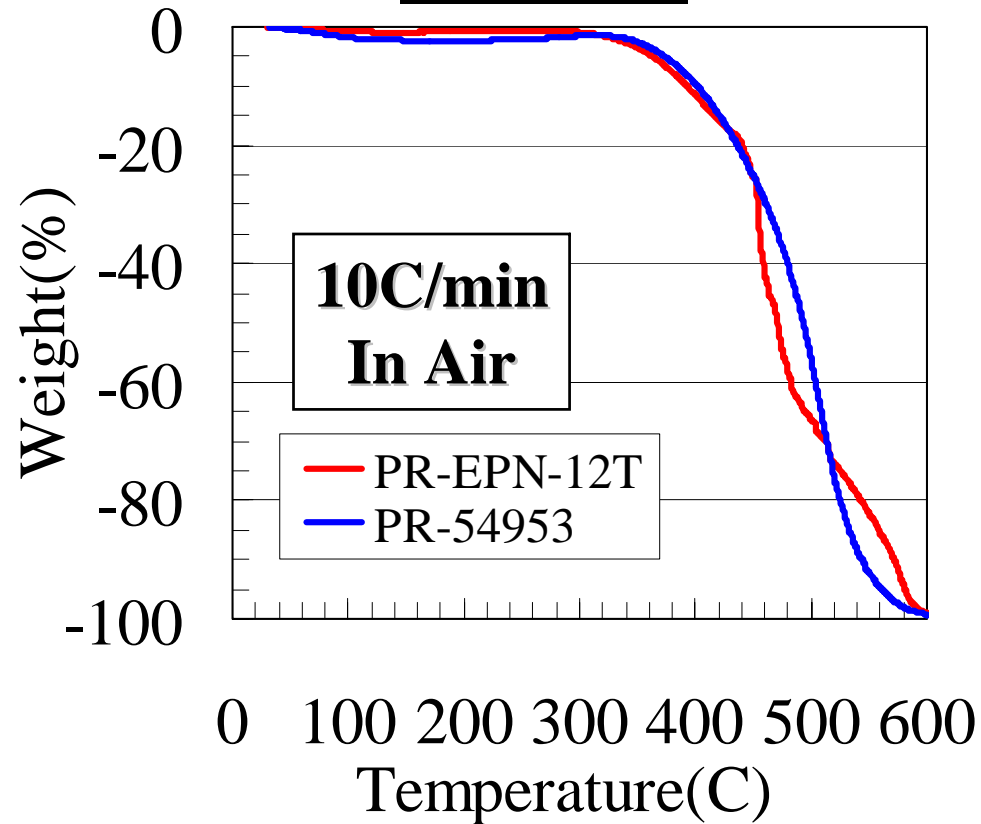
PR-54953



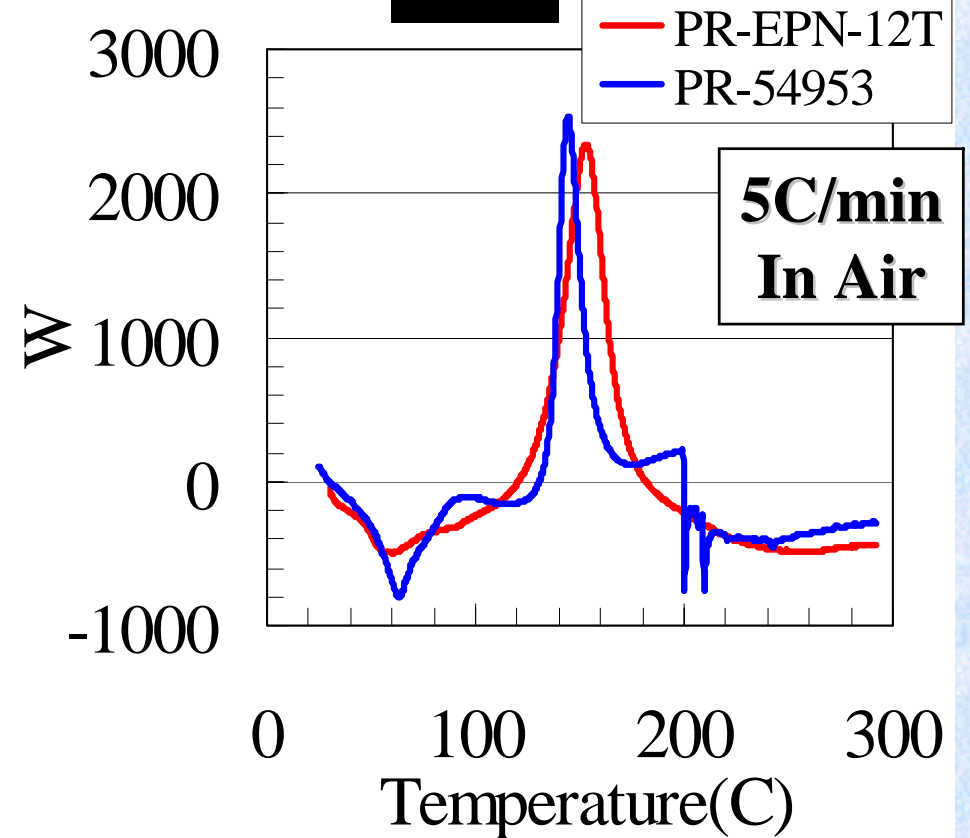
➤ **Cross-linking density of PR-EPN-12T is higher than PR-54953.**

