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DISSOLUTION TESTING: A QUICK OVERVIEW

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ABSTRACT

Dissolution testing is a critical methodology which is widely utilized in the development of a new pharmaceutical product. The test, in its simplest form, consists of placing the formulation in a dissolution apparatus containing suitable dissolution medium, allowing it to dissolve over a specified period of time and then assaying the resultant solution using appropriate analytical method to determine the amount of drug. Dissolution tests are relevant for an array of investigations like drug degradation profiles, stability and shelf life studies, physical and mechanical testing of dosage forms, incoming QC testing on raw materials etc. The present review outlines the recent findings on various dissolution apparatus use, their modifications, methods for degassing of media like Helium sparging, heating and filtering, vacuum degassing, sonication and dissolution testing of various dosage forms like Immediate release (IR) dosage forms, Delayed release dosage forms, Extended release dosage forms, Transdermal delivery systems, powders, Chewable tablets, Buccal tablets, Chewing gums, Soft gelatin capsule , aerosols, suppositories and other semisolids.

Key Words: Dissolution, Applications, Apparatus, Modifications, Deaeration, Dosage forms

INTRODUCTION

Dissolution is defined as the process by which solid substance enters in solvent to yield a solution. Simply, dissolution is a mass transfer from a solid surface to liquid phase. It clearly states that dissolution is a dynamic property. Dissolution testing has almost had a century of development. It expanded over years beyond the ordinary tablets and capsules, first to Extended-release and Delayed-release (enteric-coated) articles, then to transdermals, multivitamin and mineral products, and to class monographs for non-prescription drug combinations. It was in the year 1897 that Noyes and Whitney published a paper on "rate of solution of solid

substances in their own solution" which gave the first known reference to dissolution testing.

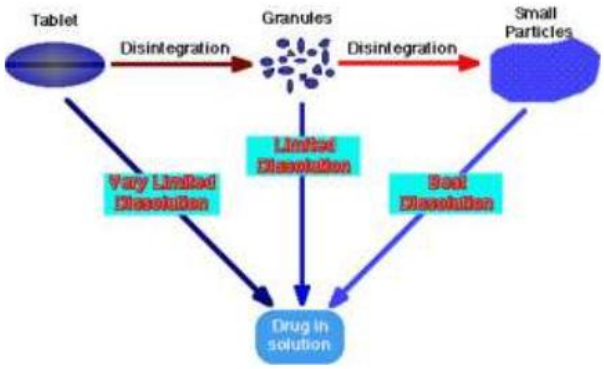

Fig No. 1: Dissolution

- The effectiveness of dosage forms relies on the drug dissolving in the fluids of the gastrointestinal tract prior to absorption into the systemic circulation. The rate of dissolution of the tablet or capsule is therefore crucial.
- One of the problems faced by the pharmaceutical industry is to optimize the amount of drug available to the body, i.e. its '**bioavailability**'. Inadequacy in bioavailability can mean that the treatment is ineffective and at worst potentially dangerous (toxic overdose).
- Drug release in the human body can be measured 'in-vivo' by measuring the plasma or urine concentrations in the subject concerned. However, there are certain obvious impracticalities involved in employing such techniques on a routine basis. These difficulties have led to the introduction of official 'in-vitro' tests which are now rigorously and comprehensively defined in the respective Pharmacopoeia.
- Dissolution is a standardized method for measuring the rate of drug release from a dosage form. Although initially developed for oral dosage forms, the role of the dissolution test has now been extended to 'drug release' studies on various other forms such as topical and transdermal systems and suppositories.
- The importance of dissolution can be determined if the IDR is known. Intrinsic dissolution rate (IDR) is defined as "the rate at which a pure substance dissolves from constant surface area under constant temperature, pH, Agitation and Ionic Strength of dissolution medium. When the drug is released from dosage form, if the IDR value of a drug candidate is greater than or equal to 1.0 mg/min/cm^2, it infers that drug dissolution will not be the rate limiting/determining step to absorption, if the IDR value is less than or equal to 0.1 mg/min/cm^2 it infers that drug dissolution will be the rate limiting step to absorption. While

the intermediate value of IDR represents the "may be" version of rate limiting step. Therefore, dissolution studies are particularly important for poorly soluble drugs like BCS class II, IV drug candidates where their absorption is typically dissolution rate-limited.

