

Novel Controlling Technique of Polyamide Resins via Polyvinylpyrrolidone Mixing

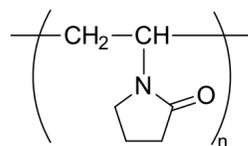
1. INTRODUCTION

■ Polyamide [PA]



Although conventional polyamide resins, such as PA6 and PA66, exhibit excellent mechanical properties and heat resistance, their rapid crystallization often causes poor processability at injection molding.

■ Polyvinylpyrrolidone [PVP]



PVP is an amorphous, hydrophilic polymer with good heat resistance. However, it is oxidized at high temperatures.

We investigated the structure, crystallization behaviors, and moisture contents of PA resins containing PVP. Besides conventional PA6, a low-crystalline polyamide was also employed in this study.

2. EXPERIMENTAL

■ Sample information

PA

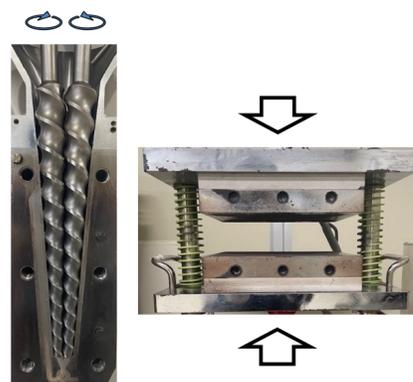
- PA6 ($T_m = 220\text{ °C}$)
- PA-L [amide copolymer] ($T_m = 90 - 120\text{ °C}$)
 ※PA6 = 55 mol%, PA66 = 13 mol%, and PA610 = 32 mol%

PVP

- PVP-H ($M_w = 2.1 \times 10^4\text{ Da}$, $T_g = 162\text{ °C}$)
 - PVP-L ($M_w = 1.1 \times 10^4\text{ Da}$, $T_g = 152\text{ °C}$)
- PVP-H and PVP-L were supplied by Nippon Shokubai Co., Ltd.

■ Melt-blending

- Internal mixer [Xplore MC15HT]
- under nitrogen atmosphere
- 250 °C [for PA6/PVP-H]
- 200 °C [for PA-L/PVP-L]
- PVP contents 0, 10, and 15 wt%



■ Film preparation

- Compression-molding
- 250 °C [for PA6/PVP-H]
- 200 °C [for PA-L/PVP-L]
- Plunged into ice-water bath, then vacuum-dried

- ✓ For industrial relevance, we analyzed crystallization behaviors and moisture contents of the blends with PA6.
- ✓ To avoid degradation, we used PA-L and PVP-L, and blended them under an inert condition at low-temperature.

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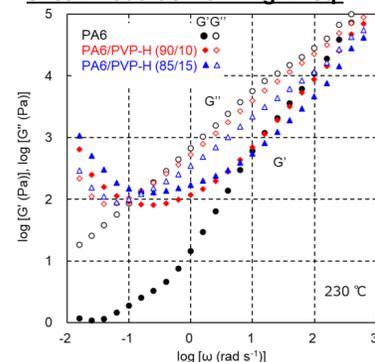
ABSTRACT:

We investigated the effects of adding polyvinylpyrrolidone (PVP) to polyamide resins, which are widely used for their mechanical strength and heat resistance but suffer from poor processability due to rapid crystallization. Our results show that PVP is miscible with polyamide through intermolecular interactions, reducing the crystallization rate, which will improve the processability at injection molding. Additionally, PVP enhances hydrophilicity, which influences moisture-dependent mechanical properties such as toughness. These findings indicate that PVP is a promising additive for controlling crystallization and tuning surface properties in industrial applications.

3. RESULTS and DISCUSSION

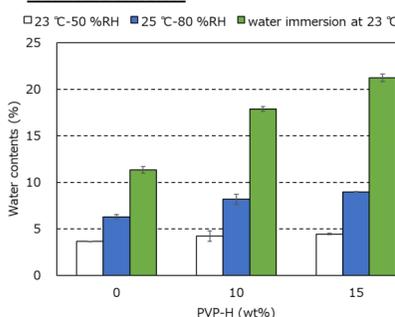
■ PA6/PVP-H Blends

Frequency sweep of oscillatory shear modulus from high freq.



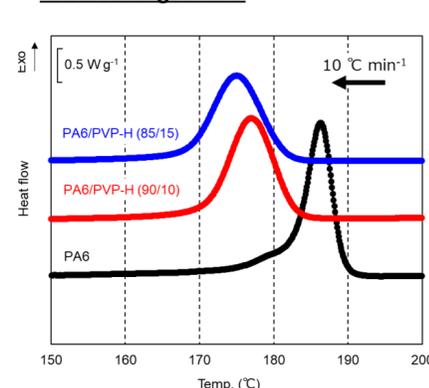
Crosslinking reaction occurred during measurements.

