EXCEVAL™

kuraray

Exceval™

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1. Introduction

Kuraray Co., Ltd. manufactures and sells polyvinyl alcohol (PVOH, PVA, Poval), a typical water-soluble synthetic polymer. With an annual production volume of approximately 300,000 tons, Kuraray holds the top global market share (excluding China).
EXCEVAL™ is a specially modified polymer developed using Kuraray' s proprietary technology accumulated over years of PVOH business. It possesses many unique features not found in conventional PVOH products and is used in a wide range of applications.

2. Characteristics of EXCEVAL™

2-1. Main Features

Characteristics of EXCEVAL™		Main Applications	
1	• High water resistance of film • Viscosity stability during storage	Vinyl acetate-based emulsions and adhesives	Improves water resistance of emulsions and adhesives retaining good flow-ability even at low temperature (winter season).
		Paper processing agents	Enhances water resistance and reduces coating weight in applications such as undercoat for release liner (solvent free), overcoat layer for thermal paper, paperboard, and pigment binders.
2	• Inherent biodegradability in aqueous solutions	Food packaging materials	By combining EXCEVAL™ with other biodegradable materials, it is possible to design packaging materials with inherent biodegradability for grease-resistant packaging (e.g., snacks, fast food), gas barrier packaging (e.g., coffee beans, bath additives), and more.
3	• Adsorption to inorganic substances	Binders for inorganic materials (e.g., ferrite)	More adsorption onto primary particles of inorganic materials such as ferrite, enhancing green strength and improving productivity.
4	• Melt processability	• Water-soluble films • Water-soluble articles, nonwoven fabrics	Possible to produce water-soluble films, articles and nonwoven fabrics by melt processing.

Table1. Characteristics of EXCEVAL™

3. Product Lineup

3-1. General EXCEVAL™

Grade name	Specifications				
	Viscosity mPa·s	Degree of hydrolysis mol%	Volatiles %	Ash %	pH
AQ-4104	3.6-4.4	98.0-99.0	≤5.0	≤0.1	3.0-7.0
RS-2117	25.0-30.0	97.5-99.0	≤5.0	≤0.4	5.0-7.0
RS-2817 SB	23.0-30.0	95.5-97.5	≤5.0	≤0.4	5.0-7.0
RS-1717	23.0-30.0	92.0-94.0	≤5.0	≤0.4	5.0-7.0

Table 2. A List of General Grades of EXCEVAL™

Note: Packaging standards and analysis methods refer to ISO-15023-2.

3-2. Dispersants for High Water Resistance Emulsions (HR Polymers)

Grade name	Specifications				
	Viscosity mPa·s	Degree of hydrolysis mol%	Volatiles %	Ash %	pH
HR-3010	12.0-16.0	99.0-99.4	≤5.0	≤0.6	5.0-7.0

Table 3. A List of HR Polymer-Grades

Note: Packaging standards and analysis methods refer to ISO-15023-2.

4. Basic Physical Properties

4-1. General Properties

Appearance : White to pale yellow powder or granules
Specific Gravity : 1.19–1.31 g/cm³
Specific Heat : 1.68×10³ J/kg·°C [0.4 kcal/kg·°C]
Melting Point : 150–230°C

4-2. Film Water Resistance

Compared to non-modified PVOH, EXCEVAL™ has higher crystallinity, resulting in superior water resistance of its film. This property is further enhanced by heat treatment. Figures 1 and 2 show the film water resistance of EXCEVAL™.

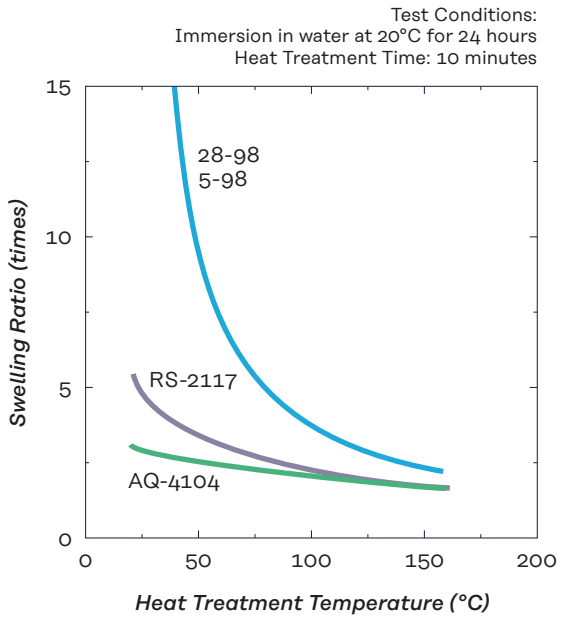


Figure 1. Swelling Ratio

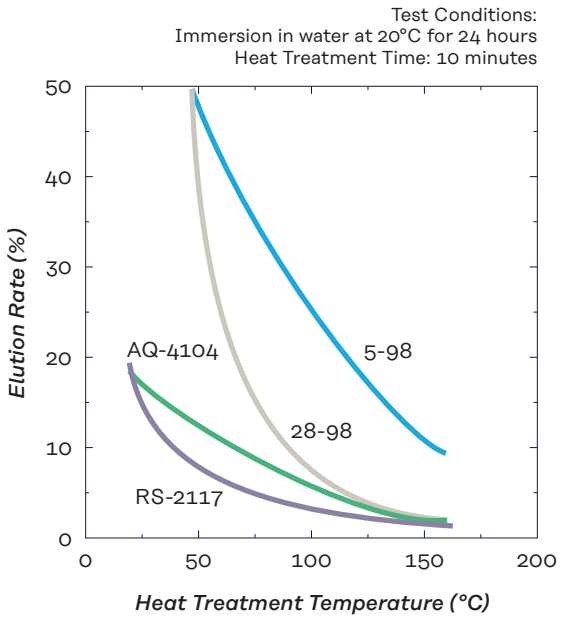


Figure 2. Elution Rate

4-3. Viscosity Stability of Aqueous Solutions

Generally, non-modified fully hydrolyzed PVOH aqueous solutions tend to significantly increase in viscosity when stored at low temperatures. However, solutions of EXCEVAL™ exhibit extremely stable viscosity under such conditions (see Figures 3 and 4).
Note: If highly concentrated solutions are left at low temperatures, viscosity may increase or gelation may occur (see Figure 5).

