measurement, including making the powder into a plate and adapting the Wilhelmy plate method, and also measuring the rate at which liquid penetrates into a packed bed of the powder. These methods and their limitations have been reviewed elsewhere (Buckton, 1995). The different methods by which contact angle is measured for powders gives rise to different results, so comparison of data should take this into account.

An alternative to contact angle measurement is to use inverse gas chromatography (IGC). Whilst IGC has been used for many years in other sectors, it has only been used pharmaceutically to any great extent in recent years. Further discussion of IGC is presented below.

Adsorption at interfaces

Adsorption is the presence of a greater concentration of a material at the surface than is present in the bulk. The material which is adsorbed is called the *adsorbate*, and that which does the adsorbing is the *adsorbent*. Adsorption can be due to physical bonding between adsorbent and adsorbate (*physisorption*) or chemical bonding (*chemisorption*). The differences between physisorption and chemisorption are that physisorption is by weak bonds (such as hydrogen bonding, with energies up to 40 kJ mol^{-1}) whilst chemisorption is due to strong bonding (greater than 80 kJ mol^{-1}); physisorption is reversible, whilst chemisorption seldom is; physisorption may progress beyond a single layer coverage of molecules on the surface (*monolayer formation* to *multilayer formation*), whilst chemisorption can only proceed to monolayer coverage.

Solid/liquid interfaces

The usual pharmaceutical situation is to have a liquid (solvent), particles of a solid dispersed in that liquid and another component dissolved into the liquid (solute). This forms the basis of stabilising suspension formulations, where there may be water with suspended active pharmaceutical ingredient and in order to help stabilize the suspension (keep the solid particles from joining together) there may be a surface active agent dissolved in the water. The surface active agent will adsorb on the surface of the powder particles and help to keep them separated from each other (steric stabilisation). It is also possible to use this surface interaction in the treatment of drug overdose, where charcoal of high surface area can be administered and the excess of drug in the patient's gastrointestinal tract can be adsorbed from solution onto the surface of the charcoal, which is then cleared from the patient. Kaolin is administered as a therapy in order to adsorb toxins in the stomach and so reduce gastrointestinal disturbances. A further example is analysis by HPLC – where molecules in solution are adsorbed onto a column to achieve separation. As a final example, the loss of active pharmaceutical ingredient, or preservative, from a solution product to a container can be a damaging effect of adsorption from solution to a solid.

The quantity of solute which adsorbs will be related to its concentration in the liquid. The adsorption will proceed until equilibrium is reached between that which has been adsorbed at the interface and that which is in the bulk.

Many factors will affect adsorption from solution onto a solid, these include temperature, concentration, and the nature of the solute, solvent and solid. The effect of temperature is almost always that an increase in temperature will result in a decrease in adsorption. This can be viewed as a consequence of giving the solute molecules more energy, and thus allowing them to escape the forces of adsorption, or simply viewed as the fact that adsorption is almost always exothermic, and thus an increase in temperature will cause it to decrease.

pH is important as many materials are ionizable, and the tendency to interact will vary greatly if they exist as polar ions, rather than a non-polar unionized material. In most pharmaceutical examples (chromatographic separation being an obvious exception), adsorption will be from aqueous fluids, and for these adsorption will tend to be greatest when the solute is in its unionized form, i.e. at low pH for weak acids, at high pH for weak bases, and at the isoelectric points for amphoteric compounds (those which exhibit acid and basic regions), although at other pH values the solubility in water will be higher (due to greater ionization favouring the interaction with water) and there will still be some unionized molecules present, which will usually adsorb on surfaces in preference to maintaining a disfavoured interaction with water.

The effect of solute solubility will influence adsorption as the greater the affinity of the solute for the liquid, the lower the tendency to adsorb to a solid. Thus, adsorption from solution is approximately inversely related to solubility.

The nature of the solid (the adsorbent) will be very important, both in terms of its chemical