

# In Vitro Dissolution Testing for Solid Oral Dosage Forms

## Introduction

Dissolution testing is a requirement for all solid oral dosage forms and is used in all phases of development for product release and stability testing<sup>1</sup>. It is a key analytical test used for detecting physical changes in an active pharmaceutical ingredient (API) and in the formulated product.

At early stages of development, *in vitro* dissolution testing guides the optimization of drug release from formulations. Over the past 50 years, dissolution testing has also been employed as a quality control (QC) procedure, in R&D to detect the influence of critical manufacturing variables and in comparative studies for *in vitro-in vivo* correlation (IVIVC).<sup>2</sup>

The FDA guidance on dissolution testing for immediate release solid oral dosage forms<sup>1</sup> includes the use of the Biopharmaceutics Classification System (BCS) guidelines for biorelevant dissolution tests, which is based upon API solubility and permeability.<sup>3</sup> According to the BCS guidelines, *in vitro* dissolution testing may be a useful tool to forecast the *in vivo* performance of drug products and potentially reduce the number of bioavailability/bioequivalence studies required. The FDA guidance on scale-up and post-approval changes (SUPAC) for immediate release oral dosage forms recommends the use of *in vitro* dissolution to justify post-approval changes.<sup>4</sup>

Despite being readily-entrained in pharmaceutical and biotechnology industry, the basics of the dissolution test are often misunderstood. The test must be rugged and reproducible and highlight or discriminate significant changes in product performance.

The specific dissolution technique employed is determined by the dosage form characteristics and the intended route of administration. For solid dosage forms, industry standard dissolution testing methodologies are the United States Pharmacopoeia (USP) Ap-

paratus 1 (basket) and the USP Apparatus 2 (paddle) (see Figure 1). Immediate-release, modified-release and extended release tablets are usually tested in classical dissolution baths with USP 2 paddles. Floating capsules and tablets generally use USP 1 baskets. Other dissolution techniques and equipment include USP 3 (reciprocating cylinders), USP 4 (flow-through-cell), USP 5 (paddle-over-disk), USP 6 (cylinder) and USP 7 (reciprocating holders).<sup>5</sup>

The development of a dissolution procedure involves selecting the dissolution media, apparatus type and hydrodynamics (agitation rate) appropriate for the product. This overview article will focus on the most commonplace (USP 1 and 2) dissolution apparatus and present an overview of typical method parameters that should be considered during dissolution development.

## Dissolution

For most dosage forms to be efficacious, the API(s) must be absorbed into the systemic circulation so that it can be transported to its site of activity. This process contributes to the bioavailability of

the drug substance and involves two steps: dissolution and absorption (or permeability). Understanding the multi-step dissolution process is essential to proper *in vitro* method development. Dissolution is the process of extracting the API out of the dosage form solid-state matrix into solution within the gastrointestinal tract. Absorption is the process of transporting the drug substance from the gastrointestinal lumen into the systemic circulation.

Dissolution testing is an *in vitro* method that characterizes how an API is extracted out of a solid dosage form. It can indicate the efficiency of *in vitro* dissolution but does not provide any information on drug substance absorption. Pharmacokinetic data supplements and provides additional information regarding API absorption rate.

Selection of the appropriate *in vitro* conditions (media and hydrodynamics) that simulate the *in vivo* conditions can lead to the generation of successful IVIVC or at the very least, *in vitro-in vivo* relations (IVIVR).<sup>2</sup> Conditions that are optimal for QC purposes may not be applicable for establishing IVIVC so it may be necessary to use two dissolution tests to meet different objectives such as development needs or regulatory demands.

## Dissolution Method Parameters

A logical, systematic approach taking into consideration both scientific and regulatory principles, should be followed when developing a dissolution method. Table 1 lists common parameters and conditions that are evaluated during method development.<sup>6</sup>

A robust dissolution method must be free of artifacts, yield low-to-moderate variability, have good profile shape and must be challenged to pick up critical quality attributes. Once the medium and apparatus are selected, the method should be further optimized for parameters such as agitation rate, ionic strength, and surfactant concentration, if applicable. The

final method should discriminate between formulations yet possess sufficient reproducibility and robustness. In terms of statistics, a relative standard deviation of <20% at early time points and <10% at later time points is common.

