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Polyethylene Glycols

PEG Products

Preface

PEG products (polyethylene glycols) are formed by ring-opening polymerization of ethylene oxide to ethylene glycol and water.

These products are generally represented by the following formula:

$$HO\ [CH_2CH_2O]_n\ CH_2CH_2OH$$

They are composed of a mixture of polyethylene glycols each with different molecular weights. Therefore, they are usually classified depending on their number-average molecular weight. Our company offers a wide range of PEG products in molecular weights ranging from 200 (PEG-200) to 20,000 (PEG-20000).

We offer the following range of PEG products:

	Number-Average Molecular Weight		
	Low	Medium	High
Product Name	PEG-200 PEG-300 PEG-400 PEG-600 PEG-1500	PEG-1000 PEG-1540 PEG-2000	PEG-4000N PEG-4000S PEG-6000P PEG-6000S PEG-10000 PEG-20000

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1. Typical Properties

Tables 1-a and 1-b show the typical properties of PEG products. The values are representative. PEG products are compatible with each other. Mixing equivalent amounts of PEG-200 and PEG-300 produces PEG products with intermediate properties between those of PEG-200 and PEG-300.

Table 1-a. Typical Properties

Product Name	Appearance	Molecular Weight *2	Hydroxyl Value *3	pH *4	Color (APHA)	Freezing Point °C	Specific Gravity (25°C / 25°C)
PEG-200	Colorless liquid	200	565	6.0	10	＜-35	1.125
PEG-300		300	375	5.5	10	＜-8	1.125
PEG-400		400	281	5.5	10	6	1.125
PEG-600		600	187	6.0	10	21	1.125
PEG-1000	White wax	1,000	113	6.5	10 *5	37	
PEG-1500 *1	White paste	550	207	5.5	10 *5	40	
PEG-1540	White wax	1,450	79	6.0	10 *5	45	
PEG-2000		2,000	56	5.5	10 *5	51	
PEG-4000N	White flake	3,100	36	6.5	10 *5	55	
PEG-4000S		3,400	33	6.5	10 *5	56	
PEG-6000P	White powder	8,300	13	7.0	10 *5	58	
PEG-6000S	White flake	8,300	14	6.5	10 *5	59	
PEG-10000		11,000	10	6.5	10 *5	59	
PEG-20000		20,000	5.6	7.0	10 *5	60	

*1 Mixture of PEG-300 and PEG-1540
*2 Number-average molecular weight calculated from hydroxyl value
*3 Hydroxyl value by acetylation
*4 Measured using a 5 wt % aqueous solution
*5 Measured using a 25 wt % aqueous solution

Table 1-b. Typical Properties

Product Name	Kinematic Viscosity mm^2/s(210 °F)	Flash Point °C	Vapor Pressure Pa(100 °C)	Specific Heat $kJ \cdot kg^{-1} \cdot K^{-1}$	Fusion Heat kJ/kg	Refractive Index (25 °C)	Surface Tension mN/m(25 °C)
PEG-200	4.1	196	1.3	2.2 *6		1.458	44.5
PEG-300	5.6	225	3.9×10^{-1}	2.2 *6	160	1.462	44.5
PEG-400	7.1	230	1.2×10^{-2}	2.2 *6	150	1.465	44.5
PEG-600	10	246	6.9×10^{-4}	2.2 *6	150	1.467	44.5
PEG-1000	17	250	4.4×10^{-7}	2.3 *7	160		
PEG-1500	16	240		2.3 *7	160		
PEG-1540	26	256	2.7×10^{-10}	2.3 *7	180		
PEG-2000	42	260		2.3 *7	180		
PEG-4000N	80	270		2.3 *7	180		
PEG-4000S	80	265		2.3 *7	180		
PEG-6000P	800	256	$< 2.7\times10^{-10}$	2.3 *7	190		
PEG-6000S	800	256		2.3 *7	190		
PEG-10000	2,100	260		2.4 *7	190		
PEG-20000	14,000	296		2.5 *7	190		

*6 The average value when measured from 30 to 60 °C
*7 The average value when measured from freezing point to 100 °C

1. Solubility and Compatibility

As shown in Table 2, PEG products are soluble in water and many other organic solvents (except aliphatic hydrocarbons), but their solubility decreases in accordance with the increase in their molecular weight.

Table 3 shows the compatibility of PEG products with various chemicals such as cellulose compounds.

