Polymer Alloys/Blends

The applications of polymers have been expanding, and performance requirements are becoming increasingly sophisticated. As a result, it is often difficult for a single polymer to satisfy all the necessary properties. In particular, there is growing demand for materials that can reconcile **conflicting characteristics**—such as impact resistance and rigidity, or heat resistance and processability.

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To address this, **polymer alloy technology** was developed, which involves blending different existing polymers in order to maximize their strengths while compensating for their weaknesses. Unlike low-molecular-weight compounds, polymers generally do not mix uniformly at the molecular level, even when their structures are similar, and thus require special techniques to achieve compatibility.

Polymer Alloys: Positioning

Homopolymer → Polymer Blend ← Copolymer

Polymer Blend		
Miscibility		Immiscibility (Compatibility)
Homogeneous	Heterogeneous	

Immiscibility (Compatibility) → Compatibilization → Alloy

Reference: Katsuhiko Hironaka; The Society of Rubber Industry, Japan Kanto branch Advantech Seminar 2014 Abstracts, p.9 (2014)

Polymer Alloys Classification, and Design Considerations

Classification		State	Conditions for Alloying
Miscibility	Homogeneous	Fully Miscible	**Miscibilization** (Thermodynamic) -Polymer selection -Use of random copolymers -Processing conditions (Heterogeneous)
	Heterogeneous	Partially Miscible	
Immiscibility		Dispersion	**Compatibilization** (Physical and Chemical) -Dispersion control (shear, compatibilizer) -Interface control (compatibilizer, polymer chain modification, reactive extrusion)

● Polymer Alloy Contract Development

Immiscible Polymer Alloy – MC15-HT Mini Kneader Example

Test Overview Using This Equipment
-Evaluation of polymer thermal stability, degradation, decomposition, and reactivity
-Assessment of additive/filler dispersion (e.g., nanoparticles)
-Polymer blends
-Reactive blends
-Small-scale kneading of lab-prepared samples
-Sample preparation for various tests

Kneading Section / Conical Screw

Benchtop Kneader

● Preparation of Thermoplastic Resins / Rubber-Based TPVs

Dynamic vulcanization allows versatile material design by combining various resins and rubbers, and is actively researched, especially for cured rubber replacement. Examples of resin–rubber combinations studied to date are shown below.

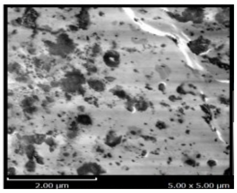
TPV face challenges, as their shape recovery, flexibility, and heat resistance are not always sufficient compared with cured rubber. Therefore, it is important to explore new applications beyond simple cured rubber replacement.

Thermoplastic Resin–Rubber Combinations

Resin, Rubber	EPDM	IIR	Acrylic	H-NBR	NR	ENR	SR
PA		●	●	●		●	●
PBT		●	●	●			
PLA					●	●	
PP	●		●				
EVOH		●					

Compounding with twin-screw extruder

Composition	Resin/Rubber = 30/70 Crosslinking/curing agent: 0.5–10 phr (rubber basis)
Equipment	Lab-scale twin-screw extruder MC-15 (Xplore Instruments)
Kneading Conditions	Cylinder temp.: 180–250 °C Screw speed: 250 rpm Time: 10–15 min
Evaluation	Phase separation structure by SPM-9700HT (Shimadzu) Measurement: Phase mode



Phase separation (SPM, phase mode)

TPV Samples

● Study on Compatibilizers for Polyester/Rubber Systems

To develop TPV-based elastomers, we investigated alloying immiscible thermoplastic resins and rubbers. Various compatibilizers were evaluated to identify effective agents and formulations. Tests were conducted using PLA, a bio-based polymer, and PET, considering the effective use of recycled materials.

Implementation Example

Formulation	BLANK	m-PO	E-GMA	PS-Ox	m-SEBS
PLA/NR	△-×	△	△-×	○-△	△
PLA/EPDM	×	○	◎	×	○
PET/EPDM	×	×-△	△	○	○
PET/IIR	×	○	×	○-△	○

Composition	Resin/Rubber = 50/50, Compatibilizer = 5 phr
Equipment	Laboplast Mill 3S150, 30 cc Mixer (Toyo Seiki Seisakusho, Ltd.)
Mixing Conditions	Cylinder temperature: 180, 260 °C Screw speed: 150 rpm Mixing time: 2 min
Evaluation	Appearance of sheets after processing Rating;◎ Completely miscible, ○ Miscible, △ Partially miscible, × Immiscible

DJK Corporation e-mail: info@djklab.com Website: http://www.djklab.com/eng