Thermal Properties

TG-DTA

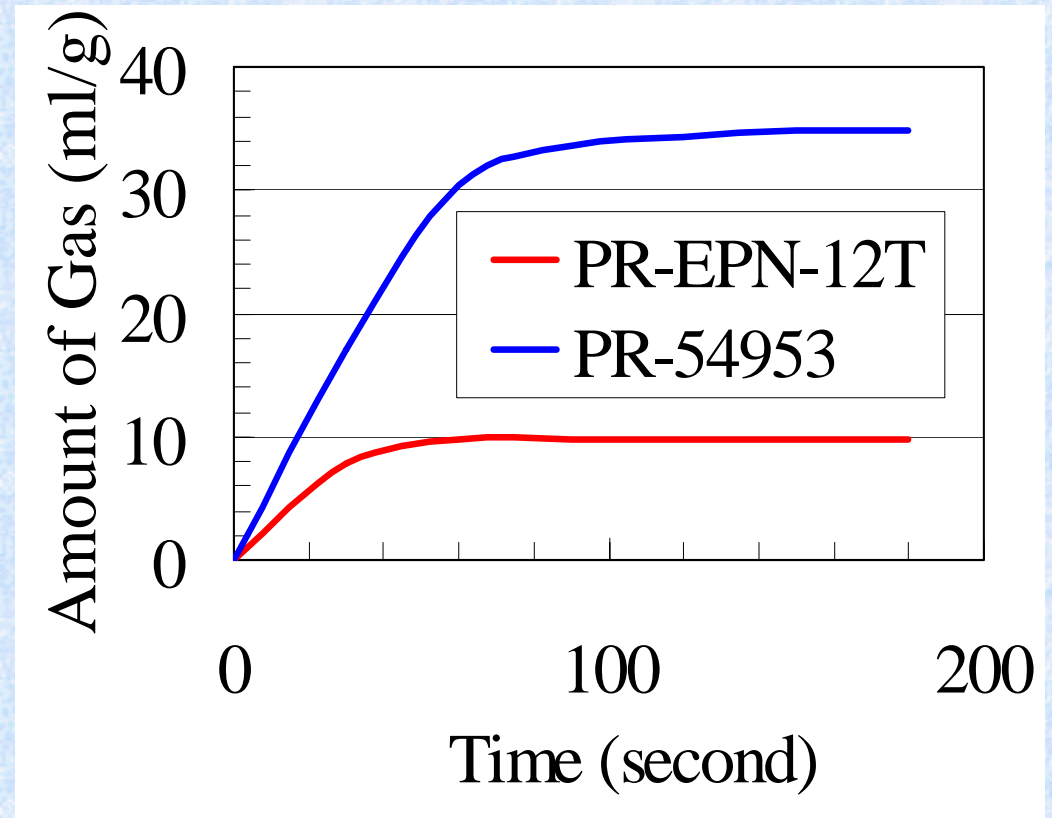
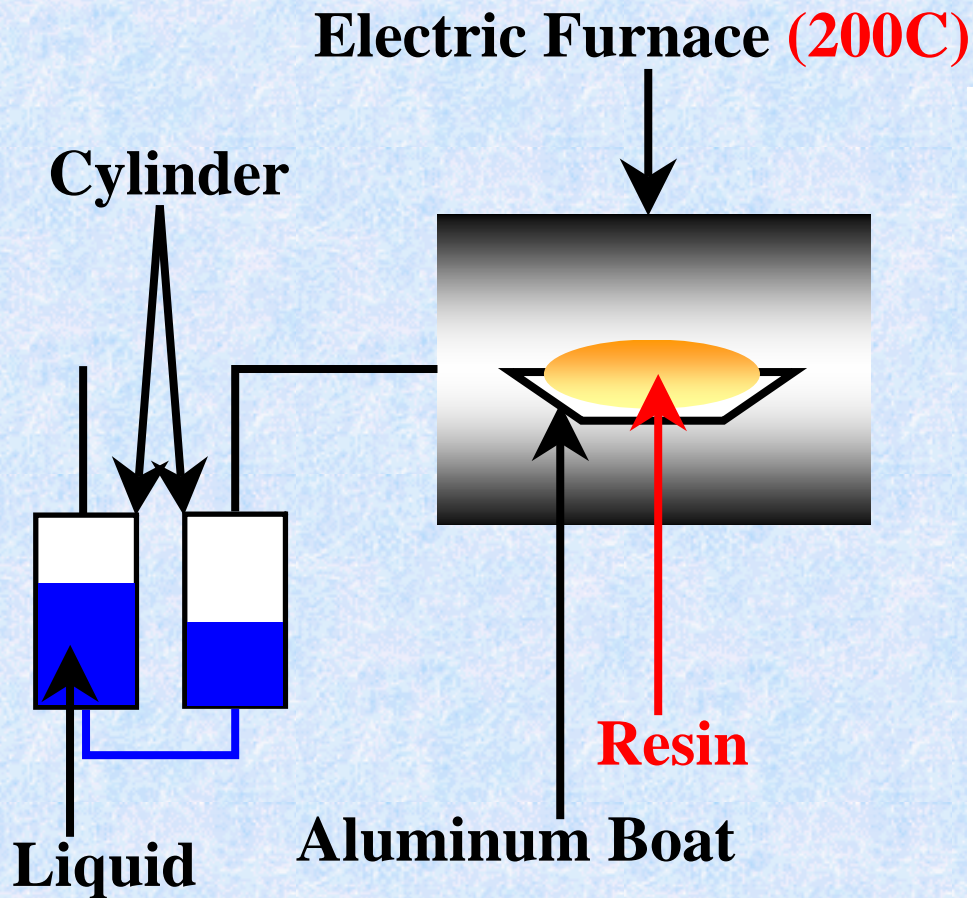


DSC



- Weight loss curve of PR-EPN-12T is similar to PR-54953.
- The DSC peak of PR-EPN-12T is slightly higher than PR-54953.

Amount of Gas During Curing



➤ Amount of gas at PR-EPN-12T was smaller than PR-54953.

Molding and Baking Condition (1)

Test Pieces of Friction Materials Were Prepared as Follows:

**Formula: Resin / Aramid Fiber / Cashew Dust
/Barium Sulfate/Calcium Carbonate
: 8/5/5/40/42 (by weight)**

Mixing: Eirich mixer, 2 min.

Pre-molding: Pressure = 29.4 MPa, Charge=160g

Molding: 150C-245C, 3-8 min.

Gas Release :

PR-EPN-12T: No Release

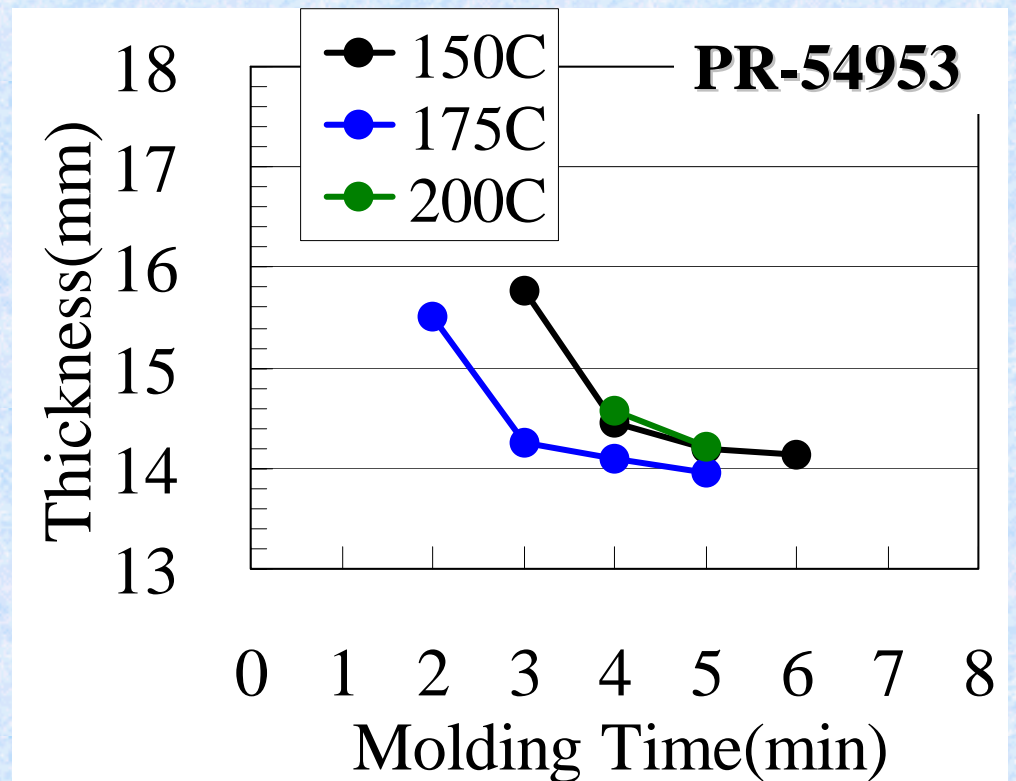
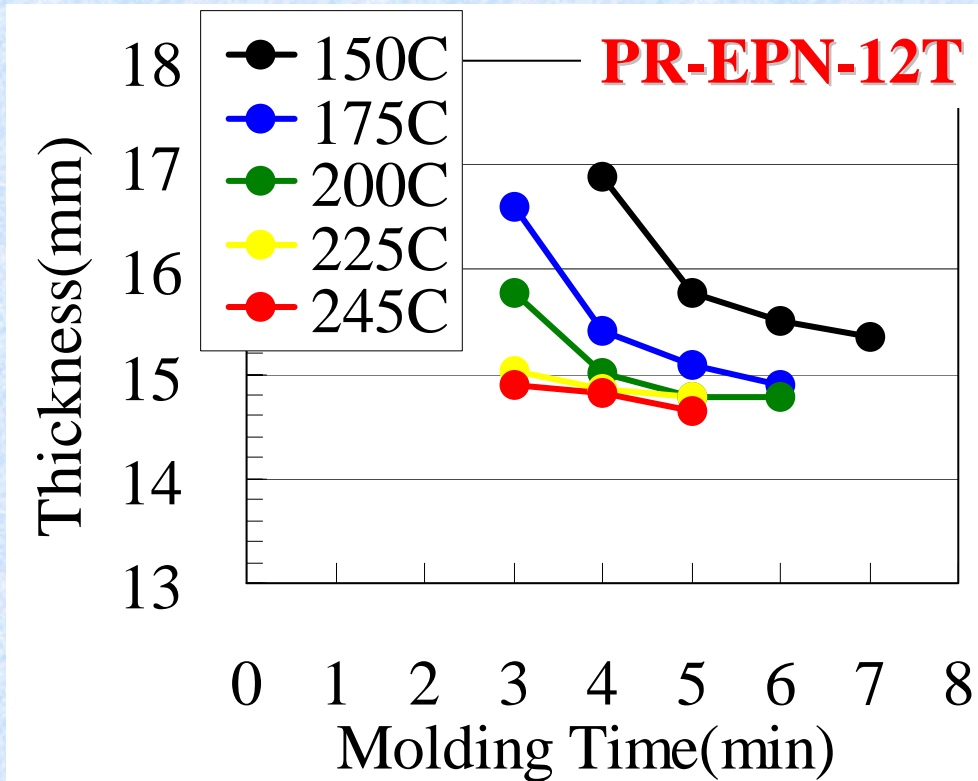
PR-54953 : (5sec+3sec)*5times

