

ensure proper processing during gel preparation and softgel encapsulation. Following encapsulation, excess water is removed from the softgels through controlled drying. In dry softgels, the equilibrium water content is typically in the range of 5–8% w/w which represents the proportion of water that is bound to the gelatin in the softgel shell. This level of water is important for good physical stability of softgels because in harsh storage conditions, softgels will become either too soft and fuse together or too hard and brittle.

### Colourants/opacifiers

Colourants (soluble dyes or insoluble pigments or lakes) and opacifiers are typically used at low concentrations in the wet gel formulation. Colourants can be either synthetic or natural and are used to impart desired shell colour for product identification. An opacifier, usually titanium dioxide, may be added to produce an opaque shell when the fill formulation is a suspension or to prevent photodegradation of light-sensitive fill ingredients. Titanium dioxide can either be used alone to produce a white opaque shell, or in combination with pigments to produce a coloured opaque shell.

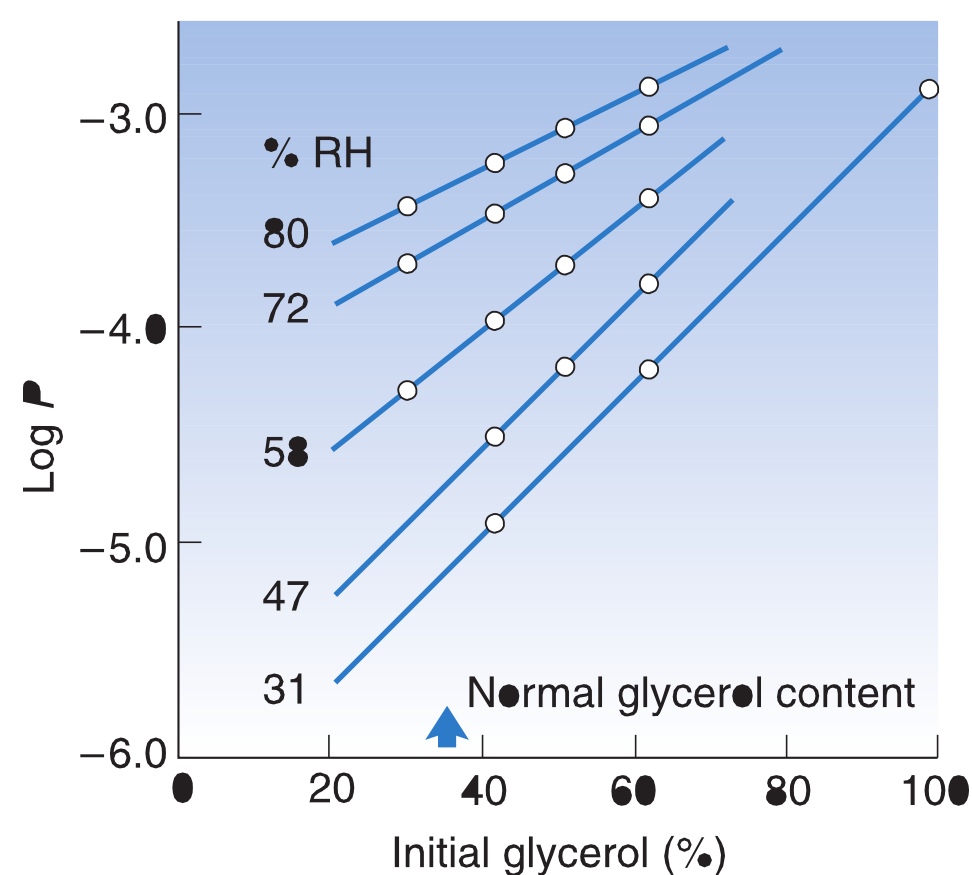
## Properties of soft gelatin shells

### Oxygen permeability

The gelatin shell of a soft gelatin capsule provides a good barrier against the diffusion of oxygen into the contents of the product. The quantity of oxygen ( $q$ ) that passes through the gelatin is governed by the permeability coefficient ( $P$ ), the area ( $A$ ), thickness ( $h$ ) of the shell, the pressure difference ( $p_1 - p_2$ ) and the time of diffusion ( $t$ ) by the following equation:

$$q = \frac{PA t (p_1 - p_2)}{h} \quad (34.1)$$

The permeability coefficient ( $P$ ) is related to the diffusion coefficient ( $D$ ) and the solubility coefficient ( $S$ ) by the equation  $P = DS$ . This relationship, described by Henry's Law, assumes no interaction between the gas and the polymeric film, but  $P$  is clearly affected by the formulation of the gelatin shell as shown in Figure 34.9.



**Fig. 34.9** • Relationship between oxygen permeability coefficient and the glycerol concentration in the shell of softgels at room temperature and a range of relative humidity values. (Reproduced from Hom et al 1975.)

Figure 34.9 shows the relationship between oxygen permeability coefficient and the glycerol concentration in the gelatin shell of softgels at room temperature and relative humidity values from 31% to 80%. The oxygen permeability decreases with the % RH and the glycerol content in the gelatin shell formulation (Hom et al 1975). For maximum protection against the ingress of oxygen, the gelatin shell should be dry and formulated to contain about 30–40% glycerol.

### Residual water content

Softgels contain little residual water and compounds which are susceptible to hydrolysis may be protected if dissolved or dispersed in an oily liquid fill material and encapsulated as a soft gelatin capsule. Figure 34.10 shows the relationship between the equilibrium water content and the concentration of glycerol in the gelatin shell of a softgel, stored at room temperature and environmental relative humidities of between 31% and 80%. The data show that the minimum water values are found at glycerol levels in the shell of between 30% and 40%. Such a formulation dried at 31% RH has a water content in the shell of about 7% (Hom et al 1975), and a water content in the fill in equilibrium with the atmosphere. The residual water content of most pharmaceutical compounds stored at 20% RH (the drying condition for softgels) is low and the water levels in the fills of softgels therefore are very small.