Table 2. Solubility

		Water	Methanol	Ethanol	Acetone	Ethyl Acetate	Toluene	Ethyl Cellosolve	Butyl Cellosolve	Ethyl Carbitol	Butyl Carbitol	Heptane	Ethyl Ether
PEG-400	20 °C	A	A	A	A	A	A	A	A	A	A	D	D
	50 °C	A	A	A	A	A	A	A	A	A	A	D	D
PEG-1540	20 °C	A	A	D	B	C	C	D	D	C	D	D	D
	50 °C	A	A	A	A	A	A	A	A	A	A	D	D
PEG-4000S	20 °C	B	C	D	D	D	D	D	D	D	D	D	D
	50 °C	A	A	A	A	A	A	A	B	B	B	D	D
PEG-20000	20 °C	C	C	D	D	D	D	D	D	D	D	D	D

Value of Symbols

A : Higher than 100 g of PEG dissolves in 100 mL solvent.
B : From 50 to 100 g of PEG dissolves in 100 mL solvent.
C : From 1 to 50 g of PEG dissolves in 100 mL solvent.
D : Lower than 1 g of PEG dissolves in 100 mL solvent.

Table 3. Compatibility

	Nitrocellulose	Ethyl Cellulose	Methyl Cellulose	Shellac	Carnauba Wax	Paraffin Wax	Beeswax	Ester Gum	Rosin	Gum Arabic	Caster Oil	Tung Oil	Mineral Oil	Olive Oil	Casein	Gelatin
PEG-400	A	C	B	B	C	C	C	C	A	C	C	C	C	C	A	C
PEG-1500	A	C	C	B	C	C	C	C	B	C	C	C	C	C	A	C
PEG-4000S	B	C	C	C	C	C	C	C	B	C	C	C	C	C	B	C

Value of Symbols

A : Compatible B : Partially compatible C : Not compatible

2. Hygroscopic Properties

PEG products are hygroscopic, and the hygroscopic properties decrease in accordance with the increase in their molecular weight. For example, PEG-200 has a high hygroscopic property similar to that of propylene glycol, whereas PEG-4000S and PEG-20000 have very low hygroscopic properties.

Figure 1 shows the equilibrium moisture regain of PEG, and Figures 2 to 4 show the change of water content over time when the relative humidity (R.H.) varies.