Water contents



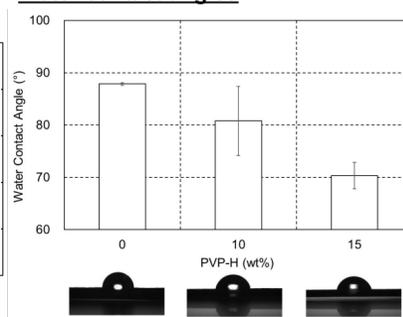
Water contents in the films increased with the PVP-H addition.

DSC cooling curves



The crystallization of PA6 was greatly retarded.

Water contact angles

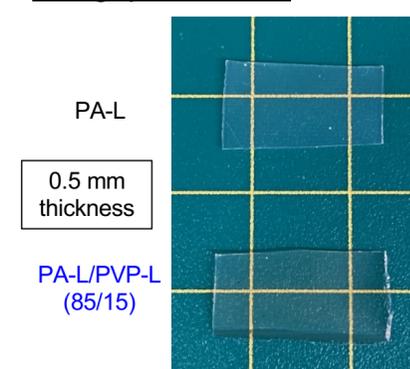


Water contact angles of the films decreased with the PVP-H amount.

- ✓ PVP significantly retarded PA6 crystallization.
- ✓ PVP enhanced the surface wettability.

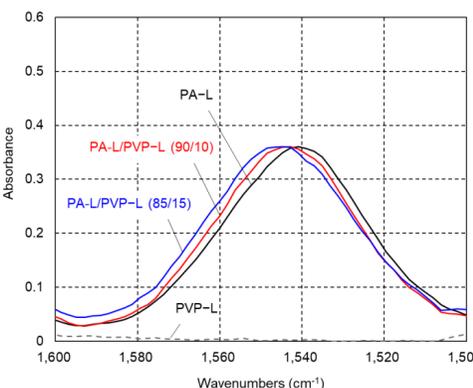
■ PA-L/PVP-L Blends

Photographs of the films



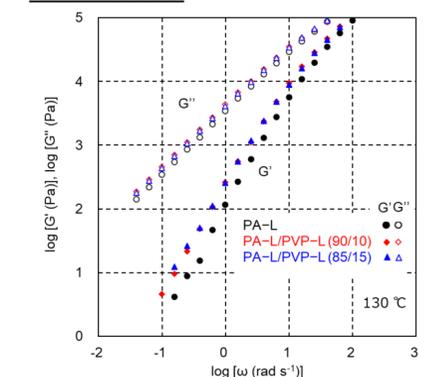
The PA-L/PVP-L (85/15) film was transparent, indicating that light scattering originated from phase-separation did not occur.

ATR-IR spectra



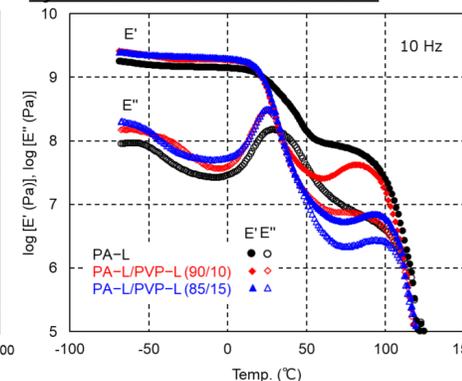
ATR-IR spectra of the films showed a peak shift of the C–N–H in-plane bonding mode in PA-L, suggesting intermolecular hydrogen bonding.

Frequency dependence of oscillatory shear modulus



Both moduli decreased monotonically without showing a shoulder. ⇒ Miscible

Temperature dependencies of the dynamic tensile modulus at 10 Hz



Dynamic mechanical analysis revealed cold crystallization behavior in the blends, suggesting retarded crystallization at film processing.

- ✓ The blends behaved as a simple polymer melt without phase separation.
- ✓ There must be intermolecular interactions between the polymers.

4. CONCLUSION

- Inert and low-temperature mixing avoided degradation and oxidation for the PA-L/PVP-L blends.
- The PVP addition decreased the crystallization temperature of PA, suggesting that PVP can be employed to improve the processability.
- Because the PVP addition improved surface hydrophilicity, surface property can be modified for industrial applications.

REFERENCE

Y. Ikemoto, M. Yamaguchi, *Polymers* **2025**, 17, 360.