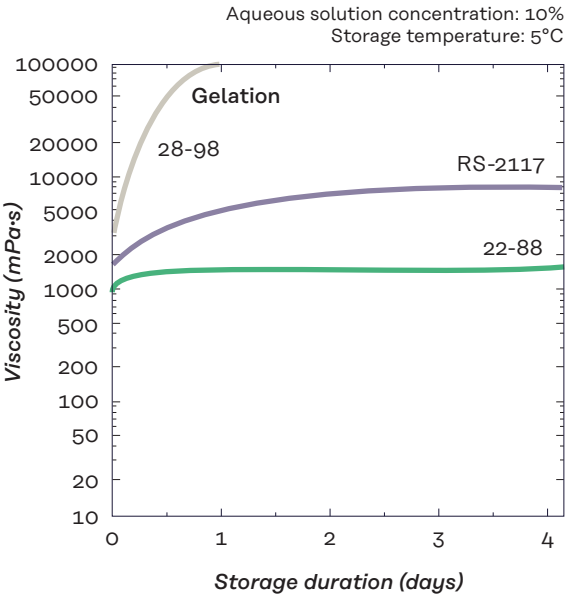


Figure 3. Viscosity Stability Over Time

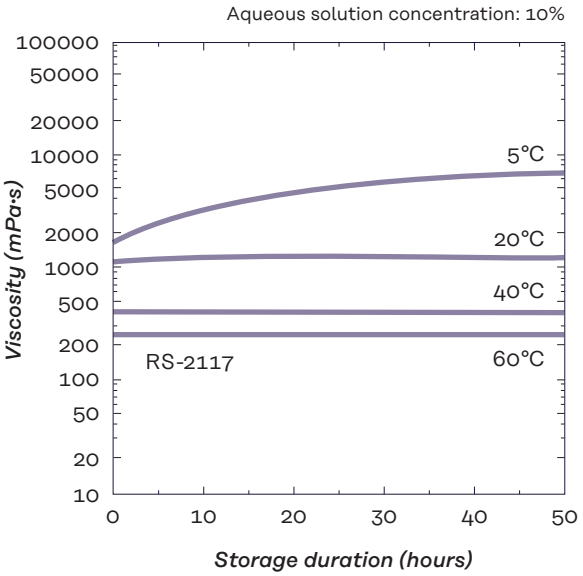


Figure 4. Viscosity Stability at Different Temperatures

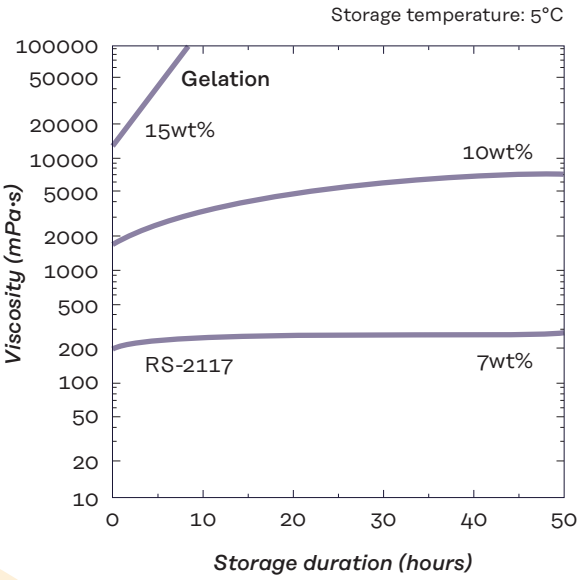


Figure 5. Viscosity Stability at Different Concentrations

4-4. Surface Tension

Compared to non-modified PVOH with the same degree of hydrolysis, EXCEVAL™ has lower surface tension. This provides many advantages, especially in use for emulsification and dispersion systems.
Figure 6 and 7 show the surface tension of solutions of EXCEVAL™.