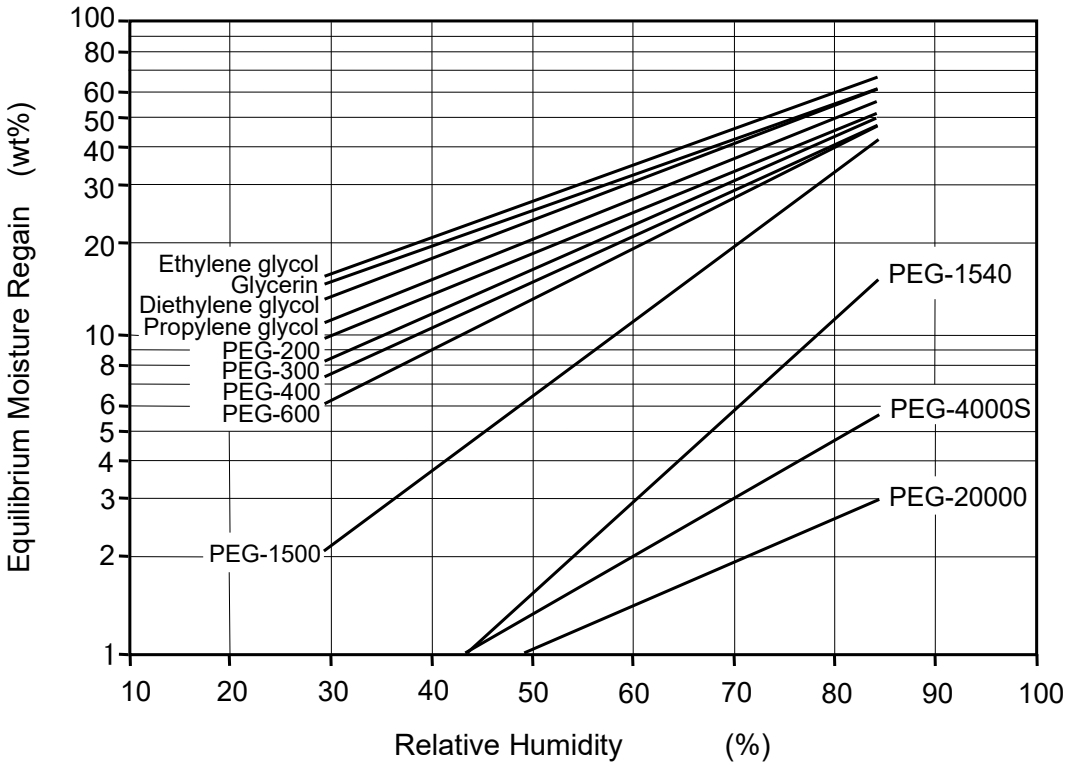

Figure 1. Relationship between Relative Humidity and Equilibrium Moisture Regain

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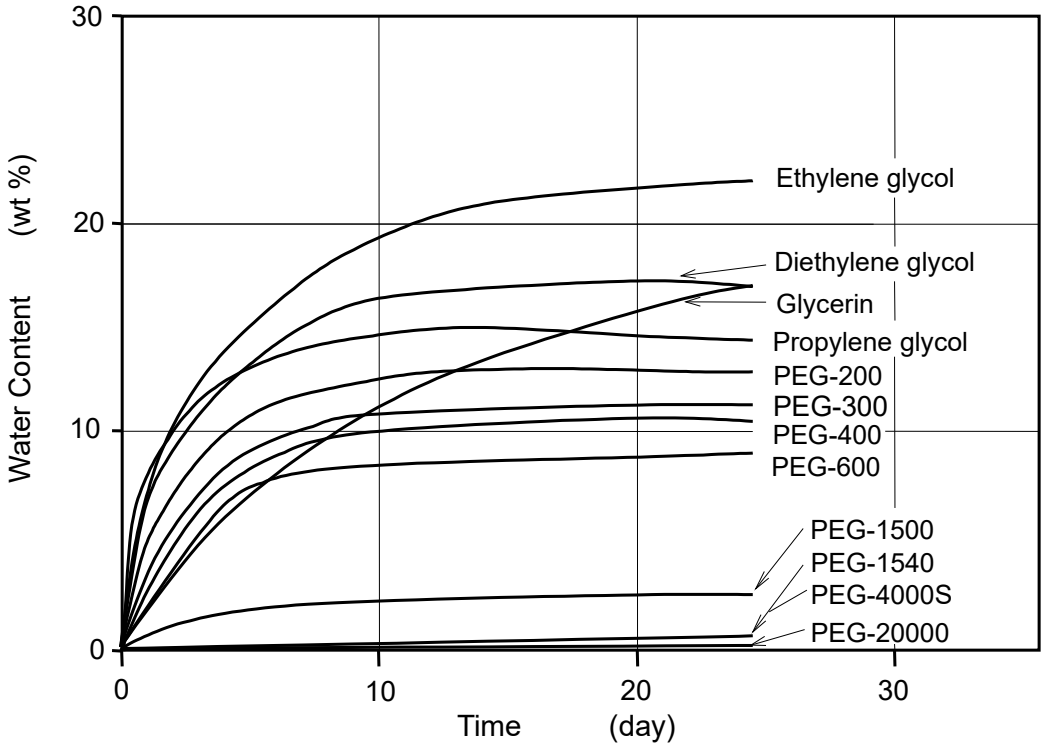

Figure 2. Change of Hygroscopic Properties Over Time (R.H.: 42 %)

Testing Method:

Two grams of a sample were placed in a 20-mL beaker, which was allowed to stand in a sealed desiccator at a relative humidity of 42 %, and then the water content was measured by investigating the variation in mass.