Applications of dissolution testing:

Dissolution testing is widely used in the pharmaceutical industry for optimization of formulation and quality control. It is useful in the pharmaceutical and biotechnology industry to formulate drug dosage forms and to develop quality control specifications for its manufacturing process. To identify the critical manufacturing variable, like the binding agent effect, mixing effects, granulation procedure, coating parameters and comparative profile studies.

- To comply with guidelines set in the scale up and post approval changes SUPAC and ICH.
- To select candidate formulation.
- To simulate food effect on bio availability.
- To measure the stability of the investigational product.
- To assess batch-to-batch consistency of solid oral dosage forms.
- To support waiver for bio equivalence requirements.
- In the study of Bio waivers.
- As a surrogate for in-vivo studies.
- In the In vitro in-vivo correlations

APPARATUS FOR DISSOLUTION TESTING

Two types of apparatus are specified

- APPARATUS 1 (BASKET APPARATUS)
- APPARATUS 2 (PADDLE APPARATUS)

Table no. 1: Seven types of apparatus as per USP are specified:-

APPARATUS	NAME	DRUG PRODUCT
Apparatus I	Rotating basket	Tablets, Capsules
Apparatus II	Paddle	Tablets, capsules modified drug products
Apparatus III	Reciprocatingcylinder	Extended-release drug products, Beads
Apparatus IV	Flowthrough cell	Drug products containing low-water-soluble drug
Apparatus V	Paddle overdisk	Transdermal drug products, Ointments, Gels, Emulsion
Apparatus VI	Rotating Cylinder	Transdermal drug products, Ointments, Gels, Emulsion
Apparatus VII	Reciprocatingholder	Extended-releasedrug products, Transdermal Patches, Ointments, Gels, Emulsion

APPARATUS 1 (BASKET APPARATUS)

- Adopted in 1970 the rotating basket method of dissolution testing was the first official method. Essentially it consisted of an approximately 1 inch (25.4mm) × 1 3/8 inch (34.925mm) stainless steel, 40-mesh wire basket rotated at a constant speed between 25 and 150rpm. This method is now called **Apparatus 1**.
- The apparatus consists a metallic drive shaft connected to the cylindrical basket. The basket is positioned inside a vessel made of glass or other inert, transparent material. The temperature inside the vessel is kept at a constant temperature by being placed inside a water bath or heating jacket. The solution in the vessel is stirred smoothly by the rotating stirring element.
- A speed-regulating device is used that allows the shaft rotation speed to be selected and maintained at a specified rate, within ± 4 per cent.
- Shaft and basket components of the stirring element are fabricated of stainless steel, type 316 or equivalent, to the specifications shown in Figure.
- A basket having a gold coating of about 2.5 µm (0.0001 inch) thick may be used. The dosage unit is placed in a dry basket at the beginning of each test.
- The distance between the inside bottom of the vessel and the bottom of the basket is maintained at 25 ± 2 mm during the test.
- Other types of basket exist for specific applications. For example, **suppository baskets** are normally manufactured from plastic and have vertical slits to facilitate the dissolution.
- **Japanese baskets** are sometimes confused with dissolution baskets although they are actually sinkers. Products manufactured under the JP may require the use of this basket.
- This apparatus is used mainly for testing of uncoated tablets, Enteric coated tablets, Sublingual tablets, hard gelatin capsules and Soft gelatin capsules.

MODIFICATIONS

(i) WATERLESS BATH DISSOLUTION APPARATUS

Here vessels are heated with a water jacket, not submerged into a water-bath.

(ii) PEAK VESSELS

Its having a cone shaped glass vessel.

Mainly useful for the products having dense excipients, which are having tendency to cone rather than to disperse freely inside the vessel. E. g. Guar Gum, Ethyl Cellulose etc.

(iii) CLIP and CLIPLESS BASKETS

It helps to retain tablet in proper position. Spring Clips are official in USP while 'O' Rings are non-official.

