

Gel Dosage Forms: Theory, Formulation, and Processing

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I. THEORY

Gels are transparent to opaque semisolids containing a high ratio of solvent to gelling agent. When dispersed in an appropriate solvent, gelling agents merge or entangle to form a three-dimensional colloidal network structure. This network limits fluid flow by entrapment and immobilization of the solvent molecules. The network structure is also responsible for a gel's resistance to deformation and, therefore, its viscoelastic properties.

A variety of structures are associated with gel networks. Figure 1 illustrates some of the most common ones. *Random coils* are the least ordered and occur most frequently with synthetic polymers such as resins and cellulose derivatives. The *helix* is a more ordered structure formed from the intertwining of two polymer chains. Xanthan gum and starch are typical examples. *Stacks*, or the egg-box model, as it is sometimes called, results from cross-linking of polymer chains by divalent cations. Calcium alginate is a classic example. The *house of cards* structure is characteristic of gel-forming colloidal particles such as bentonite and Veegum. In the case of Veegum, the structure results from the alignment of the positively charged edges with the negatively charged flat surfaces of the clay particles (1). Because most gels that are used in the pharmaceutical industry are associated with the random coil network, further discussion will be centered around that structure.

Random coil gelation mechanisms are rooted in the polymer-polymer and polymer-solvent interactions. With a given polymer, the gel network forms through successive increases in concentration.