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poval
exceval
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**KURARAY POVAL™ for
suspension PVC**



KURARAY POVAL™ for suspension PVC

1. Introduction

Kuraray has much expertise in the use of polyvinyl alcohol (PVA or PVOH) based suspending agents for the needs of PVC manufacturers. In this application, polyvinyl alcohol is used as a protective colloid for the polymerisation of PVC. Vinyl chloride monomer is suspended in water by means of stirring, in combination with a suspending agent to allow the polymerisation reaction to proceed. The physical properties of the resulting PVC, including size, shape of the grains and bulk density, are directly related to the grain forming process during polymerisation. Kuraray's primary and secondary suspending agents allow precise control of the grain formation and its resulting structure and morphology. Furthermore, the surface active performance can be widely optimised by selecting an appropriate combination of Kuraray's suspending agents. This diversity enables the PVC manufacturer to produce a very versatile range of PVC

resins, varying in morphology and K value according to the intended end application

PVC resin can be used in many applications to replace such materials as wood, glass and some metals. Thanks to the economics, durability and self-extinguishing properties of PVC it can be used for water pipe, electrical cable and a variety of building products.

PVC also finds use in wallpaper and window profile, agriculture and automotive parts, synthetic leather and film for packaging. Because of its use in many applications it is a material present in our everyday life. The majority of PVC resin is manufactured by the suspension polymerisation process. Polyvinyl alcohol is an essential part of this process as the main suspending agent.

2. Production of PVC resin.

PVC can be manufactured in a number of ways from suspension polymerisation, emulsion polymerisation and bulk polymerisation but the most popular is suspension polymerisation.

PVC resin is manufactured with a mean grain size of around 150 micron by adding water and suspending agent, polyvinyl alcohol (PVOH) into the reactor together with liquid VCM monomer under pressure. This mixture is agitated to create fine droplets. To achieve PVC resin of this type it is required to control a number of parameters including particle size and morphology, which will influence bulk density and porosity and help processing of the PVC resin at a later stage.

Polyvinyl alcohol is an important additive as a suspending agent in this process to influence such properties as mentioned above to control PVC quality and technical performance.

KURARAY POVAL™ properties are mainly controlled by the degree of hydrolysis and degree of polymerisation as shown in Fig 1. For PVC suspension polymerisation the degree of hydrolysis and degree of polymerisation are important properties for surface activity and protective colloidability in the PVC polymerisation process.



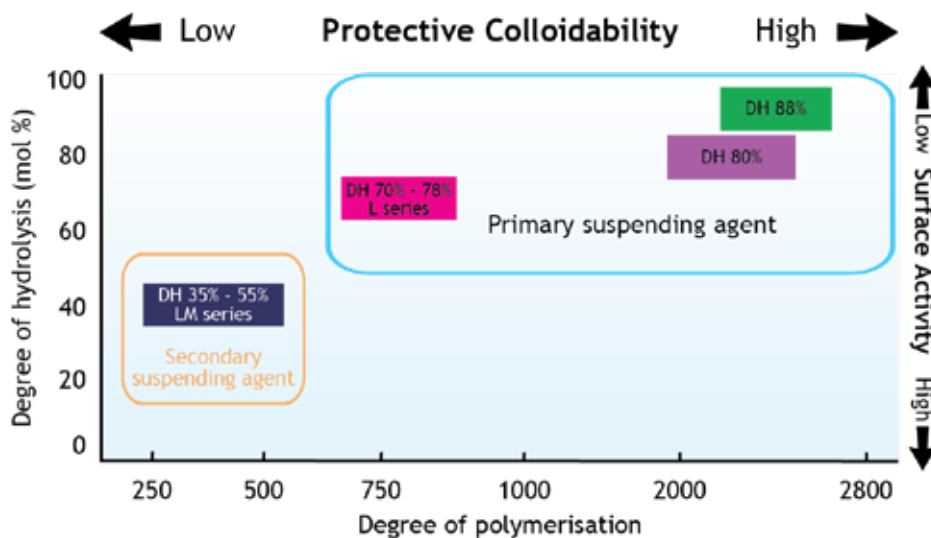


Fig 1 The role of polyvinyl alcohol for PVC polymerisation and PVC resin properties.

The role of polyvinyl alcohol for suspension polymerisation is different depending on the degree of conversion of VCM to PVC. The required properties of the polyvinyl alcohol for each stage (<0.1% compared to 0.1% to <30% compared to >30%) will be explained below.