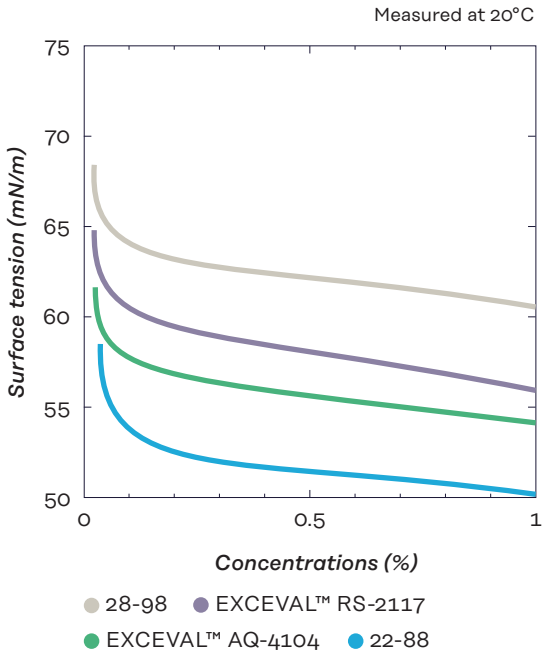


Figure 6. Fully Hydrolyzed EXCEVAL™

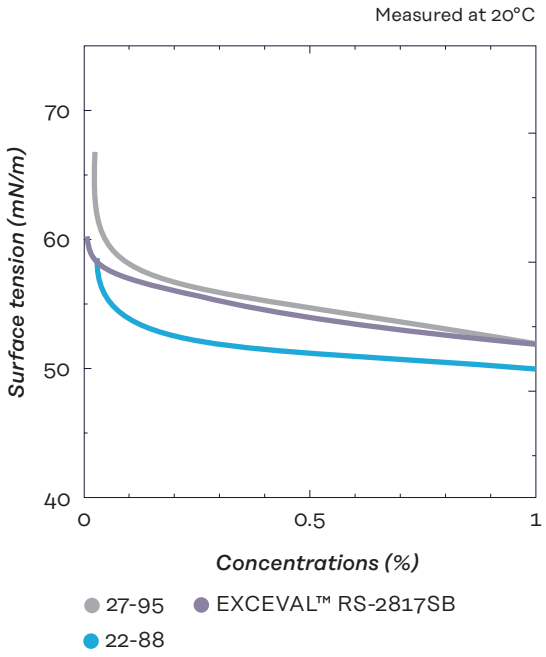
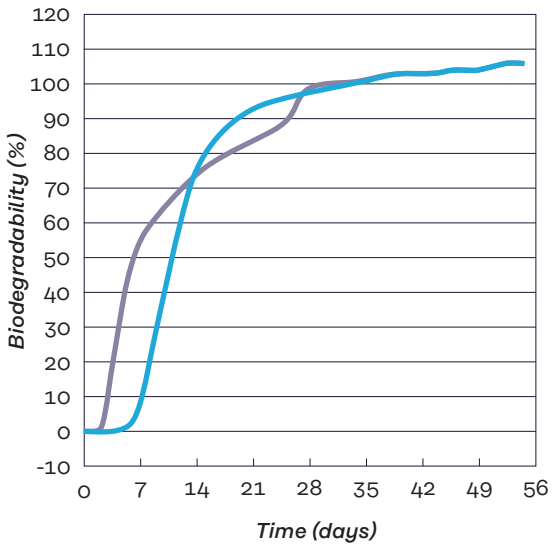


Figure 7. Partially Hydrolyzed EXCEVAL™

Measurement Method: Wilhelmy method using surface tensiometer (CBUP-A3, Kyowa Chemical)

4-5. Biodegradability

EXCEVAL™ exhibits inherent biodegradability in aqueous solution, the same as non-modified PVOH.
Figure 8 shows the test results of EXCEVAL™ AQ-4104 using the ISO 14851 method.
EXCEVAL™ AQ-4104 is one of the most biodegradable grades among EXCEVAL™ products.



Cellulose
EXCEVAL™ AQ-4104

Test Conditions:
- Test guideline : ISO 14851
- Test organization : OWS nv (Normec OWS)
- Sludge concentration : 100mg/L
- Sample concentration : 100mg/L

Figure 8. Biodegradability Test Results of EXCEVAL™ AQ-4104

4-6. Film Properties

Compared to non-modified PVOH, films using EXCEVAL™ tend to have lower moisture absorption (equilibrium moisture content) and higher tensile modulus under the same humidity conditions. Refer to Table 4 and Table 5 for details.

Grade	Heat Treatment Condition	Equilibrium moisture content %	Tensile modulus kg/mm²	Tensile strength kg/mm²	Tensile elongation %
RS-2117	No heat treatment	9.1	76.8	5.2	222
28-98	No heat treatment	10.6	58.3	5.0	197
RS-2117	120°C×10 minutes	8.1	86.2	5.9	178
28-98	120°C×10 minutes	8.9	74.3	5.5	184

Table 4. Film Properties (20°C 65%RH)

Grade	Heat Treatment Condition	Equilibrium moisture content %	Tensile modulus kg/mm²	Tensile strength kg/mm²	Tensile elongation %
RS-2117	No heat treatment	13.3	15.9	4.7	306
28-98	No heat treatment	14.7	10.7	4.3	253
RS-2117	120°C×10 minutes	11.7	26.1	5.0	228
28-98	120°C×10 minutes	13.1	21.3	4.8	214

Table 5. Film Properties (20°C 84%RH)

4-7. Other General Properties

Solubility : Soluble in water. See the dissolution section for details.
Acid/Alkali Resistance : Little effect from weak acids or weak alkalis.
Film-Forming Ability : Easily forms threads or films with excellent physical properties such as tensile strength, tear strength, and frictional properties.
Moisture Absorption : Lower than non-modified PVOH, with relatively small changes due to humidity.
Grease/Chemical Resistance : Strong resistance to many organic chemicals including fats, mineral oils, aliphatic hydrocarbons, aromatic hydrocarbons, ethers, esters, and ketones.
Adhesion : Extremely high adhesion to polar substances such as cellulose-based materials (paper, textiles, wood).
Compatibility : High compatibility with starch; mixed aqueous solutions tend to have less phase separation.

5. Dissolution Methods of EXCEVAL™

5-1. Dissolution Procedure

EXCEVAL™ should be gradually added to room-temperature water while stirring, then heated to dissolve. Heating methods include direct steam heating or indirect heating via a jacketed system. Since dissolution methods vary slightly depending on the grade, please refer to the following procedures:

1. Gradually add EXCEVAL™ while continually stirring room-temperature water.
2. Continue stirring and begin heating.
3. A. After reaching 95°C, maintain temperature and stir for 1–2 hours.
   B. After reaching 90°C, maintain temperature and stir for about 1 hour.
   C. After reaching 95°C, maintain temperature and stir for about 2 hours.
4. Turn off the heat source and reduce the stirring power. Stop stirring once the temperature drops to 40°C.
   Note: Rapid cooling or continued stirring below 40°C may cause the solution to become cloudy.