MEDIA DEGASSING

There are various methods of degassing media Helium sparging, warming and subsequent filtering and vacuum degassing are the most popular. The method suggested in the USP is to heat the media at 45°C and then filter it through a 0.45µm filter under vacuum and stirred for about 5 minutes before being placed directly into the dissolution vessel.

This method of degassing has been shown to reduce the level of dissolved gases by about 85% which is enough to ensure that the air will not affect the dissolution results.

METHODS FOR DEAERATION

1. Helium sparging can be effective but is costly to use for large volumes, as it requires a constant supply of helium gas to continually bubble through the media. It degasses the liquid by absorbing the gases that are dissolved in the media into the helium bubbles and carrying them out of solution.

- One of the major problems with this method is that the media can become saturated with helium which causes similar problems to being saturated with air and it is difficult to measure the amount of helium in the liquid.

2. **Heating and filtering** the media is fairly reliable and is the method described in USP 23 (it actually specifies heating to 45 °C, followed by filtration through a 0.45µm filter membrane).This will remove about 85% of the dissolved oxygen, although the media then has to be cooled before the dissolution test which gives it time to reaerate.

3. **Vacuum degassing** can remove more than 95% of the dissolved gas and if the media is held under vacuum then it will not be able to reaerate before it is placed in the dissolution vessel.

4. Other common laboratory methods of degassing such as sonication or membrane degassing are not practical for degassing the large volumes required for dissolution testing and are more suited for HPLC.

METHOD	%REDUCTION (APPROX.)
USP	84.9 ± 11%
Filtering	65 ± 3%
Heating to 45°C	10 ± 14%
Boiling	49 ± 3%
Vacuum degassing	

APPARATUS 2 (PADDLE)

- **Apparatus 2**: commonly known as the paddle method, was originally developed by Poole (1969) and was refined by scientists at the FDA for Drug Analysis in St Louis. The specifications for Apparatus 2 are identical with those for Apparatus 1 except that the paddle is substituted for the rotating basket.
- The USP specifies that the paddle must rotate smoothly without significant wobble. The arc of the paddle blade creates considerable flow and wobble has the effect of increasing the angular velocity at the paddle tips in a manner that couples with the fluid much more significantly than would a comparable wobble in the basket.
- The contours of the paddle blade must not include any sharp edges — at the tips for instance — that could produce turbulent instead of laminar flow patterns. The USP constrains wobble and vertical alignment with the axis of the vessel to within ±2.0mm.
- The USP suggests that paddles 'may' be coated with polyfluoro carbon and most commercial paddles are accordingly coated.
- Such coating serves two purposes: it prevents corrosion and the introduction of unwanted ions into the media and it seals the joint where the blade is attached to the shaft, thus preventing the accumulation of traces of contaminants.
- Because of the precise geometry required for the repeatability of the paddle method, the stirring paddle has been specified as a stainless steel device rather than a glass one with a detachable blade, largely because glass cannot be manufactured to such close cost specifications without incurring excessive cost.
- Rotation speed for solid dosage forms is 50 rpm, while for Liquid dosage forms (SUSPENSION) it is 25rpm.
- It cannot be used for testing of POWDER DOSAGE FORMS.
- This apparatus is used mainly for testing of uncoated tablets, Enteric coated tablets, Sublingual tablets, hard gelatin capsules and Soft gelatin capsules, Gels, Ointments.

APPARATUS 3 (RECIPROCATING CYLINDER)

The assembly consists of

- A set of cylindrical, flat-bottomed glass vessels;
- A set of glass reciprocating cylinders.

- Inert fittings (stainless steel type 316 or other suitable material) and
- Screens that are made of suitable non-absorbing and nonreactive material, and that are designed to fit the tops and bottoms of the reciprocating cylinders;
- A motor and drive assembly to reciprocate the cylinders vertically inside the vessels.
- The vessels are partially immersed in a suitable water-bath of any convenient size that permits holding the temperature at 37 ± 0.5 °C during the test.
- A device is used that allows the reciprocation rate to be selected and maintained at the specified dip rate, within ± 5 per cent.
- This apparatus resembles the Disintegration apparatus.
- Upward and downward strokes of cylinder are observed.
- It's quite useful for beaded products like pellets, granules etc.
- Also useful for controlled and immediate release products.