Fig 2 shows the polymerisation mechanism starting with conversion <0.1% which is the stage that the initiator is distributed throughout the VCM monomer. The initiator and monomer will be mixed by the monomer droplet coalescence and dispersion caused by the agitation in the reactor. If this

As shown below in Fig 2, the next phase shows the conversion below 30% which is the stage when the PVC primary particles are generated in the VCM monomer droplets. Polymerisation occurs in each monomer droplet and the PVC primary particle around 1 micron in size is precipitated in the monomer droplet as the PVC resin is not soluble in VCM monomer. In this process it is said that primary particles agglomerate in the monomer droplet to form a network structure due to the frequent coalescence and dispersion of the monomer droplets. Because of this the internal structure of the PVC resin becomes more porous leading to benefits in porosity for

coalescence and distribution process is poor, the achieved conversion of each droplet will be non-homogenous. PVC monomer droplets with high levels of initiator will have high conversion which can lead to issues with fish eyes in thin film applications. To enhance this coalescence and dispersion behaviour a polyvinyl alcohol which has a higher surface activity and lower protective colloidability will be required. The most suitable KURARAY POVAL™ grades for the above process will be our L and LM grades.

easier absorbance of plasticiser and additives giving greater processability of the PVC resin.

On the contrary if coalescence and dispersion is not efficient during this stage the primary particle will not have a network structure in the monomer droplet and the PVC resin will become less porous which would lead to a resin of poor processability. To enhance this coalescence and dispersion behaviour a polyvinyl alcohol which has a higher surface activity and lower protective colloidability will be required. The most suitable KURARAY POVAL™ grades for the above process will be our L and LM grades.



The final phase for conversion above 30% which is the stage when the PVC resin particles will be formed by the agglomeration of primary particles, coalescence and dispersion of monomer droplets will not occur due to the increase of conversion. The protective colloidability of the polyvinyl alcohol can control this agglomeration process. Lower protective colloidability can lead to too much agglomeration and generate large particles and the

polymerisation will become unstable. Higher protective colloidability leads to more balanced agglomeration and polymerisation will be stable.

For this stage a polyvinyl alcohol with higher protective colloidability will be required. The most suitable KURARAY POVAL™ grades for the above process will be products with a degree of hydrolysis of 80 mol% or higher and our L grades.

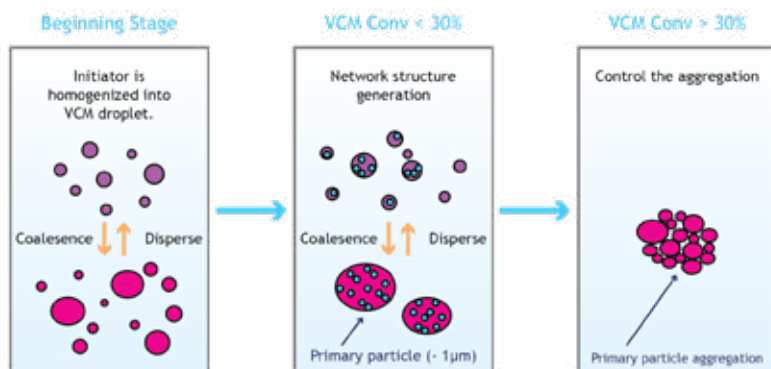


Fig 2 the polymerisation mechanism

SURFACE ACTIVITY	PROTECTIVE COLLOIDABILITY
High = small monomer droplets	High = less agglomeration
Low = large monomer droplets	Low = more agglomeration

High protective colloidability polyvinyl alcohols which are required for stability in the polymerisation process are called primary suspending agents. On the other hand higher surface activity polyvinyl alcohols which are required for greater porosity generation in the polymerisation process are called secondary suspending agents.

The required performance of a polyvinyl alcohol as a suspending agent will be different for each polymerisation stage but in the actual process each polyvinyl alcohol is added into the reactor at the same time, at the beginning of the process. It is important to design the recipe using a combination of suitable polyvinyl alcohols for each part of the polymerisation process taking into account the attributes of the equipment being used in terms of agitation, baffles, jacket or condenser cooling and reactor size and geometry.