Grade	Dissolution Type	Note
AQ-4104	A	Exhibits cloud points.
RS-2117	A	
RS-2817SB	B	
HR-3010	C	

Table 6. Dissolution Type of Each Grade of EXCEVAL™

5-2. Solubility at Elevated Temperatures

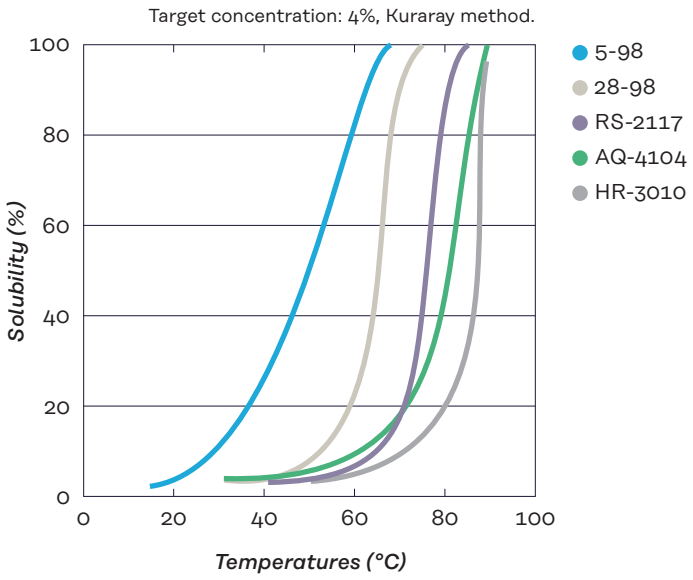


Figure 9. Fully hydrolyzed EXCEVAL™

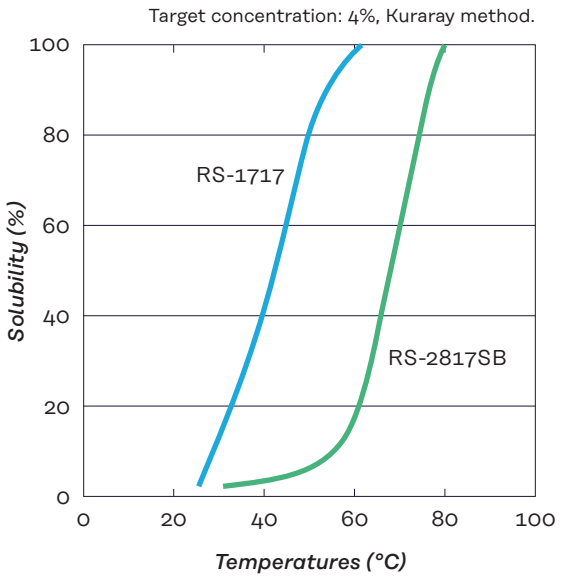


Figure 10. Partially hydrolyzed EXCEVAL™

5-3. Foaming and Defoaming Measures

When dissolving EXCEVAL™ in water or using its aqueous solution, foaming may occur depending on viscosity and stirring speed. Foaming can be suppressed by adding defoamers (500–5000 ppm per EXCEVAL™). However, please note that the type and amount of defoamers may affect the original properties of EXCEVAL™.

5-4. Storage Methods

1) Viscosity
Aqueous solutions of EXCEVAL™ generally do not show significant viscosity increase during storage (especially at low temperatures), but it is recommended to use them as soon as possible.

2) Mold, Spoilage, and Rust
When storing EXCEVAL™ in aqueous form for extended periods, mold, spoilage, or rust may occur depending on the equipment specifications, materials, and storage conditions. It is recommended to add anti-mold, anti-corrosion, and anti-rust agents.

5-5. Viscosity of Aqueous Solutions

The relationship between concentration, viscosity, and temperature of aqueous solutions of EXCEVAL™ is shown in Figures 11 and 12.

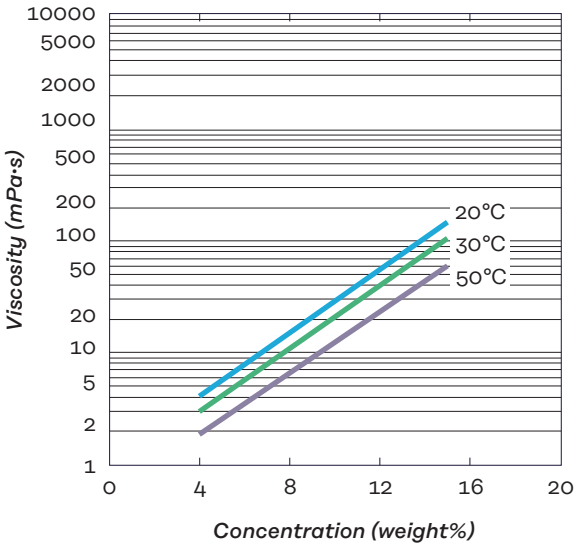


Figure 11. AQ-4104

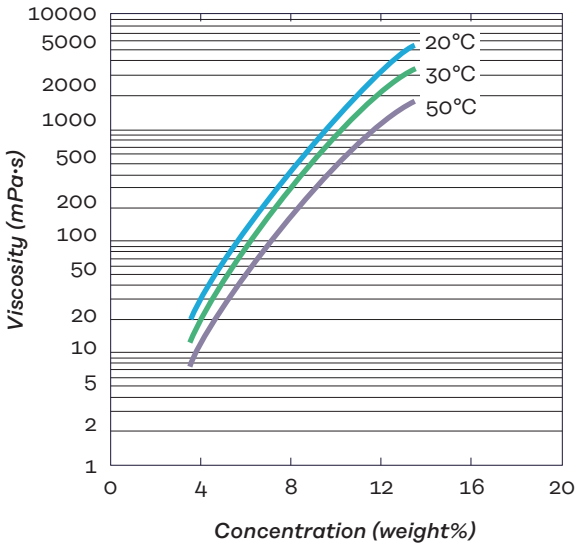
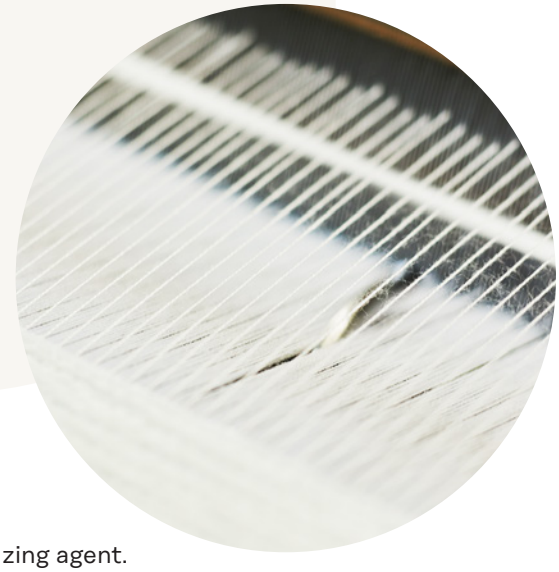


Figure 12. RS-2117



6. Applications

6-1. Textile Processing

EXCEVAL™ can be used as a sizing agent for warp yarns.