Typically, the percent dissolved API (up to 100%) vs. time is plotted. Dissolution profiles of dosage forms with known formulation, manufacturing or bioavailability differences can aid in identifying a discriminatory set of media/hydrodynamic conditions. Figure 2 illustrates a dissolution plot at 50 rpm (tablet with increased release variability due to a method artifact known as coning), 75 rpm (tablet showing proper release), and a mis-manufactured tablet at 75 rpm (showing slower and improper/incomplete release).

## API

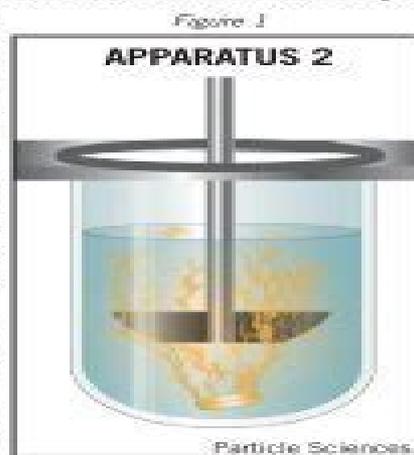
Review of API properties (BCS-classification, pK<sub>a</sub>, stability, solubility as a function of pH/surfactant concentration, particle size, and polymorphism) that are likely to affect the *in vitro* dissolution behavior should be evaluated as part of method development.

## Dosage Form

The key properties of the dosage unit, including dosage form type (tablet, capsule), expected number of potencies and desired release mechanism plus specific formulation information such as excipients, lubricants, disintegrants, moisture content, surface coating and known stability issues (cross-linking, friability) are all important factors to consider. Manufacturing variables such as lubrication blend time, compression force, excipient/API addition order, drying parameters and coating parameters are also critical to understanding API release differences between formulations.

## Media

The first step is to screen formulations with aqueous-based media in the range of pH 1.2 to 6.8 at



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## **In Vitro Dissolution Testing For Solid Oral Dosage Forms:**

*In Vitro Drug Release Testing of Special Dosage Forms* Nikoletta Fotaki, Sandra Klein, 2019-10-11 Guides readers on the proper use of in vitro drug release methodologies in order to evaluate the performance of special dosage forms In the last decade the application of drug release testing has widened to a variety of novel special dosage forms In order to predict the in vivo behavior of such dosage forms the design and development of the in vitro test methods need to take into account various aspects including the dosage form design and the conditions at the site of application and the site of drug release This unique book is the first to cover the field of in vitro release testing of special dosage forms in one volume Featuring contributions from an international team of experts it presents the state of the art of the use of in vitro drug release methodologies for assessing special dosage forms performances and describes the different techniques required for each one In Vitro Drug Release Testing of Special Dosage Forms covers the in vitro release testing of lipid based oral formulations chewable oral drug products injectables drug eluting stents inhalation products transdermal formulations topical formulations vaginal and rectal delivery systems and ophthalmics The book concludes with a look at regulatory aspects Covers both oral and non oral dosage forms Describes current regulatory conditions for in vitro drug release testing Features contributions from well respected global experts in dissolution testing In Vitro Drug Release Testing of Special Dosage Forms will find a place on the bookshelves of anyone working with special dosage forms dissolution testing drug formulation and delivery pharmaceuticals and regulatory affairs *Guidance for Industry*, 1995 **Developing Solid Oral Dosage Forms** Yihong Qiu, Yisheng Chen, Geoff G.Z. Zhang, Lirong Liu, William Porter, 2009-03-10 Developing Solid Oral Dosage Forms is intended for pharmaceutical professionals engaged in research and development of oral dosage forms It covers essential principles of physical pharmacy biopharmaceutics and industrial pharmacy as well as various aspects of state of the art techniques and approaches in pharmaceutical sciences and technologies along with examples and or case studies in product development The objective of this book is to offer updated or current knowledge and skills required for rational oral product design and development The specific goals are to provide readers with Basics of modern theories of physical pharmacy biopharmaceutics and industrial pharmacy and their applications throughout the entire process of research and development of oral dosage forms Tools and approaches of preformulation investigation formulation process design characterization and scale up in pharmaceutical sciences and technologies New developments challenges trends opportunities intellectual property issues and regulations in solid product development The first book ever that provides comprehensive and in depth coverage of what s required for developing high quality pharmaceutical products to meet international standards It covers a broad scope of topics that encompass the entire spectrum of solid dosage form development for the global market including the most updated science and technologies practice applications regulation intellectual property protection and new development trends with case studies in every chapter A strong team of more than 50 well established authors co authors of

diverse background knowledge skills and experience from industry academia and regulatory agencies      **Oral**