KURARAY POVAL™ grade list for PVC suspension polymerisation

Grade name KURARAY POVAL™	Viscosity ⁽¹⁾ JIS K 6726 [mPa·s]	Degree of hydrolysis [mol%]	Non-volatile ⁽²⁾ content [%]	Ash ⁽³⁾ content [%]	pH
Primary Suspending Agent					
32-80	29.0-35.0	79.0-81.0	97.5±2.5	≤ 0.4	5.0-7.0
35-80	32.0-38.0	79.0-81.0	97.5±2.5	≤ 0.4	5.0-7.0
40-80E	37.0-45.0	79.0-81.0	97.5±2.5	≤ 0.4	5.0-7.0
48-80	45.0-51.0	78.5-80.5	97.5±2.5	≤ 0.2	5.0-7.0
L 8	5.0-5.8	69.5-72.5	98.5±1.5	≤ 1.1	5.0-7.0
L 9	5.5-6.1	69.5-72.5	98.5±1.5	≤ 1.1	5.0-7.0
L 9-78	6.0 - 6.7	76.5-79.0	98.5±1.5	≤ 1.2	5.0-7.0
L 9P	6.2-7.2	71.5-73.5	98.5±1.5	≤ 0.5	5.0-7.0
L 10	5.0-7.0	71.5-73.5	97.5±2.5	≤ 1.1	5.0-7.0
L 11	5.5 - 7.5	71.5-73.5	98.5±1.5	≤ 0.4	5.0-7.0
L 508W	6.0-7.0	71.5-73.5	97.5±2.5	≤ 0.4	5.0-7.0
44-88	40.0 -48.0	87.0-89.0	97.5±2.5	≤ 0.4	5.0-7.0
49-88	45.0 -52.0	87.0-89.0	97.5±2.5	≤ 0.4	5.0-7.0
55-95	50.0-60.0	95.0-96.0	97.5±2.5	≤ 0.4	5.0-7.0

(1) of a 4 % water solution at 20 °C DIN 53015 / JIS K 6726
(2) after 3 hours drying at 105 °C DIN 53189 / JIS K 6726
(3) calculated as Na₂O

KURARAY POVAL™ grade list for PVC suspension polymerisation

Grade name KURARAY POVAL™	Viscosity ⁽¹⁾ [mPa·s]	Degree of hydrolysis [mol%]	Non-volatile ⁽²⁾ content [%]	Ash ⁽³⁾ content [%]	pH
Secondary Suspending Agent					
LM-10 HD	4.5 - 5.7	38.0 - 42.0	98.5 ± 1.5	≤ 0.6	NA
LM-20	3.0 - 4.0	38.0 - 42.0	98.5 ± 1.5	≤ 1.0	NA
LM-30	9.3 - 10.3 ⁽⁴⁾	45.0 - 51.0	98.5 ± 1.5	≤ 0.6	NA
LM-40 HT	3.1 - 4.3	38.0 - 42.0	98.5 ± 1.5	≤ 1.5	NA

(1) of a 4 % methanol / water (1/1) solution at 20 °C DIN 53015 / JIS K 6726
(2) after 3 hours drying at 105 °C DIN 53189 / JIS K 6726
(3) calculated as Na₂O
(4) of a 10% methanol / water (1/1) solution at 20 °C



Characteristics of KURARAY POVAL™ for PVC suspension polymerisation Kuraray primary suspending agents

KURARAY POVAL™ grades with a degree of hydrolysis 80 mol%

These grades have a high degree of hydrolysis and a high degree of polymerisation among our primary suspending agents. With these grades suspension polymerisation can be

carried out in a stable manner, especially for the combination with a secondary suspending agent. It is possible to stabilise the PVC resin particle size.

KURARAY POVAL™ L grades

These grades have a low degree of hydrolysis and low degree of polymerisation among our primary suspending agents. Compared to our grades with a degree of hydrolysis at 80 mol% they can reduce the polyvinyl alcohol use in the recipe. They can also control the PVC particle size easily by adjusting the amount used. They can provide good porosity PVC resin

maintaining good bulk density. Plasticiser absorbance speed, fish eye level and residual VCM level will be improved leading to a good balance of properties for the PVC resin produced. These grades also provide a narrow PVC resin particle size distribution and improved morphology giving more spherical particles leading to better processability.

KURARAY POVAL™ grades with a degree of hydrolysis 88 mol% to 95 mol%

These grades have a high degree of hydrolysis and a high degree of polymerisation among our primary suspending agents. Combining these grades with grades of hydrolysis at

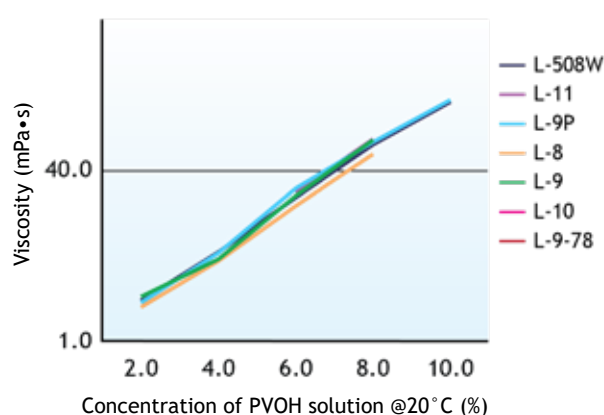
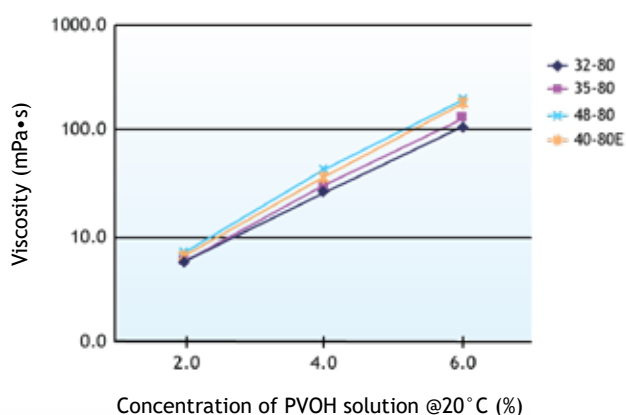
80 mol% it is possible to obtain high bulk density PVC resin. KURARAY POVAL™ 55-95 can also be used in recipes to increase the bulk density of the PVC resin.