1. Key Features

1) EXCEVAL™ provides excellent weaving performance when used as a warp sizing agent.
   1. Produces sized yarns with superior smoothness, improving shed opening on looms.
   2. Achieves high abrasion resistance.
   3. Reduces the generation of fly yarn during weaving due to the smoothness of the sized yarn.
   4. Offers better compatibility with starch than non-modified PVOH, enabling excellent film formation even in starch-blended formulations.
      → This allows for lower sizing pickup while maintaining equivalent weaving performance compared to conventional sizing agents.

2) EXCEVAL™ is a suitable sizing agent for small-lot, multi-product production.
   1. Prevents the formation of lumps (non-gelling).
   2. Applicable to a wide range of yarns from 100% cotton to polyester/cotton blends.
      → Enables effective reuse of leftover sizing solution, reducing costs.

3) EXCEVAL™ has good biodegradability, helping reduce environmental impact after discharge of sizing wastewater.

2. Physical Properties of Sized Yarn (100% Cotton)

Using Kuraray's test sizer, sized yarns were prepared and their properties were measured to evaluate weaving performance.

1) Sizing Conditions

Yarn	: 40/1 combed cotton yarn
Sizer	: Kuraray test sizer (20-tape sizer)
Sizing Speed	: 40 m/min
Solution Temperature	: 90°C
Squeeze Pressure	: Air pressure 2 kg/cm^3 (equivalent to 700 kg in actual sizer)
Drying Temperature	: Cylinder surface approx. 115°C

2) m-f Friction Coefficient

Measured the friction resistance between warp yarns and metal parts such as droppers, heddles, and reeds on the loom.
Lower values indicate less friction with metal.
From Figure 13, it is evident that sizing agents using EXCEVAL™ exhibit high smoothness, leading to improved shed opening and reduced fly yarn, significantly enhancing weaving performance.

3) Abrasion Resistance (TM Method)

Sizing agents using EXCEVAL™ have a low m-f friction coefficient, which reduces friction with metal parts and consequently improves abrasion resistance.
See Figure 14 for reference.

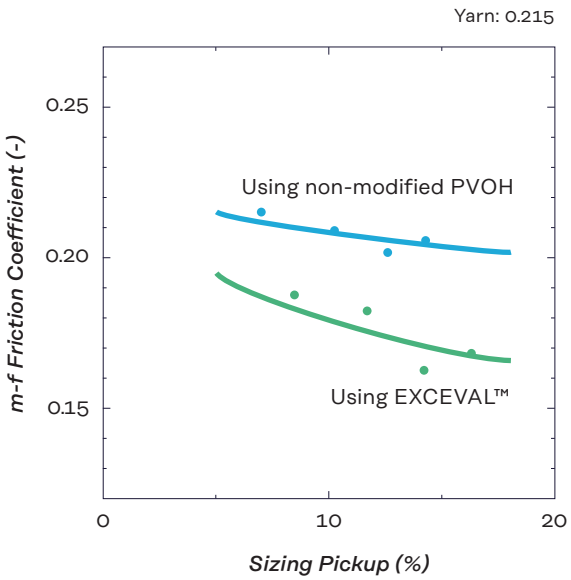


Figure 13. Relationship between m-f friction coefficient and sizing pickup

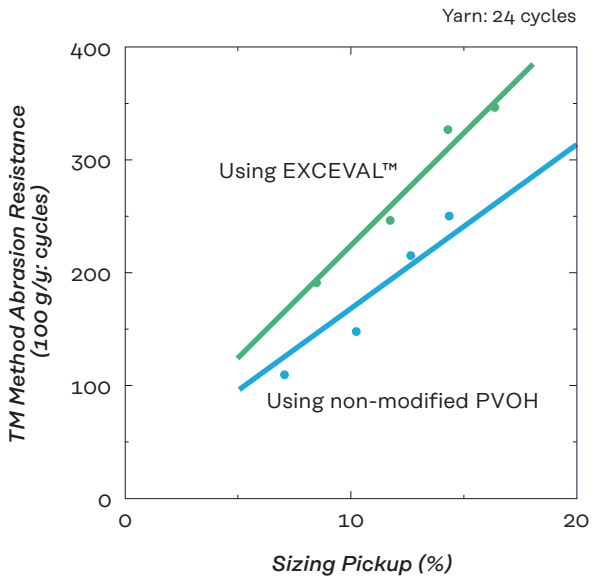


Figure 14. Relationship between abrasion resistance and sizing pickup

6-2. Paper Processing

EXCEVAL™ can be used as a surface treatment agent for paper. This section introduces its use as an undercoating agent for release paper, leveraging its film-forming ability, water resistance, and flex resistance.

1. Key Features

1. Can be applied using various size press methods such as 2-roll size press, gate roll size press (GRC), and Rod metering size press such as SymSizer (Sym), enhancing barrier properties.
2. Exhibits high water resistance, making it suitable for solvent-free silicone (emulsion or non-solvent types) and solvent-free adhesives (emulsion types).