**Bioavailability** Xiaoling Li,2011-08-04 Understand and assess the design delivery and efficacy of orally administered drugs  
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*Formulations, Third Edition* Sarfaraz K. Niazi,2019-12-06 The Handbook of Pharmaceutical Manufacturing Formulations  
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**Pharmaceutical Manufacturing Formulations** Sarfaraz K. Niazi, 2016-04-19 The fourth volume in the series covers the techniques and technologies involved in the preparation of semisolid products such as ointments, creams, gels, suppositories and special topical dosage forms. Drug manufacturers need a thorough understanding of the specific requirements that regulatory agencies impose on the formulation and efficacy determinants.

**Controlled Release Veterinary Drug Delivery** Michael J. Rathbone, R. Gurny, 2000-07-20 Many controlled release veterinary drug delivery systems (CRVDDS) are presently in use and recently there has been a host of new CRVDDS within veterinary medicine. The challenges of this area of drug delivery arise from the unique anatomy and physiology of the target animal, the cost constraints associated with the value of the animal being treated, and the extended periods of time that delivery must be sustained for, often measured in months. The purpose of this book is to introduce the reader to the unique opportunities and challenges of the field of CRVDDS and to explain and discuss the basic controlled release principles underlying the development of CRVDDS. Its aim is to provide an overview of many of the areas where CRVDDS have application and to highlight the opportunities and prospects for controlled release technology in the veterinary field. **Controlled Release Veterinary Drug Delivery** comprises chapters that provide workers in the field and those interested in this area with information on the design, development, and assessment of a variety of CRVDDS. The book contains chapters that describe the relevant animal physiological and anatomical considerations alongside descriptions of current and emerging controlled release delivery systems for a variety of routes for drug delivery and present overviews on the physical and chemical assessment of veterinary controlled release delivery systems. The veterinary area is abundant with opportunities for the development of controlled release drug delivery technologies. It is an area of medicine that is open to the acceptance of novel drug delivery devices and which readily encompasses the use of novel routes of administration. It is an area of many unmet needs, most of which offer opportunities and unique challenges for the innovative formulation scientist to provide solutions. This book will provide an insight into the biological, clinical, and pharmaceutical challenges that face the formulation scientist in this interesting and diverse area of research.

**Oral Bioavailability and Drug Delivery** Ming Hu, Xiaoling Li, 2024-01-09 **ORAL BIOAVAILABILITY AND DRUG DELIVERY** Improve the performance and viability of newly developed and approved drugs with this crucial guide. Bioavailability is the parameter which measures the rate and extent to which a drug reaches a user's circulatory system depending on the method of administration. For example, intravenous administration produces a bioavailability of 100% since the drugs are injected directly into the circulatory system. In the case of oral administration, however, bioavailability can vary widely based on factors which, if not properly understood, can result in a failure in drug development, adverse effects, and other complications. The mechanics of oral bioavailability are therefore critical aspects of drug development. **Oral Bioavailability and Drug Delivery** provides a comprehensive coverage of this subject as well as its drug development applications. Beginning with basic terminology and fundamental concepts, it provides a thorough understanding of the

challenges and barriers to oral bioavailability as well as the possibilities for improving this parameter The resulting book is an indispensable tool for drug development research Oral Bioavailability and Drug Delivery readers will also find Discussion questions in many chapters to facilitate comprehension Detailed discussion of topics including dissolution absorption metabolism and more Real world examples of methods in actions throughout Oral Bioavailability and Drug Delivery is ideal for pharmaceutical and biotechnology scientists working in drug discovery and development researchers in chemistry biology pharmacology immunology neuroscience and other related fields and graduate courses in drug development and delivery

