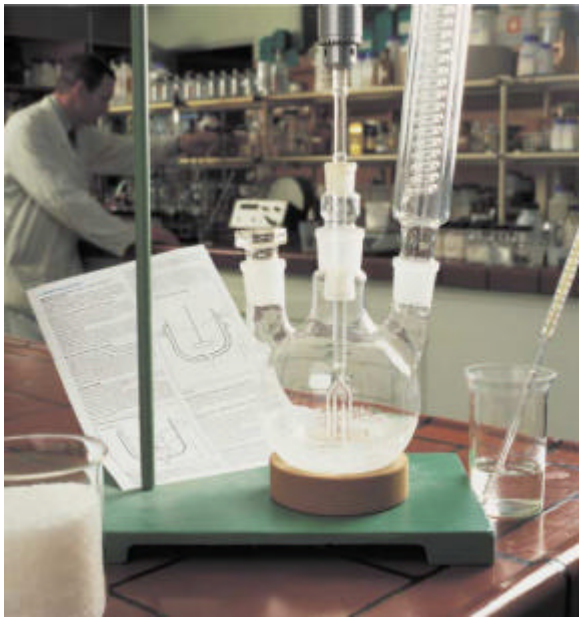

Production of Mowiol Solutions

Water is the most commonly used and technically most important solvent for polyvinyl alcohol.
The dissolving procedure is simple, especially for Mowiol granules.

The photograph shows starting product, dissolving procedure and solution.

Solubility of Mowiol

Water is the most common solvent for polyvinyl alcohol and, for practical applications, the most important.

The solubility of Mowiol in water can be defined as the quantity of Mowiol which dissolves at a certain temperature in a given time in comparable apparatus (dissolving curve).
It is natural feature of polymers that the production of a »saturated solution« is impossible, as for each grade an increase in concentration is accompanied by a rise in solution viscosity, the limit to which is set by that solution's industrial processability.

Determination of the relative Rate of Dissolution of Mowiol

The relative rate of dissolution of Mowiol can be determined in the laboratory equipment described below:

180 g of deionized water at about 20 °C is poured into a 500 ml three-necked flask fitted with a reflux condenser and impeller stirrer. 20 g of the Mowiol to be tested are sprinkled through a powder funnel during stirring (manual operation of the agitator used). The weight of volatile constituents must be taken into account. When the filling process is completed, the flask is placed in a thermostatically controlled water bath and the contents are stirred at about 250 min–1. The start of agitation is taken as the zero point of the dissolving-time measurement. Experience shows that the water bath has to be heated to 95 – 99 °C *to give the required temperature of 90 °C in the dissolver*. The latter temperature is reached in a few minutes.

10% solutions are produced to standardize the experiments.

Because the diffusion of the water molecules in solvation is relatively slow and heavily dependent on viscosity, higher concentrations naturally require longer dissolving times.

Every five minutes, one drop of the solution is removed by capillary pipette and used to determine the solution concentration by refractometry. From these values the dissolving characteristics of a Mowiol grade can be plotted on the relevant concentration/time graph.

Towards the end of the dissolving process a visual check must be made to determine clarity, specks and freedom from lumps.

To determine further aspects of the various Mowiol grades' dissolving properties, this process can also be used at temperatures below 90 °C (eg at 60, 40 and 20 °C).

As a general rule, a fall in the degree of polymerization and hydrolysis is accompanied by a rise in the rate of dissolution in water, as is clearly evident at different dissolving temperatures.

In fully hydrolysed polyvinyl alcohols the effect of the degree of polymerization is generally more pronounced than in partially hydrolysed ones. Polymers whose level of hydrolysis is below 88% are more soluble in water at low temperatures than at high temperatures.

Industrial Production of Mowiol Solutions

Mowiol is usually processed in the form of its aqueous solution. Particular attention must therefore be paid to the way that this solution is produced. Stainless steel vessels, enamelled containers or polyester tanks should always be used as Mowiol solutions tend to be slightly acid.

Mowiol is supplied in the form of granules. This ensures that no lumps develop when the hydrophilic polymer is sprinkled into the water. *The temperature of the water used should not exceed 20 – 25 °C, particularly for dissolving the partially hydrolysed Mowiol grades.* The addition of defoamer prevents the formation of foam during the dissolving process.

In practice two dissolving methods can be used:

a. The use of directly heated dissolving vessels

In this case the weighed quantity of Mowiol is sprinkled into the measured volume of *cold* water, which is agitated at the same time. The agitation process should be vigorous so as to dislodge the Mowiol particles settling on the bottom of the vessel, but it should not be so fast as to cause foaming.

The suspension is heated while being continuously stirred. The contents of the vessel should reach a temperature of at least 90 °C as quickly as possible. At this temperature the Mowiol grades dissolve completely in a maximum of about 45 minutes .

b. Injection of steam into a suspension of Mowiol granules

The injection of live steam into a Mowiol suspension is a useful and quick method of dissolving Mowiol. The Mowiol is sprinkled into a small proportion of the calculated quantity of water for dissolving it while this is agitated vigorously, and live steam at a temperature of 110 – 140 °C is then introduced. Some of the steam condenses. The weight or volume of water needed to adjust the solution to the desired concentration is determined at the end of the dissolving process and this quantity is then added.

As with other polymers, no exact dissolving time can be given for Mowiol, as it depends mainly on the intensity of agitation, temperature control, grade and particle size. In general the partially hydrolysed products dissolve more quickly than the fully hydrolysed ones. In both the partially and fully hydrolysed Mowiol grades the rate of dissolution also increases with a decline in molecule size and a corresponding decrease in the viscosity of the aqueous solution.

When Mowiol solutions are kept for longer periods, they must be stabilized with preservatives against attack by micro-organisms.

Other Solvents and Diluents for Mowiol

Although in practice water is virtually the only solvent used for Mowiol, a number of other solvents or solvent mixtures suitable for Mowiol do exist. In this context we should refer not to »good« or »poor« solvents but to ones with a good or poor solvating power.

The dilution energy can be seen as a measure of the affinity between solvents and dissolved matter, although in polyvinyl alcohol this is complicated by its marked tendency – which differs from case to case – to form hydrogen bridges between the individual polymer chains and within the polymer chain itself.

Huggins' empirical equation describes a relationship between the solvation potential of a solvent and the rheological properties of the solution:

$$h_{sp} / c = [h] + K_H \cdot [h]^2 \cdot c$$

The Huggins constant K_H is a relative measure of the interaction between polymer and solvent, $[h]$ is the intrinsic viscosity (h_{sp}/c for $c \mapsto 0$) and c is the concentration of the solution. Thermodynamically, the smaller K_H is, the greater is the dissolving power of a solvent for polyvinyl alcohol. For water, for example, K_H is approx 0.75; and for an 85% phenol/water mixture it is about 0.4. The dissolving power of water/solvent mixtures may therefore be greater, for example, than that of pure water. With the exception of the phenol/water mixture mentioned above, this is also true of water/alcohol mixtures, especially for the partially hydrolysed Mowiol grades.

Certain polar solvents such as diethylene triamine, dimethyl sulphoxide, formamide, dimethyl formamide and phosphoric acid trisdimethylamide are also relatively good solvents for Mowiol.

At temperatures above 100 °C, Mowiol can also be dissolved in multivalent alcohols such as glycerine, glycol and lower polyglycols, as well as in ethanolamines.