Post-Curing : 200C, 5 hr



Molding Equipment

Molding Properties



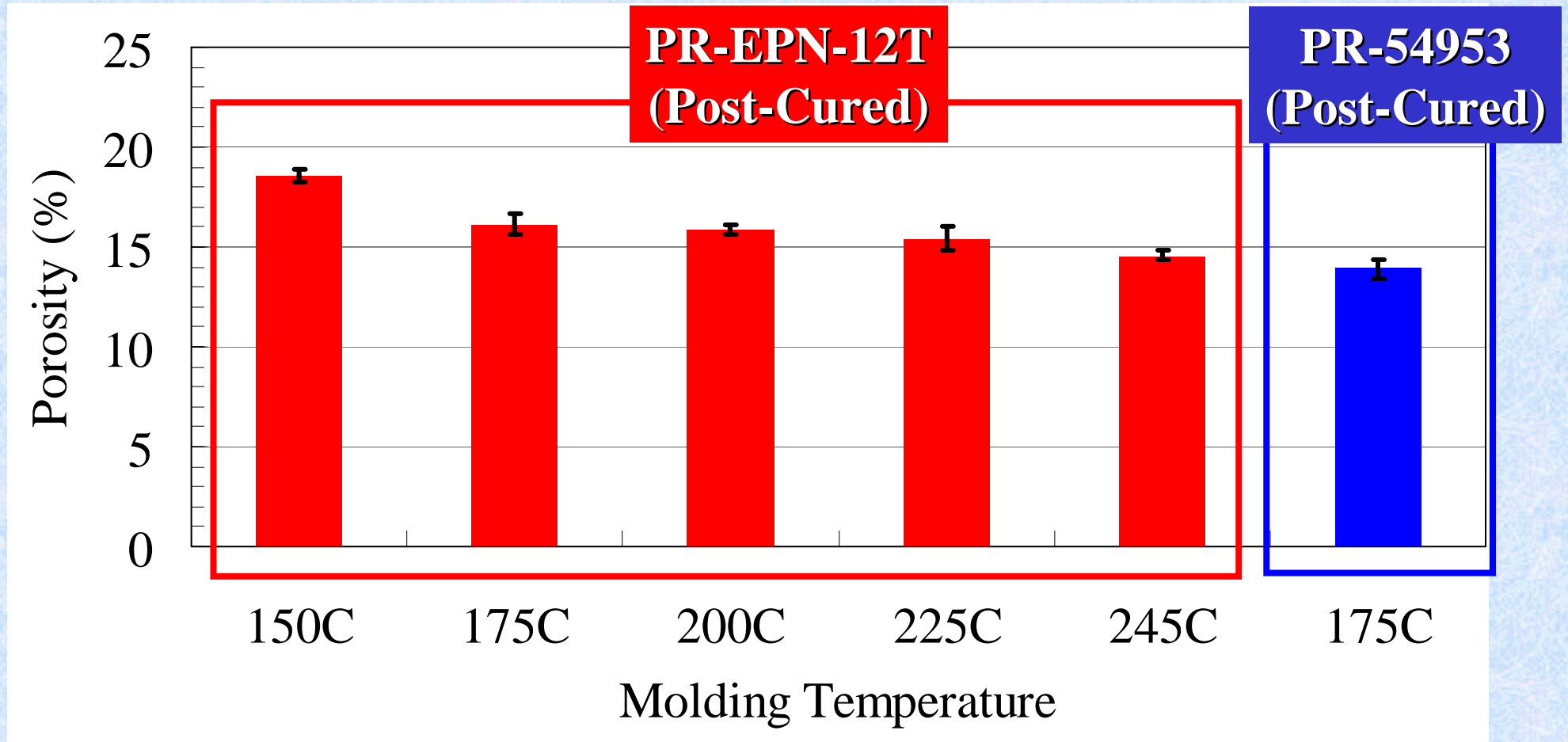
- **PR-EPN-12T** could mold in 3min even 245C.
- **PR-54953** could not mold over 200C.