**Guidance for Industry Immediate Release Solid Oral Dosage Forms**, 1995 *Pharmaceutical Dissolution Testing* Umesh V. Banakar, 1991-09-25 Introduction Historical Highlights and the Need for Dissolution Testing Theories of Dissolution Dissolution Testing Devices Automation in Dissolution Testing by William A Hanson and Albertha M Paul Factors That Influence Dissolution Testing Interpretation of Dissolution Rate Data Techniques and of In Vivo Dissolution by Umesh V Banakar Chetan D Lathia and John H Wood Dissolution of Dosage Forms Dissolution of Modified Release Dosage Forms Dissolution and Bioavailability Dissolution Testing and the Assessment of Bioavailability Bioequivalence by Santosh J Vetticaden Dissolution Rediscovered by John H Wood Appendix USP NF Dissolution Test **Dissolution Shelf Life of Hydroxypropyl Methyl Cellulose Coated Aspirin Tablets at I.C.H. Temperatures and Various Relative Humidities** Shannon Patrick Adams, 1998 *Pharmaceutical Dissolution Testing* Jennifer J. Dressman, Johannes Kramer, 2005-07-08 An expertly written source on the devices systems and technologies used in the dissolution testing of oral pharmaceutical dosage forms this reference provides reader friendly chapters on currently utilized equipment equipment qualification consideration of the gastrointestinal physiology in test design the analysis and interpretation of data **The United States pharmacopeia**, 2012 *Technical Report Series*, 2006 *Pharmaceutical Product Development* Vandana B. Patravale, John I. Disouza, Maharukh Rustomjee, 2016-05-25 Pharmaceutical product development is a multidisciplinary activity involving extensive efforts in systematic product development and optimization in compliance with regulatory authorities to ensure the quality efficacy and safety of resulting products Pharmaceutical Product Development equips the pharmaceutical formulation scientist with extensive and up to date knowledge of drug product development and covers all steps from the beginning of product conception to the final packaged form that enters the market and lifecycle management thereof Applications of core scientific principles for product development are also thoroughly discussed in conjunction with the latest approaches involving design of experiment and quality by design with comprehensive illustrations based on practical case studies of several dosage forms The book presents pharmaceutical product development information in an easy to read mode with simplified theories case studies and guidelines for students academicians and professionals in the pharmaceutical industry It is an invaluable resource and hands on guide covering managerial regulatory and practical aspects of pharmaceutical product lifecycle management *The Bioavailability of Drug Products*, 1978 APhA Bioavailability

Project,1978      **The Bioavailability of Drug Products 1975** American Pharmaceutical Association,1975      WHO Expert Committee on Specifications for Pharmaceutical Preparations World Health Organization,2006 This report presents the recommendations of an international group of experts convened by the World Health Organization to consider matters concerning the quality assurance of pharmaceuticals and specifications for drug substances and dosage forms The report is complemented by a number of annexes These include a list of available international chemical reference substances and international infrared spectra supplementary guidelines on good manufacturing practices for heating ventilation and air conditioning systems for non sterile pharmaceutical dosage forms updated supplementary guidelines on good manufacturing practices for the manufacture of herbal medicines supplementary guidelines on good manufacturing practices for validation good distribution practices for pharmaceutical products a model quality assurance system for procurement agencies recommendations for quality assurance systems focusing on prequalification of products and manufacturers purchasing storage and distribution of pharmaceutical products multisource generic pharmaceutical products guidelines on registration requirements to establish interchangeability a proposal to waive in vivo bioequivalence requirements for WHO Model List of Essential Medicines immediate release solid oral dosage forms and additional guidance for organizations performing in vivo bioequivalence studies This is an excellent book with a misleading title a good reference work for anyone seeking to understand the concept of validation and looking for general guidance on validation for both Active Pharmaceutical Ingredients API and finished pharmaceutical products Annex 5 on Good distribution practices GDP for pharmaceutical products is an excellent Annex that splits the task of GDP into 20 small easy to digest sections that guide the reader through the process of understanding the complexity of controlling distribution of pharmaceutical products It contains a comprehensive glossary of terms used in GDP a useful reference book for anyone involved in Quality Assurance Manufacturing of marketed products Clinical Manufacturing and Development Industrial Pharmacy      Journal of the American Pharmaceutical Association (1961) ,1973

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