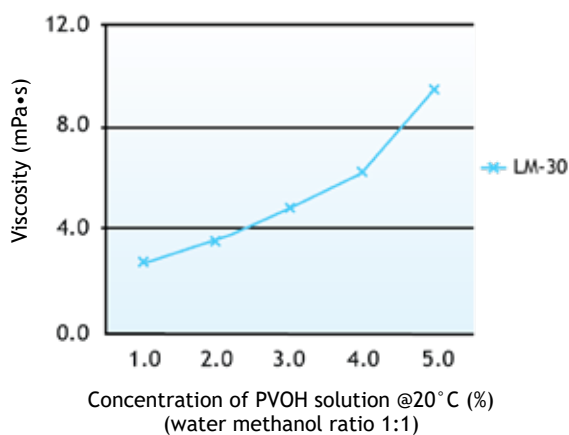
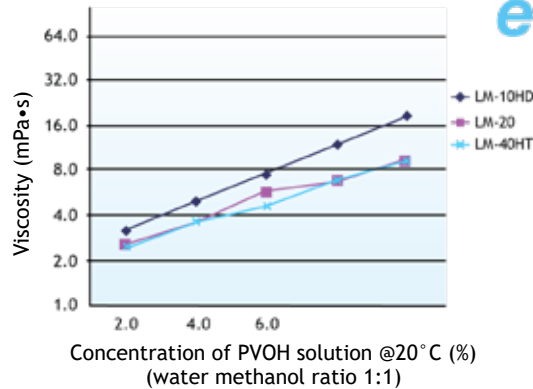
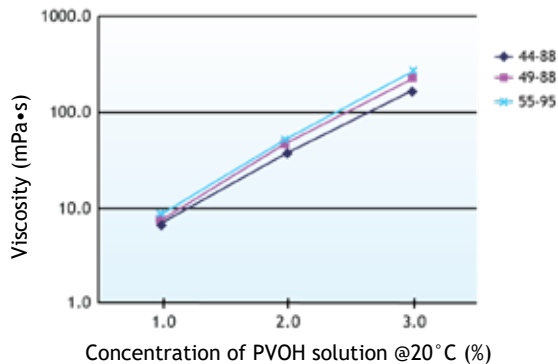
KURARAY secondary suspending agents

KURARAY POVAL™ LM grades are secondary suspending agent products with a degree of hydrolysis below 50 mol%. They provide high porosity and excellent plasticiser absorption for

PVC resins whilst maintaining good bulk density. The products are supplied as solid dry powders but can be dispersed in water without the need for organic solvents.

Viscosity vs concentration curves





KURARAY POVAL™ solution manufacture

Method 1:

KURARAY POVAL™ L grades are classed as medium hydrolysis polyvinyl alcohols varying in their degree of hydrolysis from 69.5 - 73.5 mol%. As such they are cold water soluble and solutions can be made either in cold water or in hot water. After all the KURARAY POVAL™ is added to a stirred tank of cold water to avoid lump formation. The product can be passed through a coarse mesh (10 mesh) to catch any extraneous items that may fall into the solution mixer. After all the L-grade is added the mixture is heated up to 70 -80°C with agitation. There should be sufficient agitation in the mixer

for efficient dissolution but not too intense to cause foam build up at the surface. Mix for 2 hours or until the solution is homogenous. The solution is then cooled to below the cloud point to obtain a clear solution. The solution concentration can then be checked and controlled. Before pumping to the charge vessel or reactor the solution is passed through a 200 micron filter as a final “cleaning process”. L-grades exhibit a cloud point and the prepared solutions have to be stored below the products cloud point to avoid separation during the storage.

Method 2:

KURARAY POVAL 80 mol% hydrolysis grades are classed as partially hydrolysed polyvinyl alcohols varying in their degree of hydrolysis from 76.5 - 81.0 mol%. As such they are only hot water soluble and solutions can only be made utilizing hot water.

