TABLE 11.1 Flocculant Dosages

Agent	Flocculant dose [g (100 g dry cell wt)$^{-1}$]				
	Glucose broth	Hydro-carbon broth	Resuspended cells in buffer	Penicillin broth	Dilute slurries
Polyelectrolytes					0.045–4.5
Anionic polyelectrolytes					
Polystyrene sulphate	0.2	0.1	0.06		
Polyacrylamide	Ineffective	Ineffective	Ineffective		
Cationic polyelectrolytes					
Polyethylene imine	10		7.0		
Calcium chloride				200	
Colloidal clay, bentonite	2.0	20.0	0.6		
Inorganic coagulants					0.045–4.5

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kinetics of the binding, and settling phenomena. The selection criteria usually are flocculation–sedimentation rate, floc size, and the clarity of the supernatant liquid.

11.3. CELL DISRUPTION

After cells are separated from liquid broth, if the desired product is intracellular, then the cells need to be disrupted to release the intracellular products. The method of disruption varies with the type of cells and the nature of intracellular products. Major methods of cell disruption can be classified as mechanical and nonmechanical. With small bacteria, efficient, large-capacity cell-disruption processes can be difficult to construct.

11.3.1. Mechanical Methods

Mechanical methods can be applied to a liquid or solid medium. First, consider some methods applied to a liquid medium.

Ultrasonic vibrators (sonicators) are used to disrupt the cell wall and membrane of bacterial cells. Wave density is usually around 20 kc/s. Rods are broken more readily than cocci, and gram-negative cells more easily than gram-positive cells. This method is not as effective for molds. An electronic generator is used to generate ultrasonic waves, and a transducer converts these waves into mechanical oscillations by a titanium probe immersed in a cell suspension. Intracellular compounds (enzymes, metabolites) are released into the broth upon cell disruption. Ultrasonic disruption in some cases results in denaturation of sensitive enzymes and fragmentation of cell debris. Heat dissipation is an important problem in cell disintegration, particularly if the volume subjected to sonication is large. Consequently this method is used primarily at the laboratory scale.

The Gaulin–Manton and French presses work well on a laboratory scale. The French press is a hollow cylinder in a stainless-steel block that is filled with cell paste and