the density of the tablet. There are two types of effervescent floating systems: single layer and double layer. Single layer systems consist of drug, excipients, effervescent agent, and polymer. Whereas, in bilayer systems, one layer consists of drug, gas-generating agents, and polymer and the other layer consists of immediate release drug and other excipients.

Another type of raft-forming system consists of gel-forming solution (e.g., sodium alginate) containing effervescent agents that form a gel on contact with the gastric fluid. This solution generates a gel upon swelling with entrapped CO_2 and floats on the gastric contents forming a "raft." Antacids are delivered feasibly using these raft systems.

In case of volatile liquid systems, an inflatable chamber is filled with a volatile liquid that volatilizes at the body temperature and causes inflation of the system in the stomach. Hydrophilic polymers such as alginates and different types of hydroxy propyl methylcellulose (HPMC) are employed as matrices which form hydrated layer around the system that acts as a barrier to water in flow and movement of solutes outside the matrix. The nature of the matrix and solubility of drug in water determine the kinetics and mechanism of drug release [9]. The selection of excipients and polymer for gastro-retentive floating system is very important as their density influences the lag time and total floating time.

Singhvi and coworkers designed and evaluated controlled release gastro-retentive floating tablet of an atypical psychotropic agent using HPMC, sodium CMC, and Carbopol polymer for hydrophilic matrices. Sodium bicarbonate was used as a gas-generating agent to give buoyancy to the designed matrix tablets. Results demonstrated that buoyancy lag time and the duration of buoyancy were functions of the proportion of sodium bicarbonate and HPMC [2].

2.1.2. Noneffervescent systems

These systems float because of two approaches. In the first approach, highly swellable and gel-forming capacity polymers such as cellulose derivatives and matrix-forming polymers such as HPMC, polyacrylate, polymethacrylate, and sodium alginate are used. When these systems come in contact with gastric fluid, they swell by hydration and form a gel layer that controls drug release. The entrapped air provides buoyancy.

The other approach uses a microporous component incorporating a gas-filled chamber possessing specific gravity that makes the system buoyant, allowing it to float [9, 23].

Another subtype that is hydrodynamically balanced systems (HBS™) consist of single or multiple hydrophilic gel-forming polymers in which the drug is entrapped. The mixture is administered in the form of a gelatin capsule. When it comes in contact with the gastric fluid, the capsule degrades. The polymer swells and allows controlled release of the drug by the mechanism of erosion and diffusion [24]. It was found that these systems increased the gastric residence time and the amount of soluble form of the drug that reaches the absorption site [21].

Patil et al. developed a two compartment capsule GRDDS to increase the solubility and thus, the bioavailability of ofloxacin. Different natural polymers were used to formulate the floating ring cap. The formulations depicted buoyancy for minimum 9 h. The developed formulation followed the Korsmeyer–Peppas model for drug release and released drug for up to 9 h [25].

Li et al. developed multiparticulate GRDDS pellets with excellent buoyancy. The pellets were composed of a low density and highly porous matrix core, dipyridamole-loaded HPMC layer, HPMC subcoating, and a layer of Eudragit® NE30D. The matrix core was evaluated, and it was found that the optimized formulation sustained the release of drug for 12 h and floated for 12 h on the dissolution medium without any lag time [26].

However, the action of the floating system depends on the presence of food and sufficient amount of gastric fluid in the stomach. Also, a lag time is experienced until it reaches fluctuation [9].

Madopar, Valrelease, Topalkan, and Cytotec are few examples of marketed floating drug delivery systems [27].

2.2. Bioadhesive or Mucoadhesive Systems

These delivery systems were developed to increase the affinity and duration of the contact of drug and biological membranes. Various theories were devised to explain the phenomena of mucoadhesion [14]. The drug delivery system that is coated with a mucoadhesive polymer binds to mucin present in the mucus lining, and is thus retained on the GI surface epithelium for extended period of time. A bioadhesive polymer is natural or synthetic in origin, which is capable of adhering to the epithelial surface, whereas mucoadhesive polymer adheres to the mucus layer. A bioadhesive polymer has molecular flexibility, hydrophilic functional groups, and specific physicochemical properties. Carboxymethyl cellulose, carbopol, polycarbophil, tragacanth, sodium alginate, and HPMC were found to exhibit