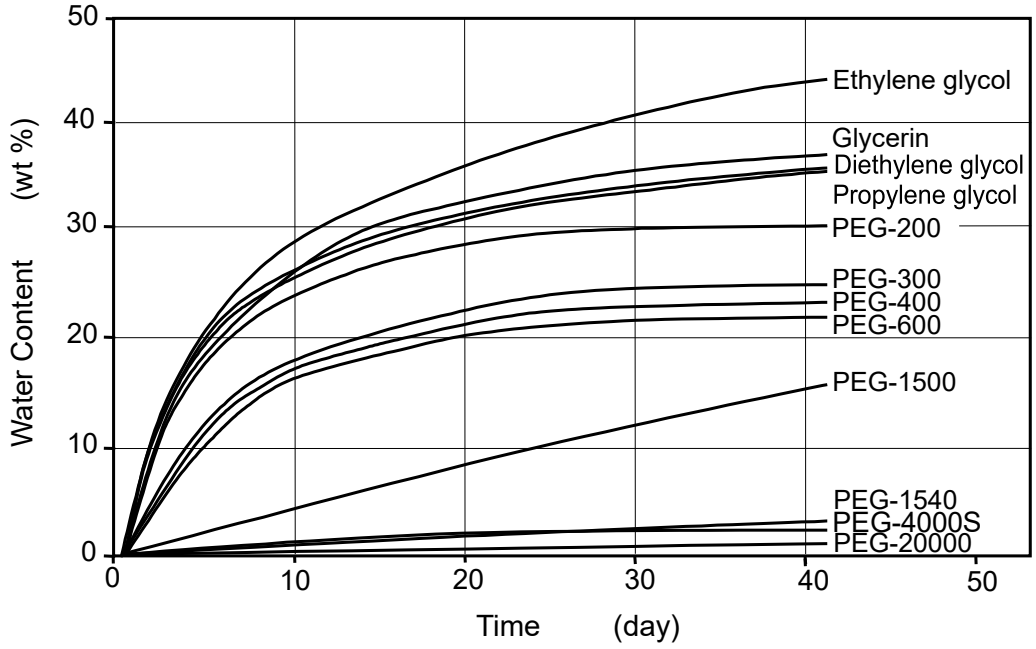

Figure 3. Change of Hygroscopic Properties Over Time (R.H.: 65 %)

Testing Method:

As described in Figure 2 except that the test was conducted at a relative humidity of 65 %.

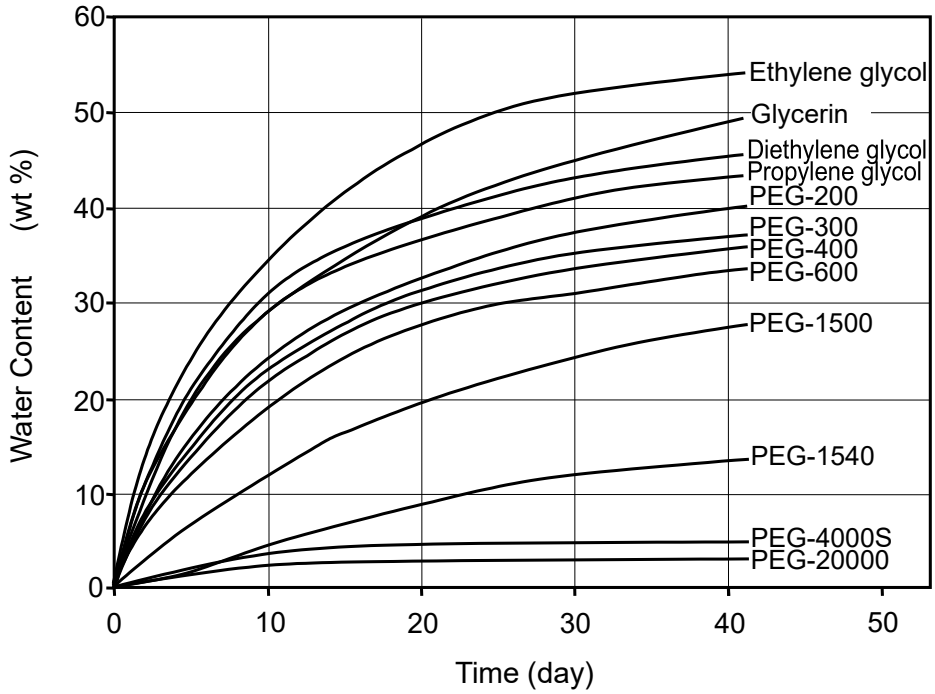

Figure 4. Change of Hygroscopic Properties Over Time (R.H.: 79.2 %)

Testing Method:
As described in Figure 2 except that the test was conducted at a relative humidity of 79.2 %

3. Lubricity

PEG products and their aqueous solutions show excellent lubricity. These products decompose at high temperatures without leaving any sludge by carbonization.

4. Safety

PEG products cause mild irritation, and have low toxicity.