APPARATUS 4 (FLOW THROUGH CELL)

The assembly consists of

- A pump for the dissolution medium;
- A flow-through cell;
- A water-bath to maintain the dissolution medium at 37 ± 0.5°C.
- The pump forces the dissolution medium upwards through the flow-through cell. The pump has a delivery range between 240 ml/h and 960 ml/h, with standard flow rates of 4 ml/min, 8 ml/min, and 16 ml/min. It must deliver a constant flow (± 5 % of the nominal flow rate). Non-pulsated flow may also be used.
- The flow-through cell of transparent and inert material is mounted vertically, with a filter system that prevents escape of undissolved particles from the top of the cell; standard cell diameters are 12 mm and 22.6 mm; the bottom cone is usually filled with small glass beads of about 1 mm diameter, with 1 bead of about 5 mm positioned at the apex to protect the fluid entry tube; a tablet holder is available for positioning of special dosage forms. The cell is immersed in a water-bath, and the temperature is maintained at 37 ± 0.5 °C
- It is mainly used for testing of Sugar coated tablets, suppositories, semisolid dosage forms, powder, granules, implants.

APPARATUS 5 (PADDLE OVER DISK)

- Transdermal or patch testing is carried out using USP method 5 (paddle over disc).
- With paddle over disc, the transdermal patch is placed between a glass disc and an inert PTFE (POLY TEFLON) mesh.
- This is placed at the bottom of the vessel, with the mesh facing upwards, under a rotating paddle.
- Unlike dissolution testing, transdermal testing is carried out at 32°C to reflect the lower temperature of the skin. Other variables such as the height setting and sampling requirements are the same as dissolution testing.
- USP 5 apparatus is made-up of borosilicate glass with a PTFE 17 mesh, held together by PTFE clips. Patches up to 90mm in diameter can be tested.

APPARATUS 6 (ROTATING CYLINDER)

- Transdermal or patch testing is carried out using USP method 5 (paddle over disc) or USP method 6, the rotating cylinder.
- The rotating cylinder is very similar to USP method 1 (the rotating basket).
- With USP method 6 however, the basket assembly is replaced by a solid stainless steel cylinder.
- The cylinder consists of two parts that fit together: the main shaft/cylinder assembly plus an extension. The extension is used when the transdermal patch requires a larger area.
- The distance between the inside bottom of the vessel and the cylinder is maintained at 25 ± 2 mm during the test.
- The temperature is maintained at 32 ± 0.5 °C. The vessel is covered during the test to minimize evaporation.

APPARATUS 7 (RECIPROCATING HOLDER)

- The vessels are partially immersed in a suitable water-bath of any convenient size that permits holding the temperature at 37 ± 0.5 °C during the test.
- A device is used that allows the reciprocation rate to be selected and maintained at the specified dip rate, within ± 5 per cent.
- Useful for testing of extended release dosage forms, Osmotic pumps, Tablets, Ointments, Gels etc.
- Cuprophan (Cellophane paper) is used for holding of semisolid dosage forms.

FIBRE OPTIC DISSOLUTION TECHNIQUE

- In the first instance the introduction of tablets or other dosage forms is as with a conventional dissolution instrument.
- The instrument is operated by WINDISS 32 Dissolution Software control.
- The sampling sequences have been replaced by direct measurement technology within the dissolution vessel itself, with each measurement cycle accomplished in seconds.
- The ***in situ*** measurement is carried out using fibre optic probes which are located in the shafts of the dissolution tools, i.e., a paddle or a basket (Apparatus 2 or 1).
- The fibre optic probe can be removed from the shaft so that various path length inserts can be employed for different active concentrations ranges.
- The fibre optic probe can then be simply reinserted into the tool shaft and the next analysis started.

ADVANTAGES:

- It's an automated process.
- Less time consuming method.
- Optic fibre probes are used, so sampling is not required.