2. Air Permeability of Paper Coated with EXCEVAL™

1) Test Method

Coating method : Lab SymSizer manufactured by Kumagai Riki Co., Ltd. (rod metering type)
- Speed: 300 m/min
- Temperature: approx. 20°C
- Nip pressure: 1.1 kg/cm² (bar/applicator), 1 kg/cm (applicator/backup roll)
- Drying: 100°C for 1 minute (rotary drum dryer)

Base paper : Glassine (72 g/m², 125 sec air permeability)
Measurement : Ohken-type air permeability tester

2) Results

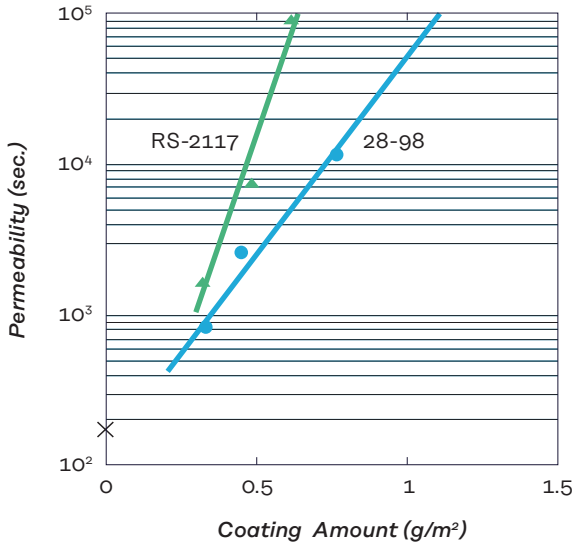


Figure 15. RS-2117 and 28-98

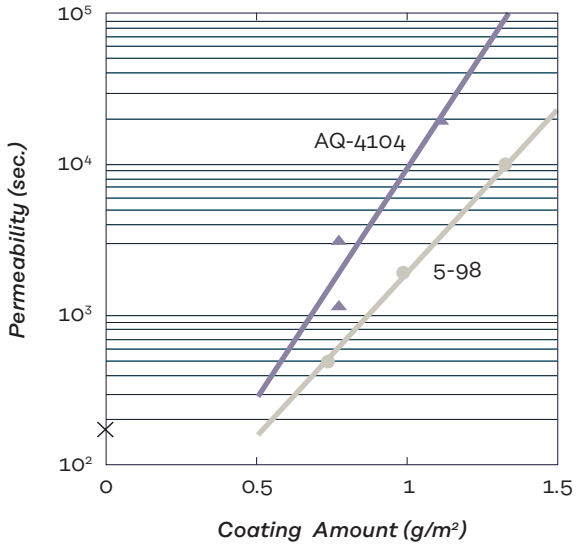


Figure 16. AQ-4104 and 5-98

No calendering treatment, Wire rod: #10, Base paper: Glassine paper (125 seconds)

6-3. Adhesives

EXCEVAL™ can be used in adhesive formulations providing strong bond strength and water resistance.

1. Key Features

1. Stable solution viscosity at low temperatures.
2. Excellent initial tack.
3. Superior water resistance.
4. Enables high concentration with low viscosity.

2. Initial Tack Performance:

Figure 17 shows adhesive viscosity and initial tack. Figure 18 shows coating amount and initial tack.

1) Test Method

Base Paper	: Kraft
Coating speed	: 0.5 m/sec
Shear speed	: 300 m/min
Bonding area	: 1 mm × 25 mm
Setting time	: 2 sec
Closed time	: 20 sec
Measurement	: Shear adhesion strength (JT-type initial tack tester)
Closed time	: 20 sec

2) Results

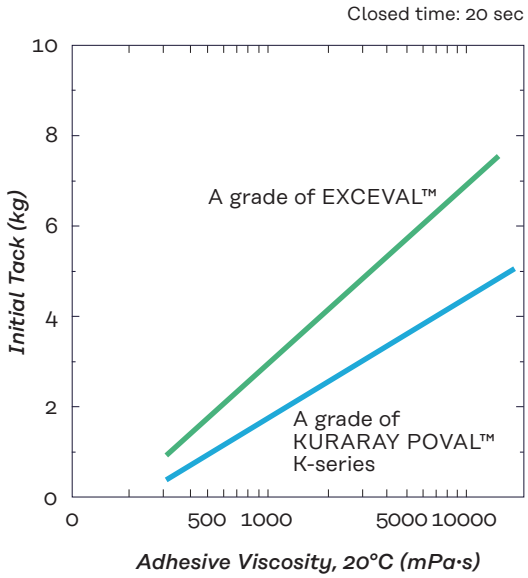


Figure 17. Viscosity and Initial Tack

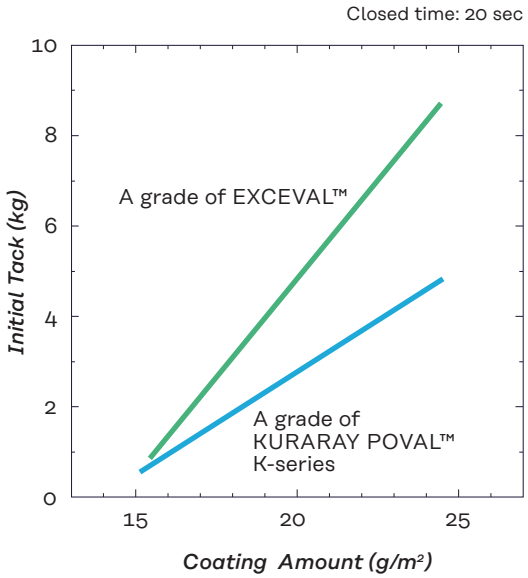


Figure 18. Coating Amount and Initial Tack

6-4. Stabilizers

EXCEVAL™ plays a crucial role as a polymerization stabilizer in vinyl acetate emulsion systems.

1. Vinyl Acetate Emulsions Using EXCEVAL™

1) Key Features

1. Excellent viscosity stability during storage, especially to avoid viscosity increase/gelation issues in winter.
2. Superior water resistance compared to non-modified fully hydrolyzed PVOH-based emulsions.
3. Enhanced emulsification power for vinyl acetate monomers compared to non-modified fully hydrolyzed PVOH to provide better emulsion polymerization stability
4. Produces emulsions with near-Newtonian viscosity.
5. Strong adhesion to wood and paper substrates.
6. High reactivity during polymerization, enabling faster monomer consumption and shorter reaction times to achieve target residual monomer concentration compared to non-modified PVOH.