The KURARAY POVAL™ partially hydrolysed grade is slowly added to a stirred tank of cold water to avoid lump formation. The product can be passed through a coarse mesh (10 mesh) to catch any extraneous items that may fall into the solution

mixer. After all the KURARAY POVAL™ is added, the mixture is heated up to 80 - 90 °C with agitation. There should be sufficient agitation in the mixer for efficient dissolution but not too intense to cause foam build up at the surface. Mix for 2 hours or until the solution is homogenous. The solution is then cooled to below the cloud point to obtain a clear solution. The solution concentration can then be checked and controlled. Before pumping to the charge vessel or reactor the solution is passed through a 200 micron filter as a final “cleaning process”.

Method 3:

KURARAY POVAL 88 mol% and 95 mol% hydrolysis grades are classed as high hydrolysis polyvinyl alcohols varying in their degree of hydrolysis from 87.0 - 96.0 mol%. As such they are only hot water soluble and solutions can only be made utilizing hot water.

The KURARAY POVAL™ high hydrolysis grade is slowly added to a stirred tank of cold water to avoid lump formation. The product can be passed through a coarse mesh (10 mesh) to catch any extraneous items that may fall into the solution mixer. After all the KURARAY POVAL™ is added, the mixture

is heated up to 90 - 95°C with agitation. There should be sufficient agitation in the mixer for efficient dissolution but not too intense to cause foam build up at the surface. Mix for 2 hours or until the solution is homogenous. The solution is then cooled to below the cloud point to obtain a clear solution. The solution concentration can then be checked and controlled. Before pumping to the charge vessel or reactor the solution is passed through a 200 micron filter as a final “cleaning process”.

Method 4:

The KURARAY POVAL™ LM grades are solid products and are classed as low hydrolysis polyvinyl alcohols varying in their degree of hydrolysis from 40.0 - 50.0 mol%. As such they are not fully water soluble but can be easily dispersed into water. The KURARAY POVAL™ LM grade is slowly added to a stirred tank of cold water to avoid lump formation. The product can be passed through a coarse mesh (10 mesh) to catch any extraneous items that may fall into the dispersion

mixer. There should be sufficient agitation in the mixer for efficient dissolution but not too intense to cause foam build up at the surface. Mix for 1-2 hours or until the dispersion is homogenous. The solution concentration can then be checked and controlled. For storage of LM-grade aqueous dispersion, solid content should be less than 5% and the temperature below 40°C.

Method 5:

KURARAY POVAL™ LM-30 is slowly added to a stirred tank of a mixture of cold water and methanol or ethanol (50:50 mix) passing through a coarse mesh (10 mesh) to catch any extraneous items that may fall into the solution mixer. There should be sufficient agitation in the mixer for efficient dissolution but not too intense to cause foam build up at the

surface. Mix for 4 hours or until the solution is homogenous. The solution concentration can then be checked and controlled. Solutions of KURARAY POVAL™ LM-30 should be charged through the VCM charge line or a dedicated line due to their low solvency in water.

Grade	Method	Recommended concentration	Grade	Method	Recommended concentration
L-8	1	4 - 6 %	40-80E	2	4 - 5 %
L-9	2	4 - 6 %	48-80	2	4 - 5 %
L-9P	1	4 - 6 %	44-88	3	4 - 5 %
L-9-78	2	4 - 6 %	49-88	3	4 - 5 %
L-10	1	4 - 6 %	55-95	3	4 - 5 %
L-11	1	4 - 6 %	LM-10 HD	4	2 - 4 %
L-508W	1	4 - 6 %	LM-20	4	3 - 7 %
32-80	2	4 - 5 %	LM-30	5	3 - 7 %
35-80	2	4 - 5 %	LM-40 HT	4	2 - 5 %