METHODS FOR DEAERATION

- **Helium sparging** can be effective but is costly to use for large volumes, as it requires a constant supply of helium gas to continually bubble through the media. It degasses the liquid by absorbing the gases that are dissolved in the media into the helium bubbles and carrying them out of solution. One of the major problems with this method is that the media can become saturated with helium which causes similar problems to being saturated with air and it is difficult to measure the amount of helium in the liquid.
- **Heating and filtering** the media is fairly reliable and is the method described in USP 23 (it actually specifies heating to 45 °C, followed by filtration through a 0.45µm filter membrane).This will remove about 85% of the dissolved oxygen, although the media then has to be cooled before the dissolution test which gives it time to reaerate.
- **Vacuum degassing** can remove more than 95% of the dissolved gas and if the media is held under vacuum then it will not be able to reaerate before it is placed in the dissolution vessel. Other common laboratory methods of degassing such as sonication or membrane degassing are not practical for degassing the large volumes

required for dissolution testing and are more suited for HPLC.

Table no. 2: Typical examples of different USP dissolution media used for dissolution testing of tablets and capsules.

Dissolution medium	Example
Water	Ampicillin capsule, butabarbital sodium tablet
Buffers	Azithromycin capsule, cefixime tablet
HCl solution	Cimetidine tablet, bethanecol chloride tablet
Simulated gastric fluid	Astemizole tablet, piroxicam capsule
Simulated intestinal fluid	Valproic acid capsule, glipizide tablet
Surfactant solution	Clofibrate capsule, danazol capsule

The International Pharmaceutical Federation (FIP) guidelines published two bio relevant media,

1) Fasted State Simulated Intestinal Fluid (FaSSIF)

2) Fed State Simulated Intestinal Fluid (FeSSIF), which can be used to simulate fasted and fed states for oral dosage forms (Aiache et al., 1997).

Dissolution Testing of Various Dosage forms:

An attempt is made here in to describe the dissolution testing of various dosage forms like Immediate release, Delayed release, Modified release, Powders, Dosage forms for oral cavity including Chewable tablets, Buccal/sublingual tablets, Chewing Gums, Suppositories & Semi solid Dosage forms, Transdermal Drug Delivery Systems, Soft gelatin Capsules and Aerosols.

Dissolution Testing of Immediate Release (IR) Dosage forms (USP, IP, BP, EP, JP)

An immediate release dosage form is designed to deliver the drug rapidly into systemic circulation. Therefore the dissolution may be the rate limiting step for its absorption. Generally dissolution of IR dosage forms are been conducted using apparatuses of Basket, Paddle, Reciprocating Cylinder and Flow-through cell respectively. Most commonly I and II apparatuses are used. (USP 1 Basket, USP2 Paddle and IP 1 Paddle and IP 2 Basket apparatus). (**EP uses Paddle, Basket and Flow through apparatuses for solid dosage forms of tablets, capsules**)

The choice of apparatus is based on the knowledge regarding the formulation design, dosage form performance. Test is carried out at temperature of 37±0.5 ^{0}C. In general when Basket apparatus is used; rotating speed of 100 rpm with 40-mesh screen of the basket is used. Other mesh sizes may also be used if

supported by necessary data documentation. It is generally used for capsules and floating type of dosage forms or to those which tend to disintegrate slowly. For floating type of dosage forms sinkers may be used to prevent the floating of capsule.

Paddle apparatus is generally used for tablets. Operating speed of 50 is used in general. Numerous monographs are available evidencing the use of Basket and Paddle whilst the use of Reciprocating cylinder and Flow through cell apparatus is limited only to research works to date. Vincopecetine and Theophylline had been evaluated using Reciprocating cylinder making use of a pH gradient method and Flow through cell apparatus for reporting in vitro profiling of albendazole in 0.1N HCl. Samples are withdrawn according to specifications with tolerance of ±2%.

(Apparatus 3 Reciprocating cylinder is not accepted by JP).

The test is conducted on the equipment which was pre calibrated with USP Salicylic acid and Prednisone Calibrator tablets **(According to USP)**.The dissolution medium used should be deaerated and may be water, buffered aqueous solution of P^H 4-8 and dilute acid of 0.001 N to 0.1 N HCl are used. The test time is 30-60 minutes and with a single point specification or as specified in individual monographs.