Sample of Physical and Friction Properties

Resin	PR-EPN-12T					PR-54953
Molding Temperature	150C	175C	200C	225C	245C	175C
Molding Time	7min	6min	5min	3min	3min	5min

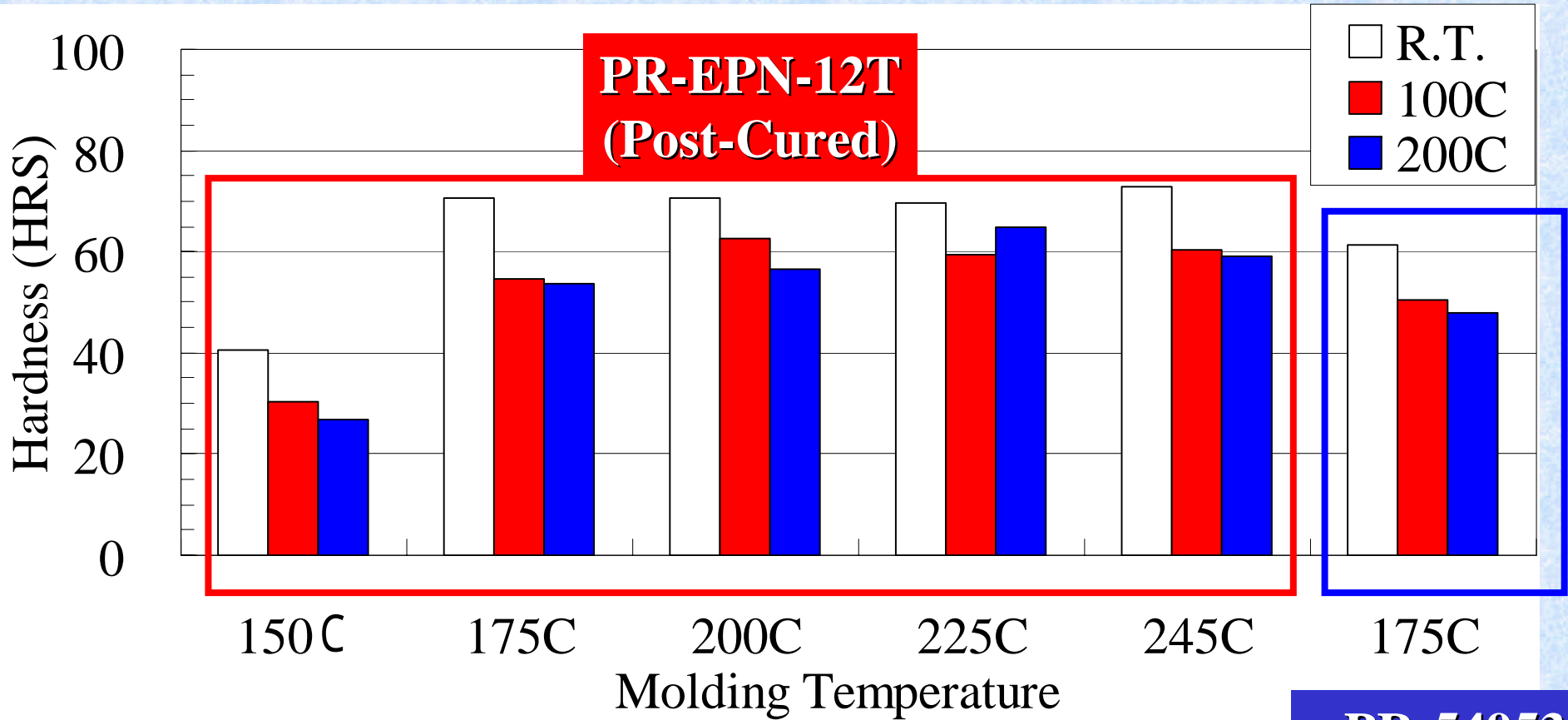
- **We chose the sample in above molding condition for analysis.**
- **We checked**
 - Physical properties; Porosity, Hardness, Flexural Strength**
 - Friction properties; Wear, Friction Coefficient**

Physical Properties (Porosity)



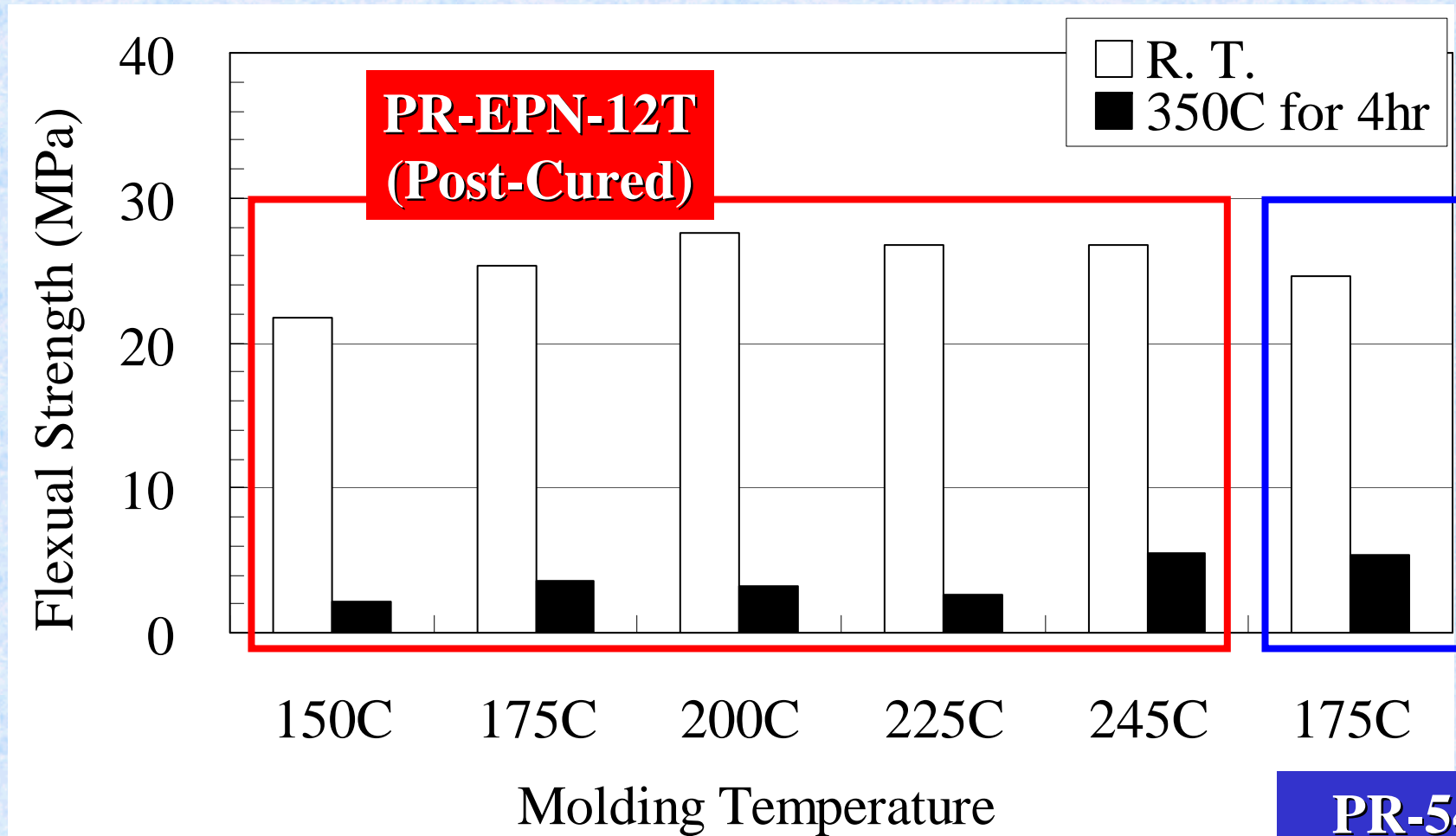
➤ Porosity decreased with increasing molding temperature.