2) Physical Properties of Vinyl Acetate Emulsions

Grade of Polymerization Stabilizer	Solid Content %	Viscosity[1] 20rpm, 30°C mPa·s	Structural Viscosity[2] (B Value)	Low-Temperature Stability[3]	Film Water Resistance		Compressive Shear Adhesion Strength[4] kg/cm²
					Water Absorption Rate %	Elution Rate %	
RS-2117	50.3	10700	0.1	1.5	25	1.1	25
RS-1717	48.3	29000	0.3	1.2	39	1.8	18
28-98	48.1	3300	0.2	3.2	41	2.0	13
22-88	47.6	30000	0.4	1.1	56	6.7	5

Table 7. Properties of Vinyl Acetate Emulsions Using EXCEVAL™

1) Viscosity: Measured using a Brookfield-type viscometer.
2) Structural Viscosity: Calculated as log (n at 2 rpm / n at 20 rpm).
3) Low-Temperature Stability: Sample stored at 0° C; viscosity increase ratio after one week compared to immediately after storage.
4) Compressive Shear Adhesion Strength: Measured after immersion in hot water (60°C for 3 hours) using Hemlock wood as the substrate.

2. Hot Water-Resistant Adhesion of Vinyl Acetate Emulsions Using EXCEVAL™

1) Key Features

Enables the production of vinyl acetate-based emulsions that exhibit excellent hot water-resistant adhesion without the need for crosslinking agents achieving a single-component system.

2) Properties of Vinyl Acetate Emulsions

Grade of Polymerization Stabilizer	pH	Film Water Resistance[1]		Adhesion Properties 1[2]		Adhesion Properties 2[3]		Viscosity Stability[4]	
		Water Absorption Rate %	Elution Rate %	wet kg/cm²	dry kg/cm²	Normal Condition kg/cm²	Hot Water Resistance kg/cm²	0°C	40°C
HR-3010	5	18	0.4	17	63 (92)	182 (30)	37	2.5	1.3
RS-2117	5	25	1.1	10	53 (88)	178 (20)	20	2.5	1.0
28-98	5	41	2.0	2	35 (30)	170 (20)	5	Gelation	1.1

Table 8. Properties of Vinyl Acetate Emulsions Using EXCEVAL™

1) Measured after immersing emulsion film in 20°C water for 24 hours.
2) BS Standard (EN204), Adherend: Beech wood, Figures in parentheses () indicate wood failure rate
Wet: Test pieces immersed in 20°C water for 4 days.
Dry: Test pieces dried at room temperature for 7 days after immersing in 20°C water for 4 days.
3) JIS Standard (K6804), Adherend: Birch wood, Figures in parentheses () indicate wood failure rate
Normal Condition: Measure as it is.
Hot Water Resistance: Test pieces immersed in 60°C water for 3 hours.
4) Measured after storage at 0°C and 40°C.
Viscosity stability = n (after 7 days) / n (initial value before storage)

6-5. Binders

EXCEVAL™ can be used as a binder for forming ferrite and ceramic components.

1. Key Features

1. Improves green strength.
2. Excellent granule flowability enables uniform molding of small and complex parts.
3. Reduces cracking after firing, improving yield.

2. Adsorption amount to Ferrite and Formed Product Strength

Figure 19 shows binder adsorption amount to ferrite primary particles. EXCEVAL™ shows higher adsorption to ferrite particles than non-modified PVOH, resulting in stronger green bodies (see Figure 20).

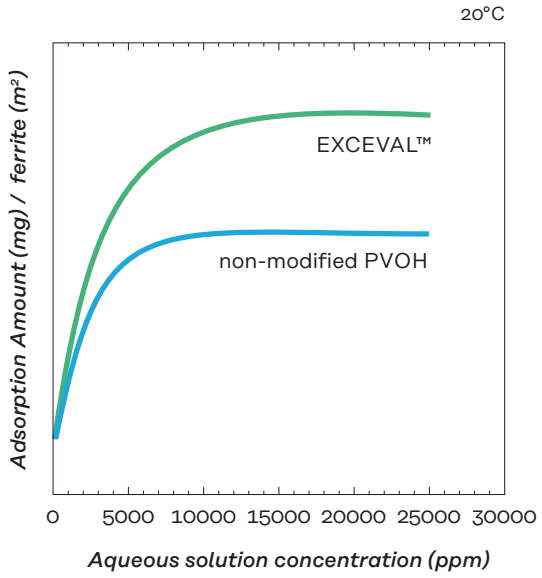


Figure 19. Comparison of Adsorption Amount to Ferrite

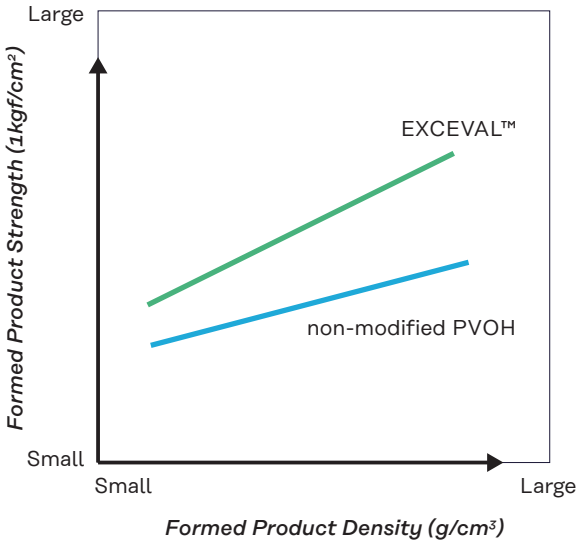


Figure 20. Image of Formed Product Strength

7. Melt Processing Methods of EXCEVAL™

EXCEVAL™ offers superior thermal stability compared to non-modified PVOH, allowing melt processing using conventional equipment in the market.