Cloud point

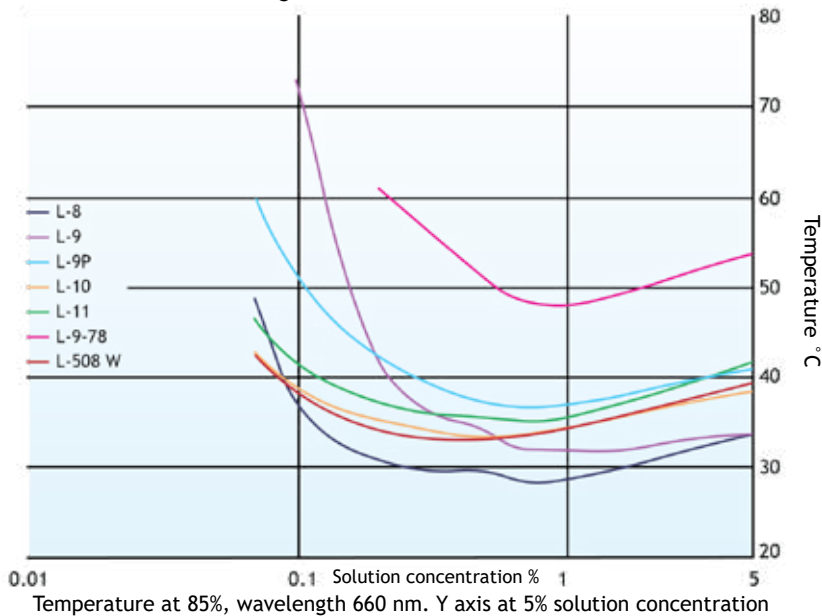
The cloud point is the temperature at which a solution of polyvinyl alcohol starts to phase separate into lower and higher concentration phases and the solution gets turbid because of the difference in refractive index of the two phases. Low hydrolysis polyvinyl alcohols are more hydrophobic and exhibit cloud points at lower temperatures. As the degree of hydrolysis of a polyvinyl alcohol increases the product becomes less hydrophobic and more hydrophilic so their cloud points tend to be at higher temperatures.

1. Use UV-visible spectrophotometer
2. Prepare PVOH solution of 5% concentration.
3. Put the PVOH solution in the quartz cell, then put the cell in UV-VIS spectrophotometer.
4. Increase temperature about 1°C per minutes.
5. Measure T% (Transparency) at 660nm at each temperature.
6. Cloud point is the temperature at T=85%.

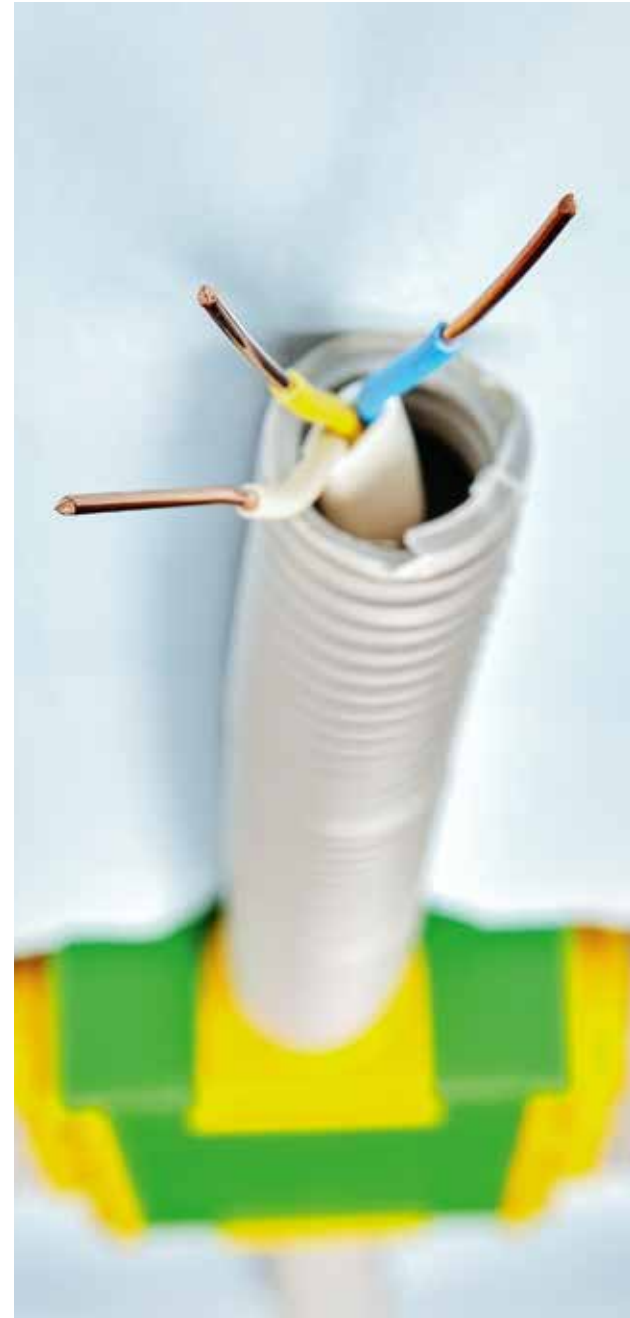
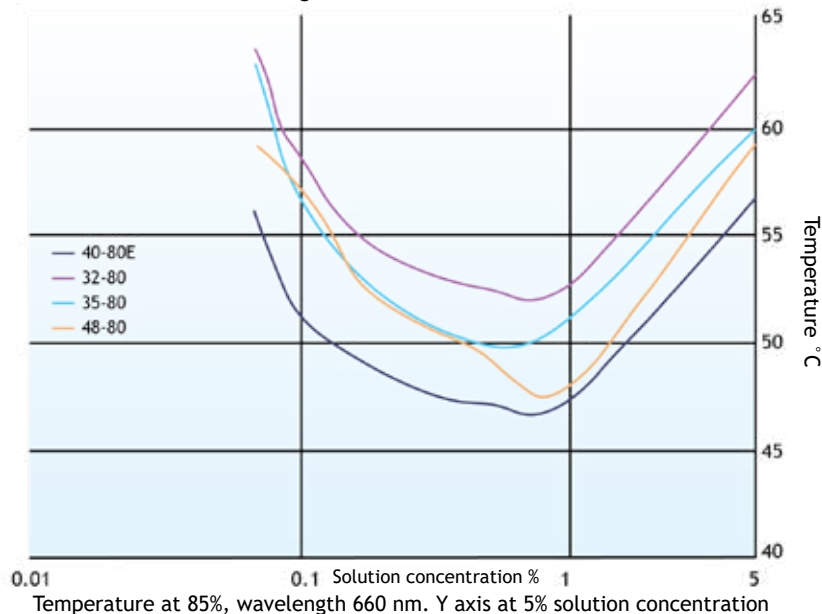
Detailed below are the cloud points of some of our different hydrolysis grades.