Physical Properties (Rockwell Hardness)



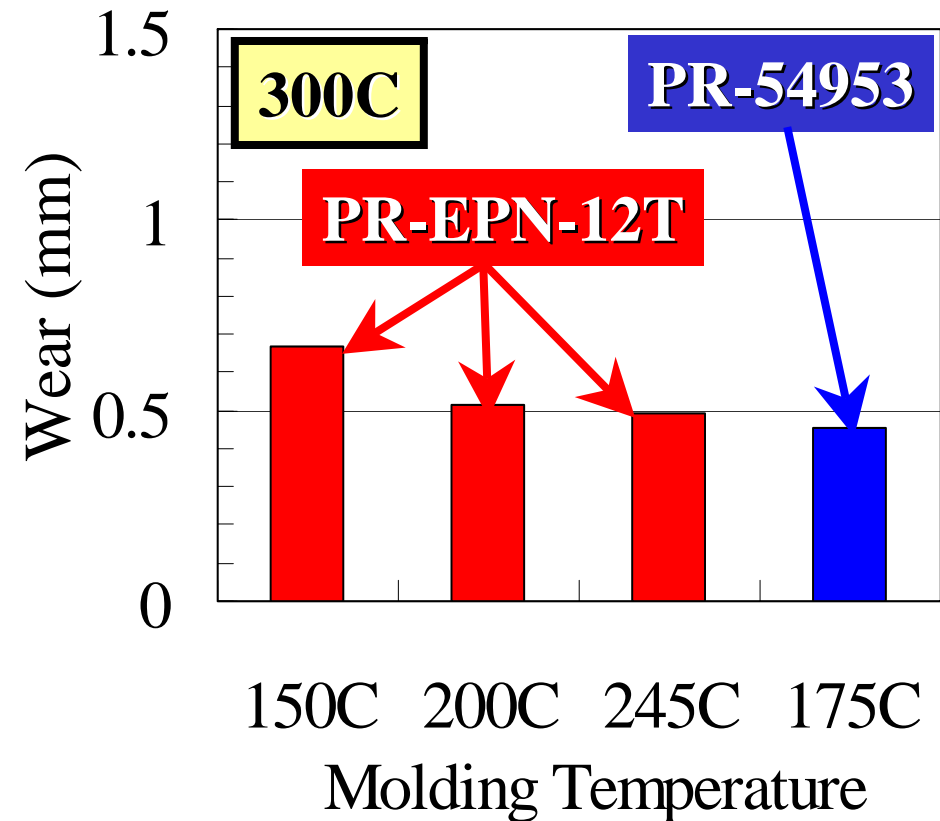
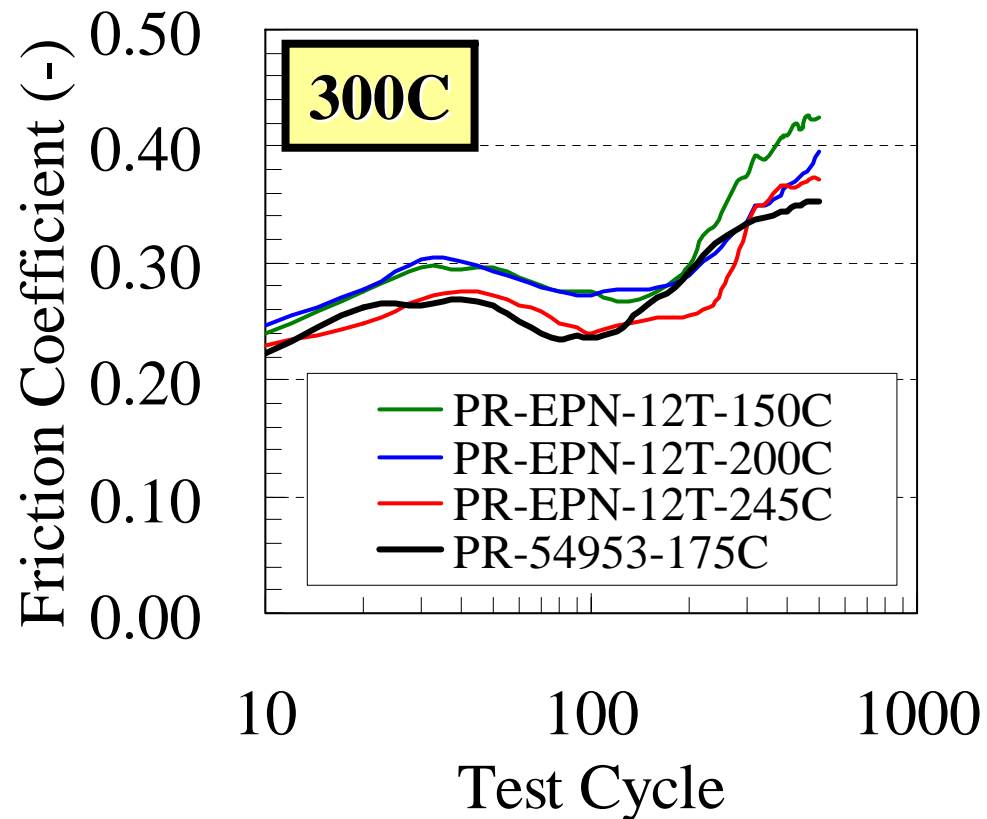
➤ **Hardness increased with increasing molding temperature.**

Physical Properties (Flexural Strength)



➤ Flexural strength increased with increasing molding temperature.

Friction Properties



- No significant change of μ was observed.
- Wear of PR-EPN-12T is slightly higher than PR-54953.

Ammonia Emission during Molding (Equipment)



