kuraray

Kuraray Poval™

KURARAY CO., LTD., Poval Resin Division
December 2023

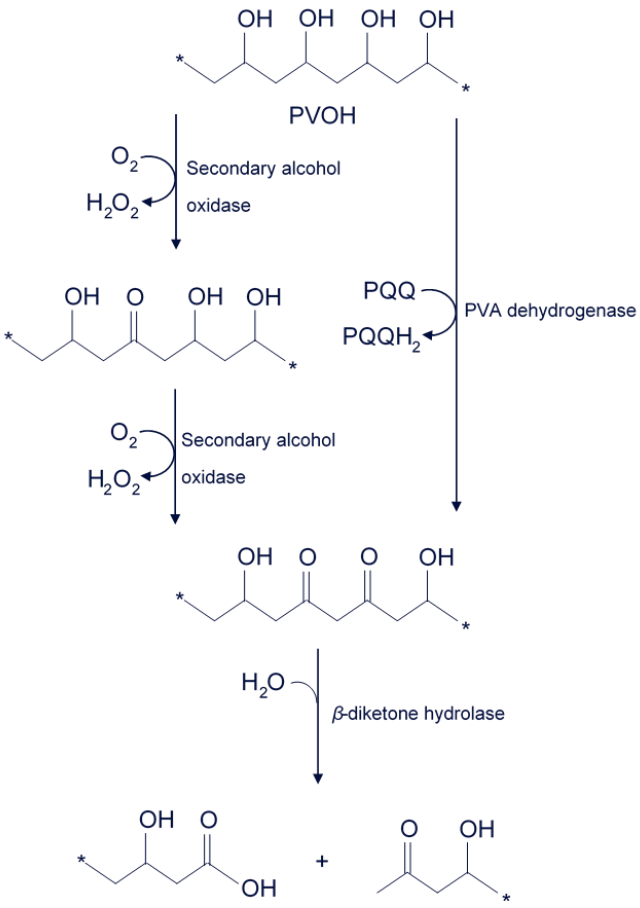
Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Polyvinyl Alcohol

Polyvinyl alcohol (PVOH) is recognized as one of the very few vinyl polymers which are water soluble and biodegradable in water in the presence of micro-organisms. Treatment of PVOH containing effluent by activated sludge is well practiced especially in paper and textile sizing industries.

The first micro-organisms capable of assimilating PVOH as their sole carbon source were isolated from soil samples and identified as Pseudomonas species [1–3]. It is thought that the first step of biodegradation is an enzymatic oxidation reaction of 1,3-glycol into 1,3-diketone and then this diketone is randomly cleaved to a shorter chain by hydrolase as shown is Scheme 1.

Scheme 1. Expected biodegradation mechanism of PVOH



kuraray

Kuraray Poval™

KURARAY CO., LTD., Poval Resin Division
December 2023

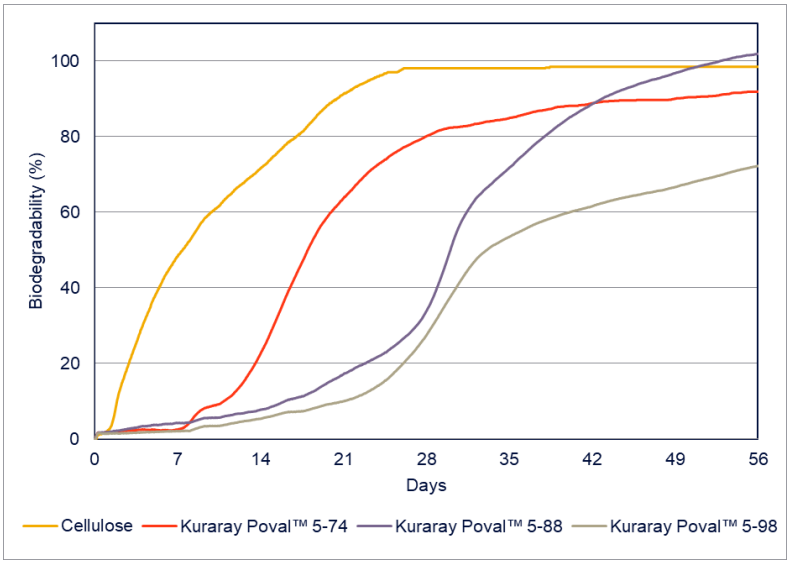
Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Kuraray Poval™ in water

Kuraray Poval™ is inherently biodegradable* in aqueous solution form, but its biodegradability is dependent on specification (ex. degree of hydrolysis, degree of polymerization, modification type) and the conditions of biodegradation (ex. test method, environmental condition). Fig. 1 and 2 show our internal biodegradability test results for some of our Kuraray Poval™ grades. The biodegradability of Kuraray Poval™ can get close to 100%. It is observed that there is a certain induction period at the initial start of biodegradation and this is understood to be micro-organisms gradually growing during this initial period. The biodegradability of some Kuraray Poval™ grades get above 100%. This is because the micro-organisms consume more oxygen than the theoretical value which can be classed as a measurement error. This phenomenon is sometimes observed in bio-degradation tests and is difficult to avoid because the micro-organisms are living species.

