measurement of dosage and, from an aesthetic point of view, produces too unsightly a supernatant layer. In many commercial suspensions, suspending agents are added to the dispersion medium to lend it structure. Carboxymethylcellulose (CMC), methylcellulose, microcrystalline cellulose, polyvinylpyrrolidone, xanthan gum, and bentonite are a few of the agents employed to thicken the dispersion medium and help suspend the suspensoid. When polymeric substances and hydrophilic colloids are used as suspending agents, appropriate tests must be performed to show that the agent does not interfere with availability of the drug. These materials can bind certain medicinal agents, rendering them unavailable or only slowly available for therapeutic function. Also, the amount of the suspending agent must not be such to render the suspension too viscous to agitate (to distribute the *suspensoid*) or to pour. The study of flow characteristics is rheology. A summary of the concepts of rheology is found in Physical Pharmacy Capsule 14.3.

PHYSICAL PHARMACY CAPSULE **14.3**

Rheology

Rheology, the study of flow, addresses the viscosity characteristics of powders, fluids, and semisolids. Materials are divided into two general categories, Newtonian and non-Newtonian, depending on their flow characteristics. Newtonian flow is characterized by constant viscosity, regardless of the shear rates applied. Non-Newtonian flow is characterized by a change in viscosity characteristics with increasing shear rates. Non-Newtonian flow includes plastic, pseudoplastic, and dilatant flow.

The Newton law of flow relates parallel layers of liquid: with the bottom layer fixed, when a force is placed on the top layer, the top plane moves at constant velocity, and each lower layer moves with a velocity directly proportional to its distance from the stationary bottom layer. The velocity gradient, or rate of shear (dv/dr), is the difference of velocity dv between two planes of liquid separated by the distance dr. The force (F′/A) applied to the top layer that is required to result in flow (rate of shear, G) is called the shearing stress (F). The relationship can be expressed:

$$\frac{F'}{A} = \eta \frac{dv}{dr}$$

where η is the viscosity coefficient or viscosity. This relationship is often written:

$$\eta = \frac{F}{G}$$

where

F = F′/A and
G = dv/dr.

The higher the viscosity of a liquid, the greater the shearing stress required to produce a certain rate of shear. A plot of F versus G yields a rheogram. A Newtonian fluid will plot as a straight line with the slope of the line being η. The unit of viscosity is the *poise*, the shearing force required to produce a velocity of 1 cm/s between two parallel planes of liquid, each 1 cm^2 in area and separated by a distance of 1 cm. The most convenient unit to use is the centipoise, or cP (equivalent to 0.01 poise).

These basic concepts can be illustrated in the following two graphs.