Gas Detector Tube



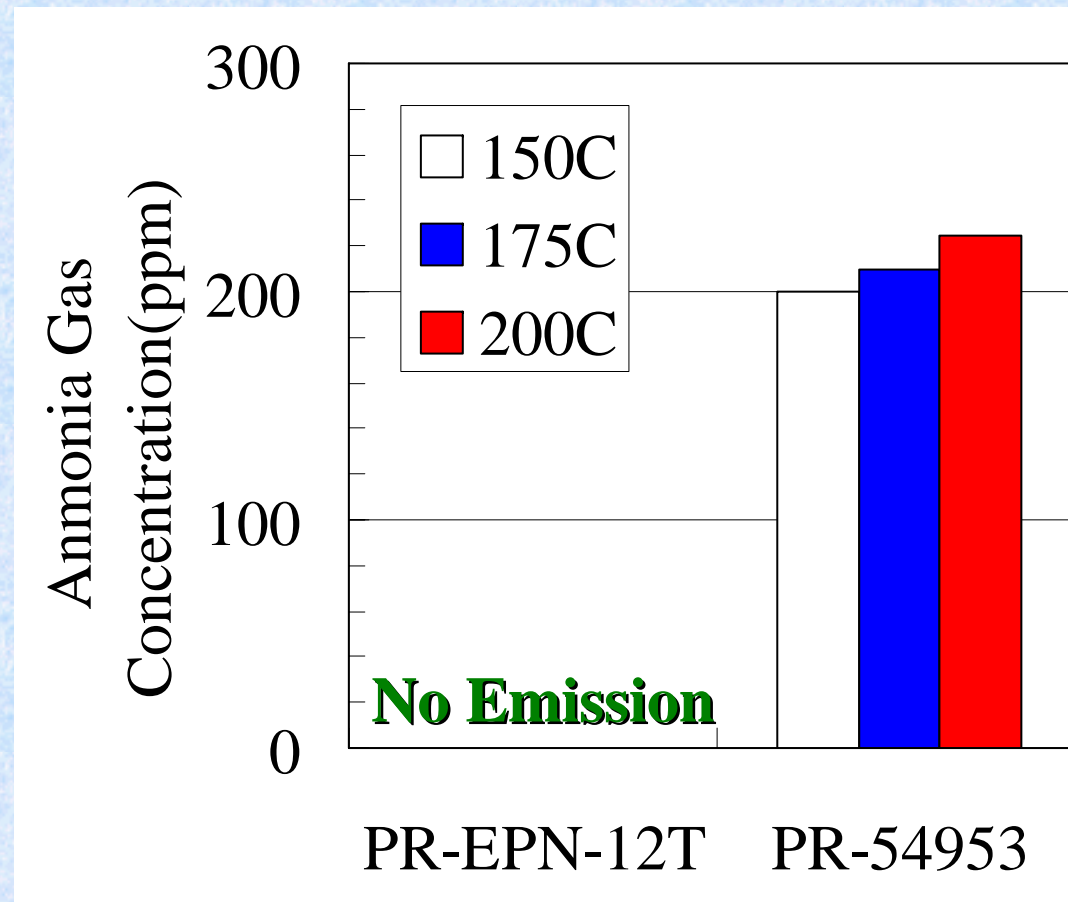
Aspirating Pump



Sampling

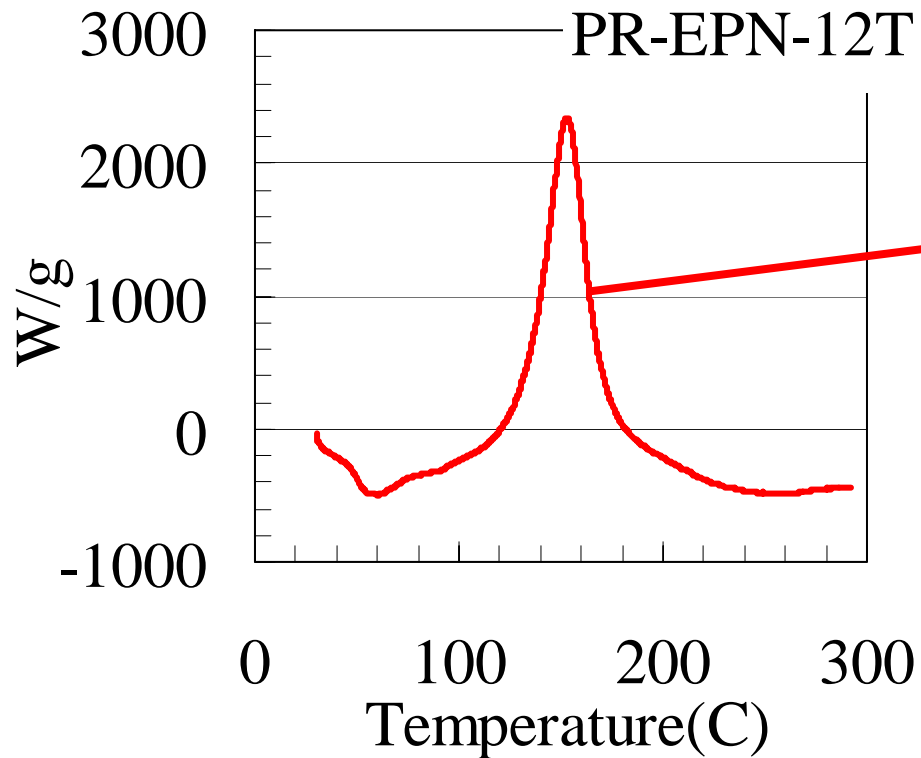
➤ **Gas sampled 20cm above mold.**

Ammonia Emission during Molding (Result)



➤ **PR-EPN-12T do not evolve ammonia gas.**

Can We Eliminate Post-Curing ?



Required energy for curing

177J/g

To introduce enough energy during molding

Can we eliminate post-curing ???

Molding and Baking Condition (2)

Test Pieces of Friction Materials Were Prepared as Follows:

Formula: Resin / Aramid Fiber / Cashew Dust

/Barium Sulfate/Calcium Carbonate

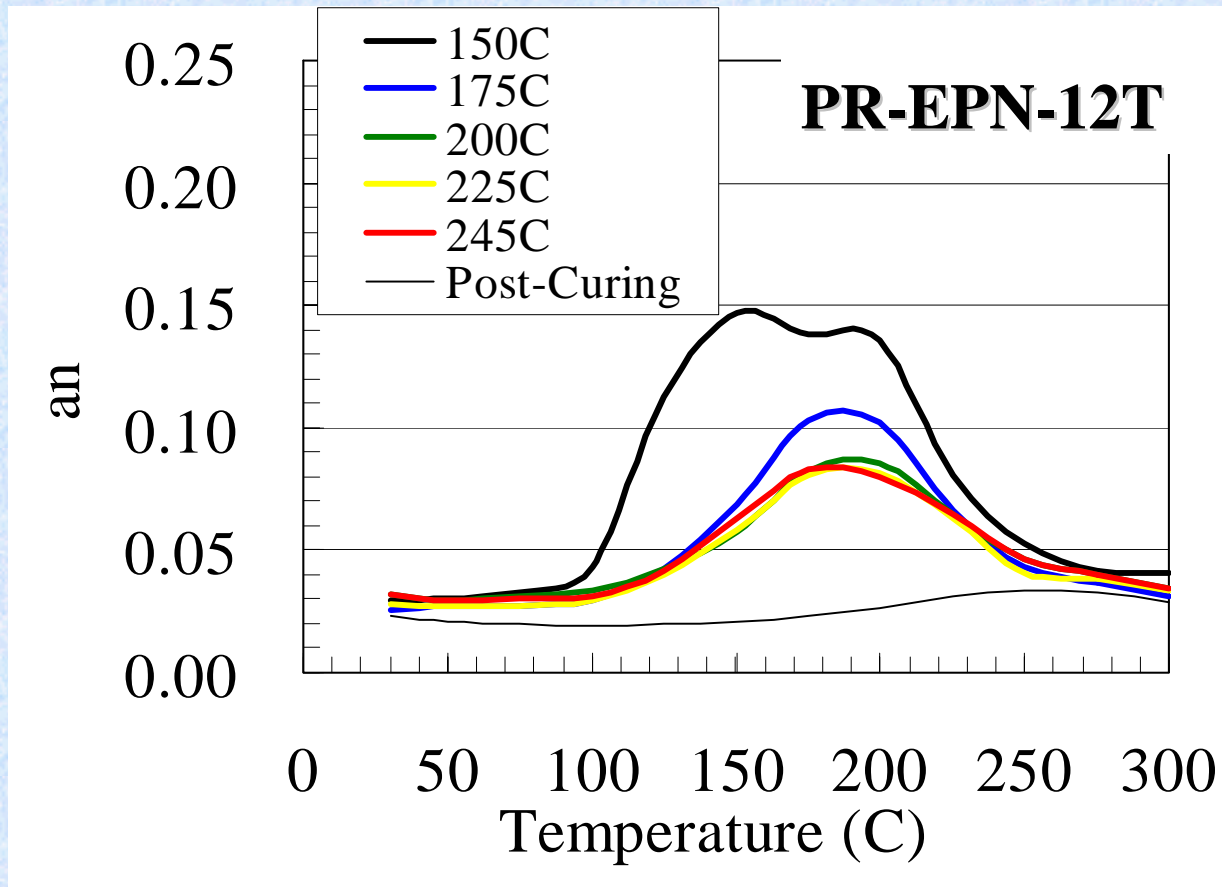
: 8/5/5/40/42 (by weight)