Interpretation:

The dissolution is done in three stages of S1, S2, and S3. In first stage S1, six units are taken and the amount of drug from each unit should not be less than Q+5%, where Q is the amount of dissolved active ingredient specified in individual monograph. Failure of first stage compensates to conductance of second stage S2, where additional 6 units are tested and the average of 12 units in two stages should be equal to or greater than Q and no unit should be less than Q-15%. Failure of stage 2 leads to conductance of stage S3 where additional 12 units are tested and the average of total 24 units of three stages S1, S2 and S3 should be greater than or equal to Q and no two units should be less than Q-15% and none should be less than Q-25%.

Dissolution Testing of Delayed Release Dosage Forms (USP, IP (Dissolution testing for prolonged dosage forms), BP, JP, EP)

According to CDER guidelines Delayed Release Dosage Forms are "the products that release the drugs at a time later than immediately after administration (i.e., these drug products exhibit a lag time in quantifiable plasma concentrations)". So, the dissolution is done to show that they are intact in stomach P^H and release the drug only in intestinal region. Test is carried out at temperature of 37±0.5 ^{0}C.Apparatuses Basket, Paddle, Reciprocating Cylinder and Flow-through cell are used for dissolution testing of delayed release dosage forms **(By USP, BP, IP and EP uses Paddle, Basket and Flow through apparatuses whilst JP recommends only Flow**

through cell apparatus for dissolution testing).

The dissolution is done in two stages one in Acid stage to show the intactness of dosage form and in Buffer stage to evidence the drug release in specific region. Two methods are used for testing which include

Method A: The test is carried out by placing the dosage form in 750 ml of 0.1N HCl. The sample was withdrawn after two hours and analyzed. Immediately within 5 minutes 250ml of phosphate buffer is added and contents are mixed thoroughly and final P^H of buffer is adjusted to 6.8±0.05. The test is run for another 45 minutes or as specified in individual monographs and the sample is analyzed.

Method B: Here the test is initially carried out by placing the dosage form in 1000ml of 0.01 N HCl and sample is analyzed after two hours and the medium is discarded and 1000ml of6.8±0.05 buffer is added and the test is run for 45 minutes more or as specified in individual monographs.

apparatuses Basket, Paddle, Flow through cell make use of method A, B while Reciprocating cylinder make use of method B with 300ml of dissolution medium.

The dissolution of delayed release dosage forms is said to be three three-tiered approach since the dissolution is done in three stages of two buffers (A1, A2, A3 & B1, B2 &B3)

Dissolution Testing of Extended Release Dosage Forms (USP, IP, JP, BP, EP (Dissolution testing for prolonged dosage forms))

These include sustained release or controlled release dosage forms which reduces the frequency of dosing compared to conventional dosage forms. The dissolution is done to study the effect of PH on release profile of dosage form when it passes through GIT. Test is carried out at temperature of 37±0.5 ^{0}C.

Apparatuses 1 (Basket) or apparatus 2 (Paddle) are used at higher rotational frequencies. (According to USP, IP, BP, JP, EP)Apparatus 3(Reciprocating cylinder) is used for testing bead type formulations. (According to USP, IP, BP)

Apparatus 4 (Flow cell) is used for dosage forms containing limited solubility of API. (According to USP, IP, BP, JP, EP)

Apparatuses 5 & 6 (Paddle over disk & Cylinder) are used for evaluating Transdermal dosage forms. (According to USP)

Apparatus 7 (Reciprocating disk) is used for evaluating Transdermal as well as non-disintegrating oral dosage forms.(According to USP)

The test is done over a wide P^H range of 0.1N HCl to 7.5 P^H over 22 hours. (According to USP). Physiological pH of 0.8-2 (stomach); pH 5-6.5 (jejunum), pH 6-7.5 (ileum) are used according to EP. Three test time points will be specified in monographs.

Early time point of 1-2 hours is established to prove that there is no probability of dose dumping of drug. Intermediate time point is established to study the in vitro release profile of drug and final time point is chosen to show the complete release of drug.