5. Other Performances

· PEG products are easily esterified and etherified, because these products have primary hydroxyl groups at both ends of its molecule.

· They are not hydrolyzed.

· The solubility in water is not affected by the presence of electrolytes. They are soluble in hard water and aqueous saline solutions, as well as in acids and alkalis (except extremely high concentrated acids or alkalis).

· Figure 5 shows the temperature-kinematic viscosity curve of PEG products, and Figures 6 to 8 show the temperature-kinematic viscosity curve of selected PEG products in aqueous solutions.

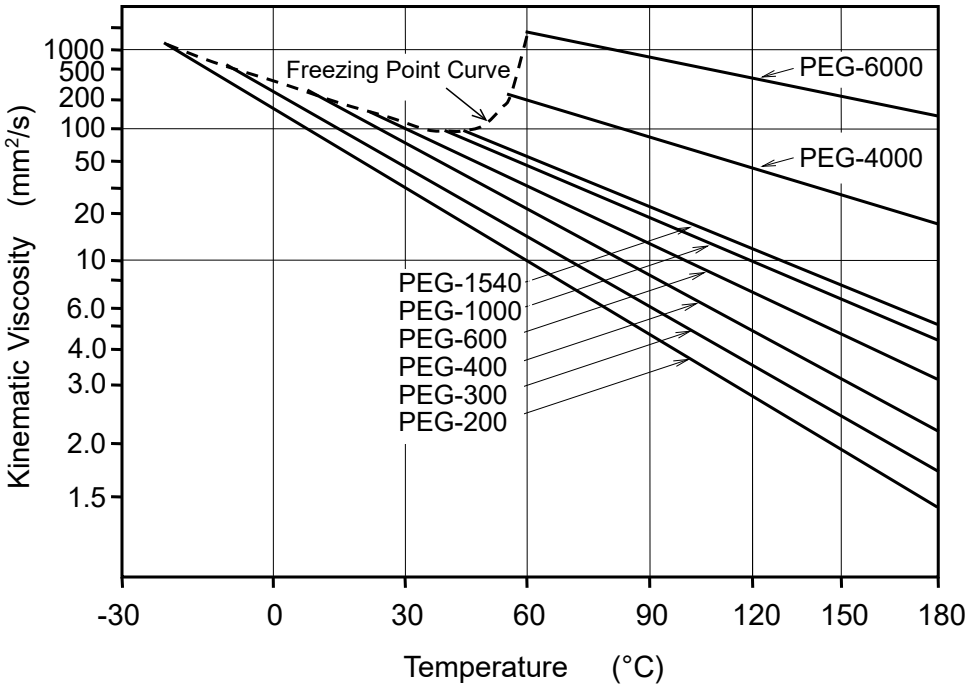

Figure 5. Temperature－Kinematic Viscosity Curve of PEG

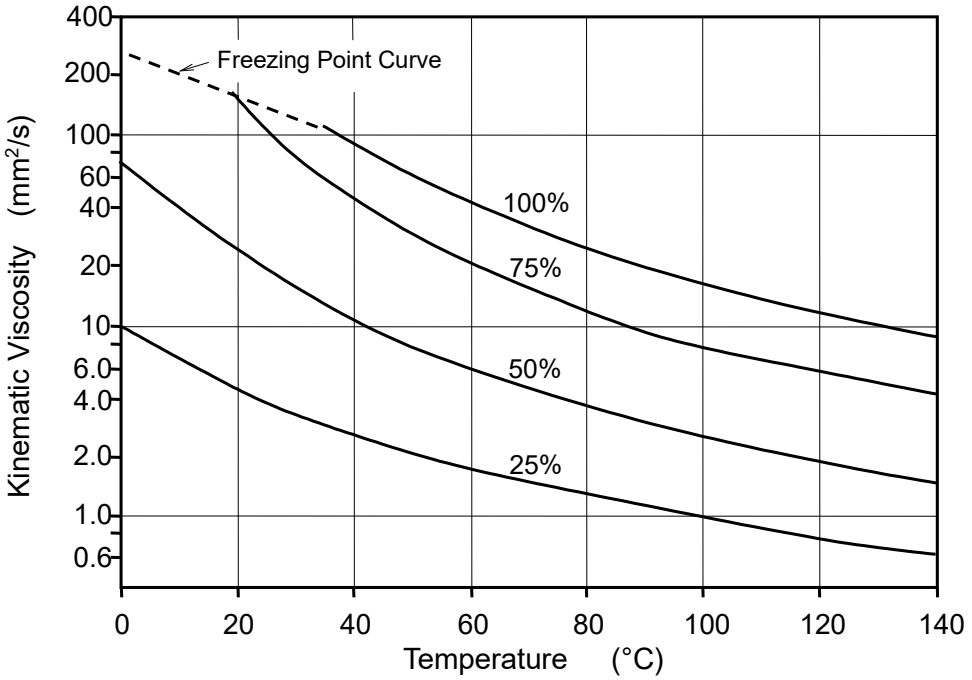

Figure 6. Temperature－Kinematic Viscosity Curve of PEG-1000 and its Aqueous Solutions

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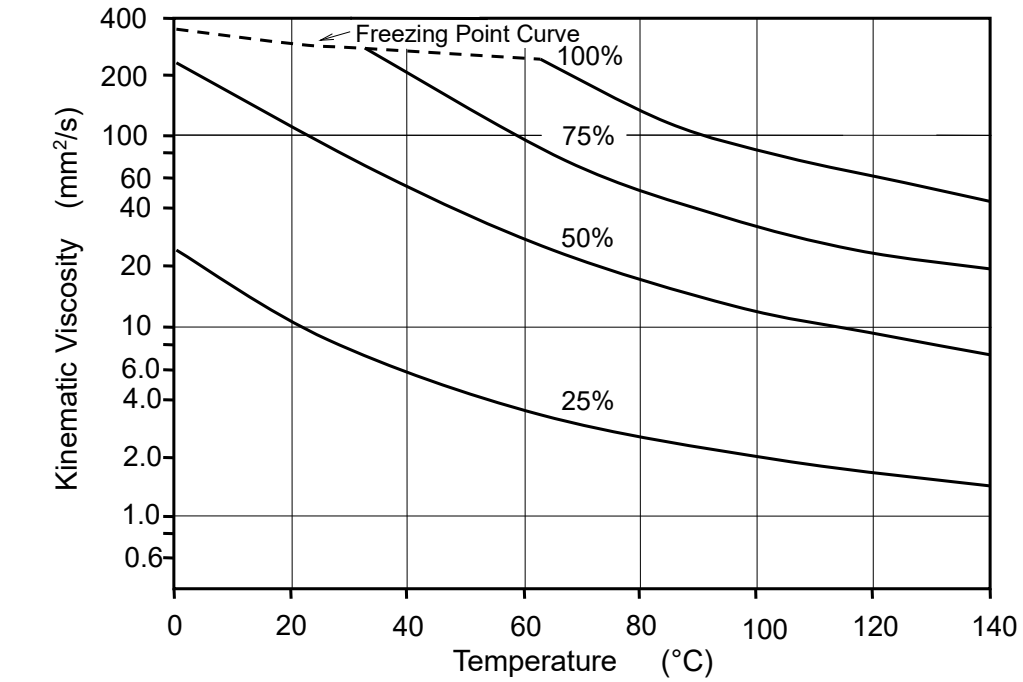

Figure 7. Temperature—Kinematic Viscosity Curve of PEG-4000S and its Aqueous Solutions