Note: EXCEVAL™ begins thermal decomposition and discoloration above 230°C. Detailed below is an example of characteristics and melt extrusion conditions of AQ-4104.

Melting Point (°C)	MFR (g/10min. at 230°C, 2.16kg)
210-215	40-60

Table 9. Properties of AQ-4104[a)]

a) Please note that this is not part of the product specifications.

Typical Specifications of Extruder

1) Example of Extruder Specifications

Extruder	40ø
L/D	26
Flight	Full Flight
Screw Pitch	Constant 40 mm
Feed Zone Length, Groove Depth	9D 9.0mm
Compression Zone Length, Groove Depth	8D 9.0mm/2.6mm
Metering Zone Length, Groove Depth	9D 2.6mm
Compression Ratio	3.5
Motor Capacity	7.5KW
Screen	50/100/100/50 mesh

Figure 10.

2) Example of Extrusion Conditions

Cylinder Temperature C_1	°C	180
C_2	°C	200
C_3	°C	220
Adapter Temperature	°C	220
Die Temperature	°C	220
Screw Speed	rpm	35
Output Rate	kg/Hr	7.8

Figure 11.

3) Guidelines of Flow Channel Design

1. The flow channel should gradually narrow from the extruder outlet towards the die.
2. Avoid creating any uneven parts or sharp corners within the flow path.
3. The flow channel diameter should be minimized as much as possible, within the limits of acceptable pressure loss.
4. The internal surfaces of the flow channel should be chrome-plated and polished for smoothness.

4) Guidelines of Resin Switching

Resin Before Switching → Resin After Switching	Switching Method
Other resins → EXCEVAL™	1. Purge with low-MFR LDPE to push out residual resin
	2. Purge thoroughly with LDPE of similar MFR of EXCEVAL™.
EXCEVAL™ → Other resins	Switch directly.

Figure 12.

5) Stopping Operation
Switch to LDPE or a similar resin, and completely purge out EXCEVAL™ before shutting down the extruder.

8. FDA Approval Status of EXCEVAL™

EXCEVAL™ complies with FDA 21 CFR 175.105 (Adhesives) for use in adhesives and emulsion stabilizers. Its use is considered compliant with FDA regulations when there is a functional barrier between the material and food.
For food packaging applications (e.g., grease-proof paper, gas barrier paper), EXCEVAL™ is registered as a Food Contact Substance (FCS) under Food Contact Notification (FCN). For more information regarding the use of this product in food packaging applications, please contact our representative.

Types of food[a)]	Usage Conditions[b)]	Maximum coating amount
Applicable to all food types (no restrictions)	Complies with Conditions C–H and part of Condition J	10 g/m²

Figure 13. FDA FCN-Approved Uses of EXCEVAL™

a) Details are provided in Table 1 of FDA 21 CFR 176.170.
b) Details are provided in Table 2 of FDA 21 CFR 176.170.

9. Handling Precautions

1) Handling Precautions

1. EXCEVAL™ as supplied contains fine powder. When adding it to a dissolution tank, dust may be generated. Please wear rubber gloves and safety goggles to protect your skin and eyes.
2. When handling large quantities, install a dust collection system. Additionally, since there is a risk of dust explosion caused by static electricity or sparks, ensure proper grounding and use conductive materials as necessary.

2) Storage Precautions

1. As the product is water-soluble, store in a cool dry place to prevent exposure to rain or moisture.
2. It is hygroscopic and may form blocks under high temperature and humidity. Avoid storing in such environments.

3) Transportation Precautions

1. Use a waterproof cover to prevent exposure to rain.
2. Do not use tools such as hooks that may damage the packaging.

4) First Aid Measures

- If it comes into contact with eyes: Rinse thoroughly with water as you would for any foreign substance, and seek medical attention from an ophthalmologist.
- If it comes into contact with skin: Whether in powder or solution form, wash off with water.
- If inhaled: Gargle and move to an area with fresh air.
- If swallowed: Give lukewarm water to induce vomiting and seek immediate medical attention.

5) Firefighting Measures

- Extinguishing method: Use water or dry chemical extinguishers as you would for a general fire.
- Extinguishing agents: Water, dry chemical extinguishers, or carbon dioxide extinguishers.

6) Measures in Case of Spillage

- Powder: It may cause slippery conditions. Clean up immediately and collect in a suitable container.
- Solution: It may cause slippery conditions. Wipe up or rinse with water. If a large amount is discharged, treat with activated sludge or similar methods.

7) Disposal Precautions

- Powder form: Incinerate as general waste.
- Solution form: Treat using the activated sludge method.

8) Other Notes

1. Please read the Safety Data Sheet (SDS) before use.
2. The information provided is based on currently available data and is accurate to the best of our knowledge, but not guaranteed.
   These precautions are intended for general handling and may not cover all specific situations, applications, or usage methods.
   Users are responsible for ensuring safe handling and usage conditions.
3. Do not use this product in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless the material has been provided from Kuraray under a written contract that is consistent with Kuraray policy regarding medical applications and expressly acknowledges the contemplated use.
   For further information, please contact your local Kuraray representative.

Adding value to your products – worldwide

KURARAY POVAL™, EXCEVAL™, ELVANOL™, and MOWIFLEX™ are the trademarks for polyvinyl alcohol (PVOH) resins made by Kuraray. Their key characteristics — outstanding film-forming properties and high binding strength — add real value to your products. Our polymers are water-soluble, highly reactive, crosslinkable and foamable. They have high pigment binding capacity, protective colloid characteristics and thickening effects. The physical and chemical properties of KURARAY POVAL™ make it ideal for a wide variety of applications, ranging from adhesives through paper and ceramics to packaging films. Many of our polymers are food contact-approved and thus suitable for food applications.

Kuraray produces its wide range of KURARAY POVAL™ grades in Japan, Singapore, Germany and the United States. Kuraray's global production and service network make us your partner of choice for innovative high-quality PVOH resins.

Kuraray Poval™

PLEASE CONTACT US

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