Dissolution Testing of Transdermal Delivery Systems

USP apparatus 5, 6 and 7(Paddle over disk, Cylinder and Reciprocating holder) are used for testing at temperature of 32±0.5°C. Generally three time points may be specified in hours and the samples should be withdrawn with +2% or -2% tolerance intervals.

Dissolution Testing of Powders (Not accepted by IP, BP, EP, JP, USP)

As such no official method was developed for dissolution testing of powders. The preliminary method used was the determination of IDR where the powders are pressed like a tablet to mimic constant surface area. Literature has been reported with use of USP apparatus 2 and 4 for dissolution testing of finely divided particles. To counteract the effect of dispersal of powders, a modified basket method was developed, where the basket was dipped into the molten wax to seal the bottom, so that there will be long term contact of drug with Excipients.

Dissolution Testing of Dosage forms for the Oral Cavity

Development of dissolution method for these dosage forms possess several challenges due to short residence time of dosage form in the mouth and limited volume of dissolution medium for dissolving the dosage form.

- **Chewable Tablets:** (Not accepted by IP, BP, EP, JP)
  USP insisted the use of apparatus 2 for dissolution excepting Ampicillin where apparatus 1 is recommended and Carbamazepine where apparatuses 2 & 3 are used. The design of apparatus should consist of a mechanical breakage of tablet prior to dissolution.
- **Buccal/Sublingual Tablets :**(Not accepted by IP, BP, EP, JP)
  Initially USP stated the use of disintegration apparatus for ergotamine category sublingual products. Later modified USP 3 apparatus with 20strokes/min was used for Hydrocortisone mucoadhesive tablets to mimic the low dissolution volume of in vivo. Later another system Continuous Flow though Filtration Cell with dip tube for filtration. 10 ml of fluid is pumped to give a short residence time of 8 minutes.
- **Chewing Gums:** (Not accepted by IP, BP, JP)
  USP has not recommended any apparatus for dissolution testing of Chewing gums. But EP has emphasized on the use of 3-piston apparatus that chews the gum at a rate of 60cycles/min in dissolution medium of P^H 6.0 at 37 C.

Still, controversies regarding this issue are existing and urges for development of an appropriate apparatus.

Dissolution Testing of Soft Gelatin Capsules (Not accepted by IP, BP, EP, JP) USP has recommended the use of apparatuses 1 and 2. But since there had been serious disadvantages related, attempts had been made in literature to develop new methods for lipid-filled soft gelatin capsules.

Dissolution Testing of Aerosols (Not accepted by IP, EP, JP, USP) Literature has reported the use of designed flow through cell apparatus for dissolution testing of aerosols. The method uses the collection of of aerosol particles on to a pre filter which are obtained through impaction. The particles are made to flow through by using HPLC pump at 0.7 ml/min flow rate and the fraction of drug dissolved was collected on the upper filter and analyzed. Different mediums were reported like Simulated Lung Fluid (SLF), Modified SLF with D-Phosphatidyl Choline (DPPC), and Serum Ultra filtrate Simulant (SUF).

Dissolution Testing of Suppositories and other Semisolids (USP, EP) Dissolution testing of Semisolid dosage forms for vaginal (pessaries), percutaneous application (gels, creams, ointments, patches), ophthalmic (gel, cream, ointment), rectal (suppository, gel, ointment, cream) may present problems like deformation, change of solid state to oily state, softening during the test. Therefore a modified flow-through cell with double chamber, modified basket or paddle with a sinker and wired screen may be suitable for lipophilic suppositories while conventional paddle, flow through, basket may be used for hydrophilic suppositories.

CONCLUSION: This brief review on the dissolution testing hereby concludes with a note that dissolution testing is considered as a most important test. There are different dissolution media and apparatuses for dissolution testing of both conventional and novel dosage forms. However, some of these methods and dissolution media which are reviewed in this article are intended to be used in research and development only and might not be suitable for routine quality control. This will ensure that *in vitro/in-vivo* correlations can be established. For the quality control purpose of certain dosage forms like gums and liquid filled capsules, as new pharmacopoeial apparatus. The discussion provided should help in making a choice for an appropriate dissolution medium and dissolution apparatus.

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