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Pre-molding: Pressure = 29.4 MPa, Charge=160g

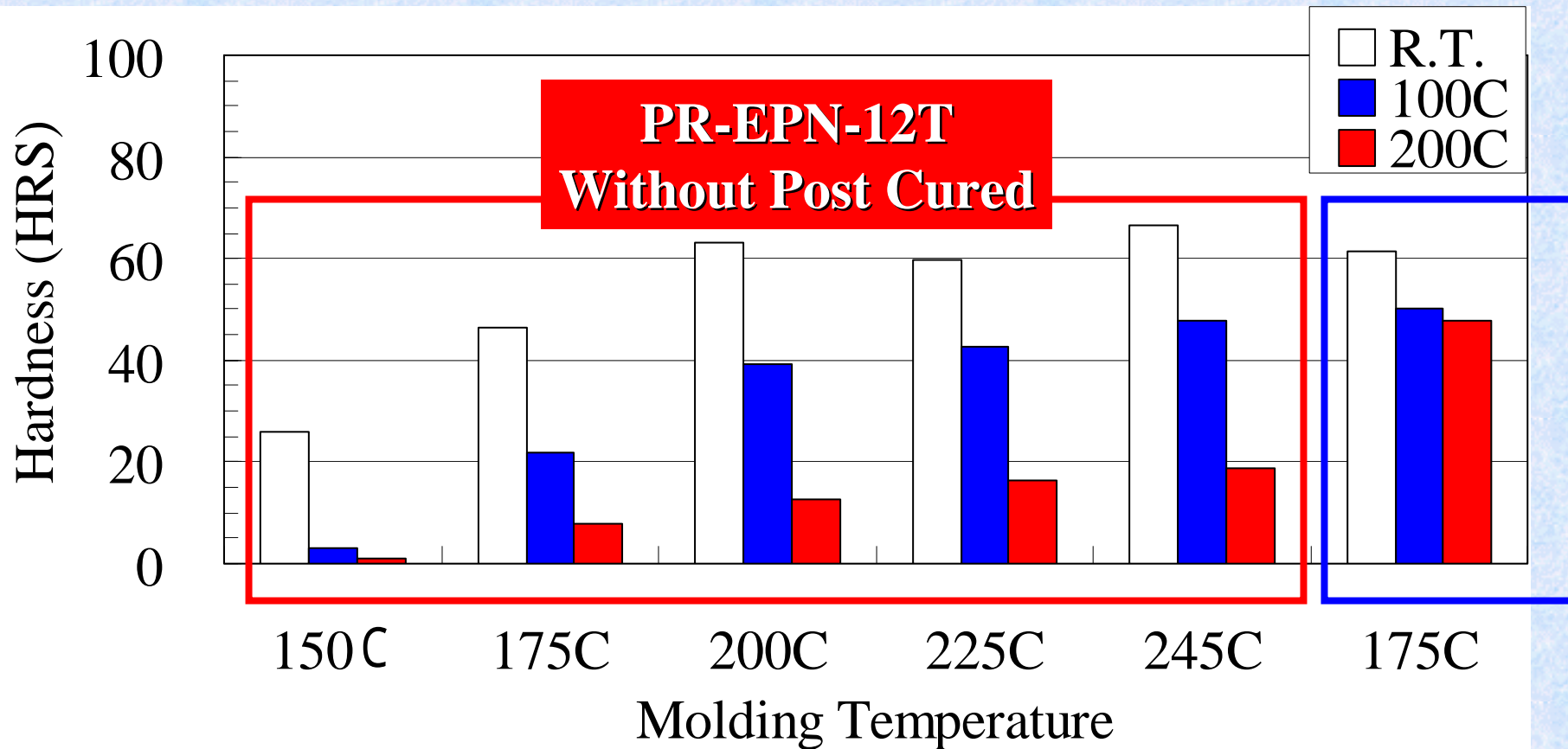
Resin	PR-EPN-12T					PR-54953
Molding Temperature	150C	175C	200C	225C	245C	175C
Molding Time	7min	6min	5min	3min	3min	5min
Gas Release	No Release					(5sec+3sec)*5times
Post-Curing	No Post-Curing					200C-5hr

Dynamic Viscoelasticity



➤ **Tan δ decreased with increasing molding temperature**

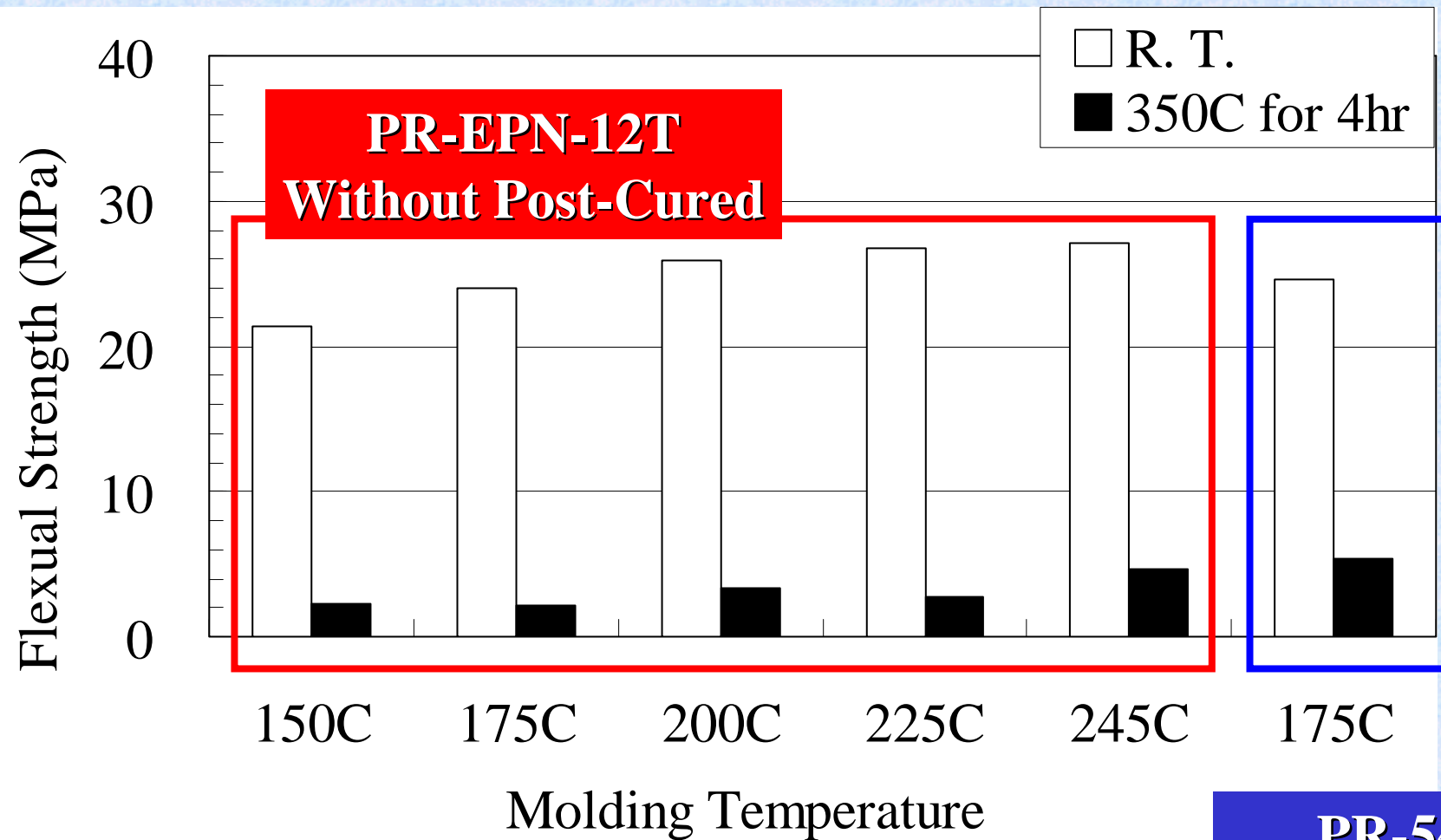
Physical Properties (Rockwell Hardness)