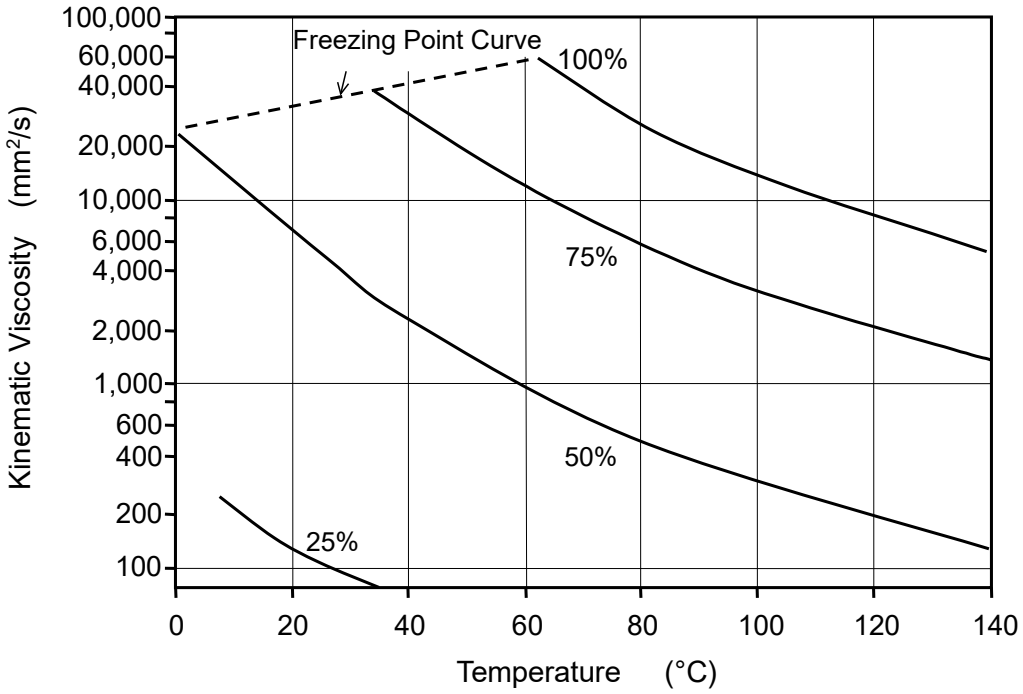

Figure 8. Temperature—Kinematic Viscosity Curve of PEG-20000 and its Aqueous Solutions

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Applications

PEG products have been used in many industries as an intermediate for the manufacture of surfactants, plasticizers, lubricants, etc.

Table 4. PEG Main Applications

Molecular Weight / Industrial Field	Low	Medium	High
Cosmetics and toiletries	Bases for cream		Binders for face powder and enzymes for detergents
Textiles	Perforating agents	Dyeing improvers	Antistatic agents
Papermaking	Softeners	Lubricants	Softeners
Rubber			Lubricants
Resins			・Lubricants ・Plasticizers ・Antistatic agents
Metals			・Lubricants ・Base polymers for quenching
Ceramics		Binders	
Woods	Anticracking agents		
Agrichemicals			Binders for granule preparation
Chemical Products	Raw materials for various products		
Others	・Heating mediums ・Desulfurization auxiliaries ・Cold insulators		Heat resevoirs

Pharmaceutical Applications

We offer polyethylene glycol as a pharmaceutical additive under the trade name of MACROGOL that conforms to Japanese Pharmacopoeia. For details, see our latest pamphlet for MACROGOL Products.

Cosmetics & Toiletries

1. Water-Soluble Bases

PEG products are very safe and soluble in water. Therefore, PEG-1500 is applicable as a water-soluble base for cosmetic creams and hand creams, and PEG-400 can be applied as a water-soluble base for skin lotions.

2. Moisturizers

PEG products with lower number-average molecular weights such as PEG-300, PEG-400 and PEG-600, are applicable as a moisturizer for toothpastes, facial cleaning foams, hair-care products and wet tissues due to their moisture-retention properties.

3. Binders

PEG products with higher number-average molecular weights such as PEG-4000S and PEG-6000S exhibit high binding power and are soluble in water. Therefore, they are applicable as binders for face powders and detergent enzymes.

4. Anticaking Agents

PEG-6000S is applicable as an anticaking agent for powdered detergents.

5. Anticracking Agents

PEG-6000S is applicable as an anticracking agent for solid soaps.

6. Antiblocking Agents

PEG-200 and PEG-300, when blended with liquid detergents such as kitchen detergents, are effective as antiblocking agents for detergent containers.

7. Dustproofing Agents

PEG-6000S is applicable as a dustproofing agent for powdered products such as cosmetics and detergents.

Textiles

1. Antistatic Agents

PEG-4000S, PEG-6000S and PEG-2000 are applicable as antistatic agents for polyester fibers.

2. Dyeing Improvers

PEG-1000 or PEG-2000 is copolymerized to produce polyester that can be easily dyed.

3. Sizing Agents

The sewing of cloth, such as polyester, nylon and rayon, that has been sized, may be obstructed due to the sizing agent adhering to the needle.

PEG-600 blended with sizing agents imparts flexibility and an antistatic property to the cloth and makes sewing easy. PEG-600 is also effective as anti-skinning agents for sizing agents.

4. Perforating Agents

PEG-400, PEG-600 and PEG-1000 are applicable as perforating agents for hollow fibers and porous fibers.

Papermaking

1. Softeners

PEG products are suitable as paper softeners; the softening effect lasts a long time due to the low volatility of PEG products.