* Inherent biodegradability refers to a classification of chemicals for which there is unequivocal evidence of biodegradation (primary or ultimate) in any test of biodegradability.

Fig.1 Biodegradation test results of Kuraray Poval™ with different degree of hydrolysis



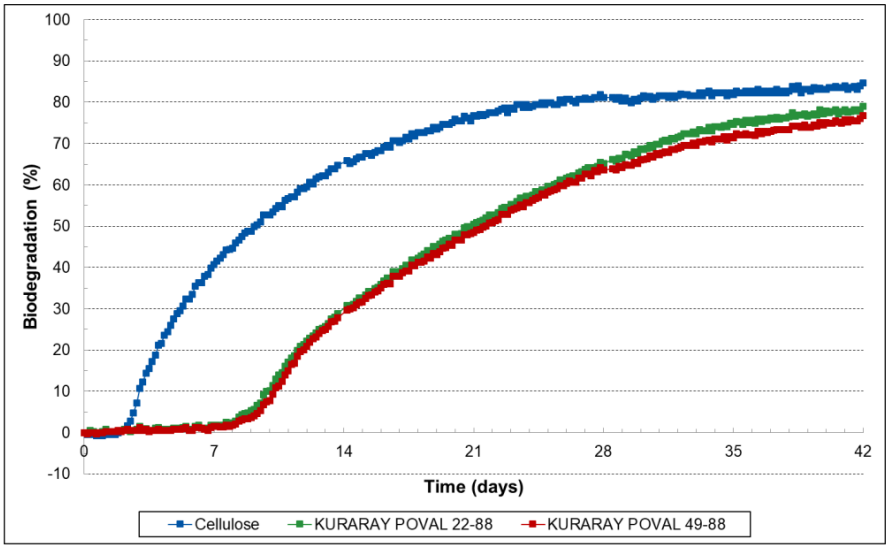
Test condition

- Test guideline; ISO 14851
- Test organization; Kuraray (internal test)
- Sludge; Sampled from wastewater treatment plant in Japan
- Sludge concentration; 100 mg / L
- Sample concentration; 100 mg / L
- Biodegradability (%) was calculated from oxygen consumption by micro-organisms

KURARAY CO., LTD., Poval Resin Division
December 2023

Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Fig.2 Biodegradation test results of Kuraray Poval™ with different degree of polymerization



- Test guideline; ISO 14851
- Test organization; OWS nv (Normec OWS)
- Sludge concentration; 100 mg / L
- Sample concentration; 100 mg / L
- Biodegradability (%) was calculated from oxygen consumption by micro-organisms

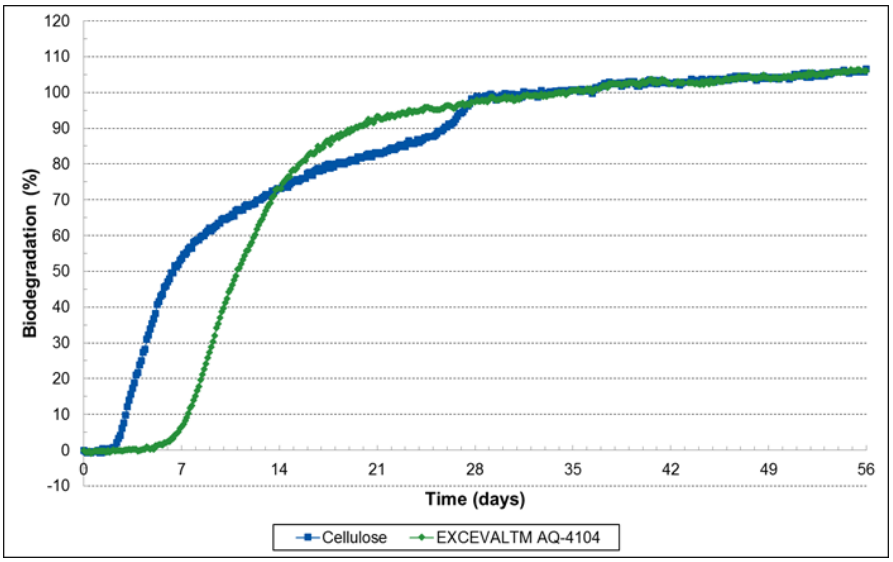
KURARAY CO., LTD., Poval Resin Division
December 2023

Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Exceval™ in water

Kuraray has several specialty grades of PVOH. Exceval™ is the trademark of Kuraray's hydrophobically modified polyvinyl alcohol especially designed for the requirements of high water resistance. Exceval™ is also inherently biodegradable in aqueous solution form. As an example, Fig.3 shows the biodegradation result of Exceval™ AQ-4104 which is the most biodegradable grade in the Exceval™ product portfolio.