When the solution is stored above its cloud point without agitation sedimentation of the higher concentration phase happens. Generally aqueous solutions of primary suspending agents have cloud points as shown in the following graph. So the solution of DH 80 mol% grade should be stored below 45°C and DH 70-72 mol% grades (L-grades) should be stored below 25-30°C to avoid sedimentation issues.

KURARAY POVAL™ L-grade Cloud Point vs solution concentration



KURARAY POVAL™ DH80% grades Cloud Point vs solution concentration



Handling and storage

KURARAY POVAL™ is an industrial chemical and as such when handling the necessary personal protective equipment (PPE) should be used for handling a fine powder. Care should be taken when discharging from plastic packaging as static charges can be generated. It is recommended that packaging and equipment is earthed to prevent static build up.

KURARAY POVAL™ should be stored in clean dry conditions and not exposed to water or high humidity for long periods

Safety

KURARAY POVAL™ is not classified as hazardous to health and is not classified as dangerous for transport.

Descriptions are based on materials, information and data available at this moment, and we do not guarantee it although we are accurate. The notes are intended for ordinary handling

of time.

KURARAY POVAL™ solutions should be stored below their cloud points in clean vessels with gentle agitation or circulation pumps. They should be protected from biological attack by micro organisms.

For more detailed information please refer to our KURARAY POVAL™ handling brochure which is available upon request.

and do not necessarily conform to all situations, uses, and usage. Therefore please set and use safe management and use conditions as these are at the responsibility of the user. *For more detailed information please refer to our product safety data sheets.*

PVC polymerisation

Fish eyes

There are a number of factors that can cause fish eyes:

- Cross contamination of low k value resin with high k value product.
- Low porosity PVC resin.
- Double polymerised grains due to poor reactor cleaning.
- Inhomogeneous reaction conditions leading to poor initiator dispersion.
- Use of high hydrolysis polyvinyl alcohol or HPMC.
- Frequent resin grades changes of different k values.

Factors to help reduce fish eyes:

- All ingredients free from contaminants.
- In-line process filters inspected and cleaned regularly.
- Reactors washed or rinsed well between polymerisations and washings sent to drain.
- Attention should also be given to condenser cleaning.
- Make use of a good antifouling agent.
- Run similar k-value grades on the same product stream.
- Disperse the initiator well at the beginning of the polymerisation. Use a polyvinyl alcohol with high surface activity.

Foaming

There are two types of foam that can be generated when using polyvinyl alcohol in suspension polymerisation.

The first is the production of wet foam when polyvinyl alcohol solutions are made. Polyvinyl alcohols by their nature are used to alter the surface tension of water and reactor contents so it is no surprise that they foam when being made into solution with possibly fast agitation. It is also possible to get wet foam during the beginning of the PVC polymerisation as the polyvinyl alcohol is dispersed in the water VCM mixture. The other type of foam is dry foam (or still could be classed as wet foam) ! As suspension reactions progress they generate heat which causes VCM to boil. The VCM gas bubbles rise to the surface of the reactor either to cool in the space above or via a condenser. As reactions run more quickly due to faster initiators more heat needs to be removed from the reactor and the use of condensers becomes the norm. The boiling