PEG-200, PEG-300 and PEG-400 are particularly suitable for softening PVA films and cellophane.

2. Lubricants

PEG-1540 and PEG-4000S blended with starch paste or protein paste are applicable as lubricants for paper calendering.

3. Anticurling Agents

Impregnation of paper with PEG-400 prevents the paper from curling due to the product's moisture-retention property.

Rubber

1. Extruding Lubricants

PEG-4000S kneaded with natural and synthetic rubbers improves fluidity of compounds and dispersibility of fillers including carbon black, and increases the vulcanization rate.

PEG-4000S also allows the rubber to be easily removed from the mold.

2. Molding Lubricants

PEG-4000S is applicable as a lubricant for use when molding natural and synthetic rubbers. After molding, this product is easily rinsed off the rubber surface.

Resins

1. Lubricants

PEG-6000S is applicable as a lubricant for nylon and polyacetal.

2. Resin Finish Baths

PEG-400 can be used in heating baths for bending such things as PVC pipes because it is water-soluble and can be easily rinsed out.

3. Plasticizers

PEG-4000S is applicable as a plasticizer for urea resins.

4. Antistatic Agents

PEG-4000S and PEG-6000S are available as polymer-alloy type antistatic agents for polyester, ABS resins, nylon, and polyacetal.

5. Resin Modifiers

PEG imparts flexibility and hydrophilic properties to polyester, polyurethane and alkyd resins when it modifies the resins by using its primary hydroxyl groups at both ends of its molecule.

Metals

1. Lubricants

PEG-20000 is applicable as a base for water-soluble press forming oils used for press working of steel plates because of its excellent lubricity.

2. Base Polymers for Quenching

PEG-20000 is available as a base polymer for water-soluble quenching oils because the aqueous solution of PEG-20000 has an adequate cooling property for quenching steel.

3. Binder and Dustproofing Agents

PEG-4000S is applicable as a binder for use in manufacturing powder metallurgy using metal powders, and as a dustproofing agent for abrasives made of aluminum oxide.

Ceramics

1. Binders

Ceramic materials blended with solutions of PEG-4000S or PEG-6000S mixed with polyvinyl alcohol, polyvinyl acetate, and/or gum arabic are viscous, easily molded, and hard to crack.
When blended with fine ceramics, PEG-20000 is effective as a binder, imparting good dispersibility and a shape retention property, yet it does not leave sludge after sintering.

Woods

1. Anti-Cracking Agents

Wood immersed in an aqueous solution of PEG-600 or PEG-1000 shows less dimensional change and is hard to crack, because PEG products become a substitute for moisture in the wood.

Deformation of the unearthed wooden cultural properties can be prevented by gradual substitution of moisture with PEG-4000S.

Agrichemicals

1. Binders

PEG-6000S is applicable as a binder for agrichemical granules.

2. Auxiliaries

PEG products are effective in controlling fluidity and anticaking for powdery preparations and flowable agrichemicals.

Chemical Products

1. Surfactants

Various surfactants can be synthesized through reactions of the primary hydroxyl groups at both ends of the PEG molecule. Among them, the higher fatty acid esters of PEG products are surfactants that are widely used as emulsifiers, dispersants and detergents.

2. Other Chemical Materials

The primary hydroxyl groups at both ends of the PEG molecule can be chemically changed to other groups (alkyl-etherified, aminated, carboxylated, glycidyl etherified, or esterified). These PEG derivatives can be used as raw materials for various chemical products.

Others

1. Viscosity Adjustors

PEG-600 and PEG-1000 are effective as viscosity adjustors for ballpoint ink; they improve ink performance including the prevention of blotting.

2. Heating Mediums

PEG-400 and PEG-600 are available as a heating medium. They have good thermal stability, a high boiling point and high specific heat. They are easily washed off with water.

3. Sensitizers

PEG-400 mixed with saturated aliphatic polyhydric alcohol is effective as a sensitizer, improving the sensitivity and contrast of photosensitive films.

4. Heat Reservoirs

PEG products are applicable as heat reservoirs due to their high fusion heat.

5. Cold Insulators

PEG-200 is applicable as a cold insulator base because it is water-soluble and has a low freezing point.

Important :
Before handling these products, refer to the Safety Data Sheet for recommended protective equipment, and detailed precautionary and hazards information.

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