Fig.3 Biodegradation test result for Exceval™ AQ-4104



Test condition

- Test guideline; ISO 14851
- Test organization; OWS nv (Normec OWS)
- Sludge concentration; 100 mg / L
- Sample concentration; 100 mg / L
- Biodegradability (%) was calculated from oxygen consumption by micro-organisms

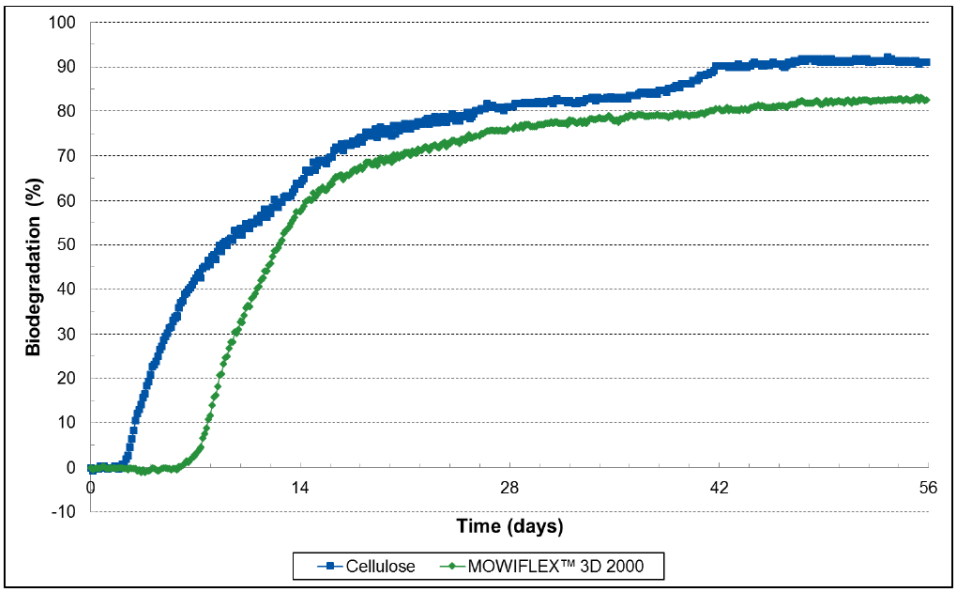
KURARAY CO., LTD., Poval Resin Division
December 2023

Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Mowiflex™ in water

Mowiflex™, is a compound of PVOH and plasticizer, which has been designed in order to suit thermoplastic processing needs. Fig.4 shows the biodegradation test result of Mowiflex™ 3D 2000 which is the one of the Mowiflex™ grades.

Fig.4 Biodegradation test result of Mowiflex™ 3D 2000



Test condition

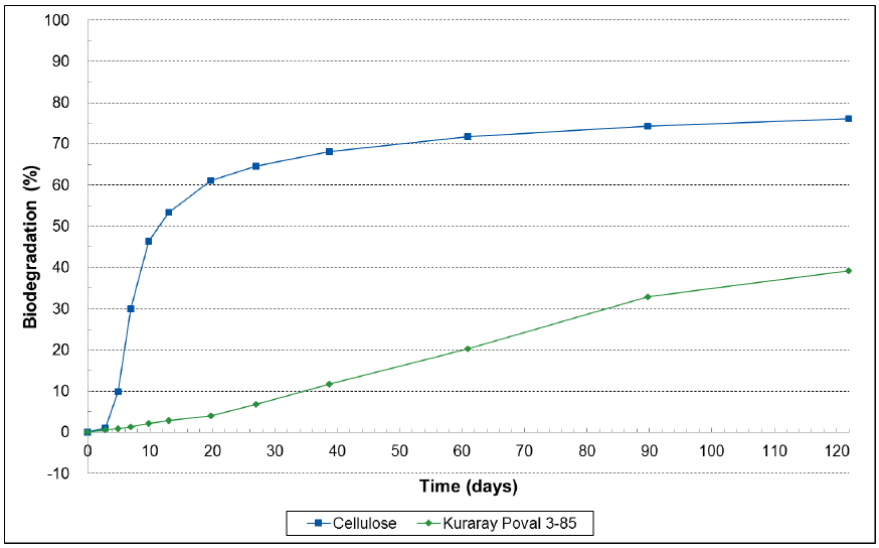
- Test guideline; ISO 14851
- Test organization; OWS nv
- Sludge concentration; 100 mg / L
- Sample concentration; 100 mg / L
- Biodegradability (%) was calculated from oxygen consumption by micro-organisms

Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Kuraray Poval™ in soil

There have been some studies undertaken to show the biodegradation of PVOH under composting conditions and in a soil environment using samples of PVOH film [4, 5] but PVOH-based films underwent limited biodegradation. This low degradation may be because of adsorption of PVOH on soil inhibits the biodegradation process [6]. According to Kuraray's biodegradation test result in soil following ISO 17556 (Fig.5), it was observed that Kuraray Poval™ can be biodegraded in soil when the Kuraray Poval™ is made into an aqueous solution and then mixed with the soil. From the test result, it could be said that Kuraray Poval™ needs to be dissolved in water for an efficient biodegradation process.

Fig.5 Biodegradation test result for Kuraray Poval™ 3-85 solution



Test condition

- Test guideline; ISO 17556
- Test organization; OWS nv
- The standard inoculum; 70% industrial quartz sand, 10% kaolinite clay, 16% natural soil and 4% mature compost
- Moisture content; 40-60%
- Biodegradability (%) was calculated from the percentage of solid carbon of the test item

kuraray

Kuraray Poval™

KURARAY CO., LTD., Poval Resin Division
December 2023

Biodegradation of Kuraray Poval™, Exceval™ and Mowiflex™

Biodegradation of Kuraray Poval™ in an aqueous marine environment.

People all over the world pay attention to micro-plastic pollution and the interest in the biodegradability of materials in the marine environment is increasing. According to an academic paper [7], marine bacteria (Vibrio alginolyticus and Vibrio parahemolyticus) which are isolated from sediments do degrade PVOH-LLDPE blended plastic films. Kuraray conducted a biodegradability test and biodegradation was observed even in sea water. This test proves the existence of micro-organisms which could degrade Kuraray Poval™ in sea water.

PVOH becomes a microplastic?

The European Union Commission adopted Regulation (EU) No. 2023/2055 to restrict synthetic polymer microparticles (‘microplastics’) as substances on their own and in mixtures. Degradable polymers in accordance with Regulation (EU) No. 2023/2055 Appendix 15 ‘Rules on proving degradability’ and polymers with a solubility of more than 2 g/L in accordance with Regulation (EU) No. 2023/2055 Appendix 16 ‘Rules on proving solubility’ are not designated as ´microplastics´. Kuraray Poval™ grades listed in table 1 meet the requirements laid down in Appendix 16 ‘Rules on proving solubility’ and are exempted from the synthetic polymer microparticle definition. Furthermore, ´microplastics´ used at industrial sites are excluded from the scope of the restriction and may continue to be sold.

Table 1: Kuraray Poval™ and Exceval™, Mowiflex™ grades with a solubility of more than 2 g/L

Partially hydrolyzed Kuraray Poval™ grades				Modified Grades
3-80	13-88	40-88	L-9P	Exceval™ RS-1717
5-82	18-88	44-88	L-10	Mowiflex™ C07
3-83	22-88	47-88	L-11	Mowiflex™ C17
3-85	22-88 SB	48-80	L-9-78	Mowiflex™ C30
3-86 SD	23-88	49-88	L-508W	Mowiflex™ C140
3-88	25-88 KL	50-92	L-508	Mowiflex™ C600
4-85	26-80	95-88		Mowiflex™ 3D200
4-88	26-88	100-88		
5-74	30-92	105-88 KX		
5-82	30-94 KM	105-88 KX SB		
5-88	32-80	200-88 KX		
5-88 FA	32-88	200-88 KX SB		
6-88	35-80	L-8		
8-88	40-80 E	L-9		

*This content reflects the current state of knowledge. Further tests are currently being performed. Thus, further adjustments are possible

Reference

[1] Watanabe Y, Morita M, Hamada N, Tsujisaka Y, Agric Biol Chem 1975; 39:2447–8.
[2] Suzuki T, Ichihara Y, Yamada M, Tonomura K, Agric Biol Chem 1973; 37:747–56.
[3] Sakai K, Hamada N, Watanabe Y, Agric Biol Chem 1986; 50:989–96.
[4] Chiellini E, Corti A, Solaro R, Polym Degrad Stab 1999; 64:305–12.
[5] Solaro R, Corti A, Chiellini E., J Environ Polym Degrad 1998; 6: 203–8.
[6] Chiellini E, Corti A, Politi B, Solaro R, J Polym Environ 2000; 8:67–79.
[7] Raghul S S, Bhat S G, Chandrasekaran M, Francis V, Thachil E T, Int. J. Environ. Sci. Technol. 2014; 11:1827–1834