VCM droplets rise to the surface of the reactor and can attach themselves to PVC resin particles. At the same time the PVC resin slurry increases in viscosity so it becomes more difficult for the VCM droplets to be released from the slurry which looks like a foam / cream at the top of the reactor contents. To reduce the generation of foam you need good end to end agitation and a good vortex at the top to try and wet out the PVC slurry. You can increase the water / monomer ratio to reduce the slurry viscosity. An injection of water will also reduce the viscosity and also help cooling. The last option is to use an antifoam. This can be a proprietary antifoam or polyvinyl alcohol. The decision on what to use would be based on performance vs cost as antifoams are more effective but are considerably more expensive than polyvinyl alcohols. If a polyvinyl alcohol is to be used it is better to use one of high molecular weight and of high degree of hydrolysis.

PVC resin whiteness

- The biggest influence on PVC resin colour is the initiator.
- Initiator residues can remain in the PVC resin particle.
- The initiator residues decompose on drying leading to the formation of coloured structures within the resin polymer chain.
- Peroxidarbonate initiators are the worst for colour generation.
- Per-ester types are much better for colour.
- Post addition of polyvinyl alcohol improves colour.

Oxygen

The commercial suspension polymerisation of vinyl chloride almost always requires that at some stage in the process, before introducing the VCM, the reactor is evacuated a number of times in order to reduce the oxygen level as low as possible and to a constant amount.

The higher the level of oxygen in a PVC reactor the finer the particle size. As PVC manufacturers moved from open reactor technology (where the reactor is opened and cleaned after every batch) to closed reactor technology (where the reactor is only opened every 200 - 300 batches) they noticed they needed more suspending agent to achieve the same mean grain size.

Sources of oxygen can be:

- Infiltration into the VCM storage system.
- Dissolved in the process water.
- In the vapour phase.
- From decomposition of the peroxide initiator.
- From the decomposition of excess H_2O_2 (when used to form in-situ initiator).

The effect of VCM impurities on PVC characteristic

The most important impurities to avoid in VCM are “unsaturates”, butadiene levels should be below 10 ppm. They affect both monomer / initiator reactivity and also granulation. Chlorinated species have less impact in spite of being at higher addition levels. For any impurity / contaminant present, the main factor is consistency. If levels vary from day to day it is very difficult to manage on a plant. It is much better to have high levels of impurities if they are consistently high rather than continuous variability. It is worth noting that if the VCM from the monomer plant is 99.98% pure, there is still 0.02%....200 ppm of impurities being added to the reactor. Bearing in mind that the level of suspending agent would be 800 to 1,000 ppm the level of contaminants for VCM is very high.

- Recovered VCM should not be used in PVC resins where colour is important.
- Butene-1 in recycled monomer will increase porosity and reduce the mean grain size.
- Oxygen in recycled monomer will increase porosity,

Ways to increase bulk density

- Reduce agitator speed.
- Increase the monomer water ratio.
- Add a buffer / calcium ions, 200 ppm Na_2CO_3 .
- Use hydroxy propyl methyl cellulose (HPMC).

The effects of Oxygen are

- It is a powerful inhibitor of polymerisation.
- It can form unstable intermediate polymers with VCM (VCP, vinyl chloride polyperoxides). These can decompose explosively in recovered monomer plants.
- Higher oxygen levels reduce the mean grain size of the PVC resin. The oxygen generates more grafting points in the grain formation process.
- Oxygen can introduce thermally labile groups which can act as sources of discolouration upon subsequent processing of the PVC resin.
- It will decrease the porosity of the PVC resin.
- Levels of oxygen greater than 5 - 10 ppm are problematical.
- The influence of oxygen is more important as the degree of hydrolysis increases (the number of graftable acetate groups decreases).

decrease mean grain size and decrease the particle size distribution.

- An increase in the level of HCl decreases porosity and mean grain size.
- The higher the level of recycled monomer in the recipe the lower the porosity and the finer the mean grain size.
- Any accumulated water in the VCM storage should be drained as it will contain iron (Fe) which will effect PVC resin colour and heat stability. The level should be less than 5 ppm.
- Fe, oxygen and acidity can all give rise to polyperoxides.
- You can use free radical scavengers to inhibit polyperoxide formation.
- Residual levels of initiator can lead to defect sites (poor colour).
- If an antioxidant is used make sure it does not form coloured bi-products.
- High pH can deactivate peroxide catalysts.



Adding value to your products - worldwide



PVOH, EXCEVAL™, ELVANOL™ and MOWIFLEX™ are the trademarks for polyvinyl alcohols 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 PVOH 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. Ecologically PVOH is advantageous due to its biodegradability and the fact that combustion does not generate residues. It is available in various particle sizes from granules to fine powders.

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

KURARAY - Here to Innovate.

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