PR-54953 With Post Cured

➤ **Hardness increased with increasing molding temperature.**

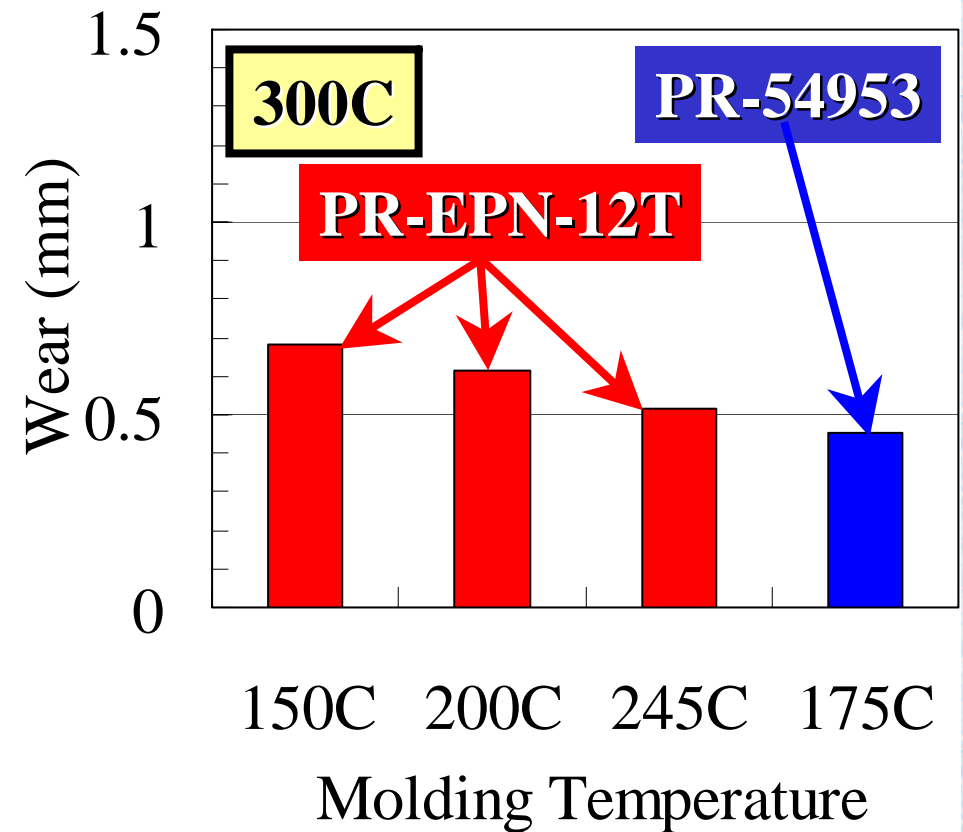
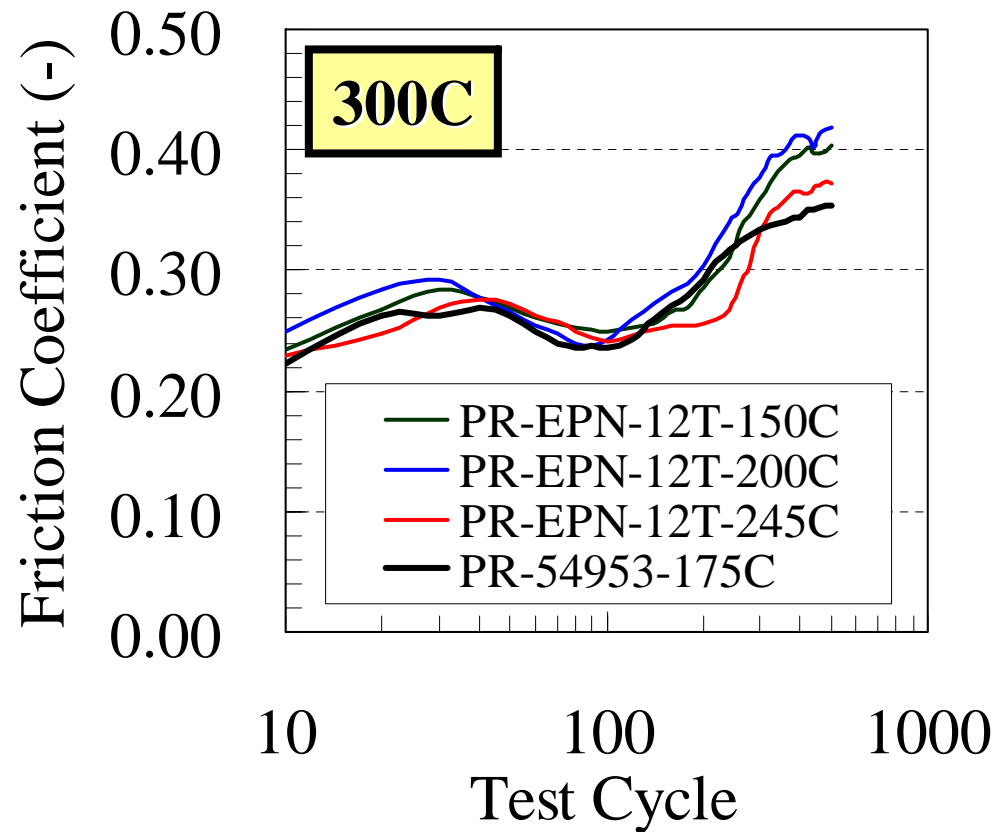
Physical Properties (Flexural Strength)



PR-54953 With Post-Cured

➤ Flexural Strength increased with increasing molding temperature.

Friction Properties



- No significant change of μ was observed.
- Wear of PR-EPN-12T is slightly higher than PR-54953.

Conclusions

➤ **PR-EPN-12T does not evolve any gas during curing.**

Good moldability

Stable friction coefficient

Low wear

➤ **PR-EPN-12T gives possibility to eliminate post-curing process.**

➤ **PR-EPN-12T is an environmentally responsible resin.**