shortcomings of conventional oral solids drove the development of oral controlled-release dosage forms. It not only gave clinical benefits such as precise control over rate of release and duration of action, maintenance of desired plasma concentration of the drug, reduced adverse reactions, enhancement in activity of short half-life drugs, and ability of site-specific targeted drug delivery but it also provided benefits to industries in protecting their patent claims or helped them to extend the patent term [11, 12]

In the next chapter, we have made efforts to cover an overview of controlled-release systems to help fellow readers to understand the basics of oral controlled-release systems and motivate the researchers to develop systems with higher potential to provide desired therapeutic effects with patient compliance.

The next chapter can essentially be divided into three sections: first part of the chapter states the need of controlled-release systems in greater detail, followed by defining while clarifying the terminology of controlled-release systems for better understanding. The next section brings the backbone of controlled-release systems into light by discussing the polymers used in controlled-release formulations and the basic principles that govern the release of drug from the designed controlled-release systems with mathematical expressions. Finally, the last section of the chapter focuses on the characterization of release patterns and evaluation of controlled-release formulations after which the chapter is concluded with insights on future prospects of this field of immense potential.

2. NEED FOR CONTROLLED-RELEASE DOSAGE FORMS

Drug delivery is a process of administering the active pharmaceutical ingredient (API) in an optimum formulation to obtain the required therapeutic effect. The most convenient method for administeration of drugs is the oral route. The ideal dosage regimen is the one in which it immediately attains the desired therapeutic concentration and maintains it constantly for the entire period of treatment. This is only possible if the medications are administered in optimum dose and frequency. Half-life of drugs and therapeutic index are significant in deciding the dosing frequency. In majority of cases, the dosing intervals are shorter than the actual half-life of the drug, consequentially leading to limitations allied by a conventional dosage form [13, 14].

The common limitations associated with conventional immediate release of solid orals are frequent administration, fluctuations in plasma concentration, dose-related local gastric irritation, precipitation of adverse effect in case of drugs with small therapeutic index when there is excess of medication, increased cost of therapy, decrease in active drug concentration at the site of action, and decreased patient compliance. Additionally, there is an increased chance of skipping a dose for drugs with short half-life for which repeated frequencies are necessary and in situations, where the therapy is for long period with increased number of medications [15–17].

Even though the oral route is considered the most patient convenient and preferred means, there are significant advances made to overcome the limitations of the conventional drug delivery systems. The basic rationale for design of controlled-drug delivery systems is to modify the pharmacokinetic and pharmacodynamics of an active moiety by modifying its physicochemical parameter inherent in a selected route of administration or using a novel drug delivery system. Fig. 1 presents the rationale for the development of modified drug release formulation. Controlled release or modified release of the drug through solid oral preparations has gained attention to overcome the limitations associated with immediate release conventional formulations. Modified-release formulations were developed to offer an effective means to optimize the bioavailability and plasma concentrations of the drug. In these formulations, the rate and site of drug release of the preparations are predicted and controlled. The deliberate modifications are attained by a special formulation design and a manufacturing method. One such modified release formulation is controlled-release system. This system achieves slow release of the drug over extended period of time, facilitates constant drug levels in the target site for therapeutic effects and also delivers the drug locally or systemically at a predetermined rate for a specific period of time [17, 18].

This can be achieved in terms of two aspects:

1. *Temporal nature of drug delivery:* The delivery of drug to the target site occurs by controlling the rate and specific time for delivering. This is advantageous for the drugs that have short half-life and those that are rapidly metabolized.
2. *Spatial nature of drug delivery:* The delivery of drug occurs by targeting it at the desired organ. Such a delivery nature is advantageous;
   - When the physiology does not allow a drug to reach the molecular site of action.
   - When the physiology causes the drugs to come in contact with various tissues and causing foremost side effects, leading to incomplete treatment [19, 20].

Various approaches to satisfy this type of drug delivery system are available such as liposomes,