Fast Dissolving film for Enhancing drug delivery: A Review

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Abstract

Fast-dissolving films (FDFs) have emerged as an innovative drug delivery system designed to enhance the solubility, dissolution rate, and bioavailability of poorly water-soluble drugs. These films offer advantages such as ease of administration, rapid disintegration, and improved patient compliance, making them particularly suitable for pediatric, geriatric, and dysphagic patients. This review explores the formulation strategies, selection of excipients, and manufacturing techniques involved in the development of FDFs. various polymers, plasticizers, and surfactants play a crucial role in determining the mechanical strength, flexibility, and drug release profile of the films. The solvent casting method remains the most widely used approach for FDFs fabrication, though advanced techniques such as hot-melt extrusion and electrospinning are gaining attention. Key evaluation parameters, including physicochemical properties, disintegration time, drug content uniformity, and in vitro dissolution studies, are discussed to ensure product quality and efficacy. Additionally, recent advancements, challenges, and future perspectives in fast-dissolving film technology are highlighted. The growing interest in FDFs as a patient-friendly alternative to conventional dosage forms underscores their potential in improving drug delivery and therapeutic outcomes.

Keywords- fast-dissolving film, Solubility enhancement, bioavailability

1. Introduction

The most popular delivery method for the systemic effect is oral. A solid dose form makes for around 60% of all formulations. Because tablets are easier to manufacture, transport, and increase patient compliance, they are the most used dose type. Typically, patients who are elderly, young, bedridden, have diarrhea, have an allergic reaction suddenly, cough, have emesis, or are in an emergency (cardiac) situation have trouble swallowing the traditional oral dose form [1]. Oral quick dissolving films are a unique formulation that was created to address this issue. These are also helpful for local effects, such a topical anesthetic for coughing, cold sores, toothaches, and mouth ulcers. By dissolving in the oral cavity after contact with less

saliva without chewing and without the requirement for water for administration, it increases the effectiveness of APIs in comparison to fast-dissolving tablets [2]. A thin film that is immediately moistened by saliva and quickly dissolves is applied to the patient's tongue or mucosal tissue as part of the delivery mechanism. After that, it dissolves and breaks down quickly, releasing the drug for oral mucosal absorption. After coming into touch with saliva, it improves the effectiveness of API within a minute of being dissolved in the oral cavity without the need for chewing or drinking. The film's enormous surface area, which wets fast in a damp environment, is the main cause of its speedy dissolving activity. To increase bioavailability, fast-dissolving drug delivery systems are specifically made for medications with high first-pass metabolism and low dosages [3].

There are some factors which are taken into consideration Drug Lipophilicity.

- Solubility
- pH and pKa of saliva.
- Drug release from theformulation.

In the late 1970s as an alternative to conventional dosage forms for pediatric and geriatric patients who experience difficulties in swallowing traditional oral solid dosage forms formulate the fast dissolving tablets by using superdisintigrant/s and hydrophilic ingredients which has the higher bioavailability, quick action and most patient compliance [4]. Many FDTs are prepared by using the expensive lyophillisation process and sometimes difficult to carry, store and handle (fragility and friability).also fear of chocking with fast dissolving tablet. To eliminate the drawbacks of fast dissolving tablet a fast dissolving film can be placed. Fast dissolving films are very similar to ultra-thin strip of postage stamp in their shape, size and thickness. Fast dissolving films are formulated using polymers, active pharmaceutical ingredients (API), plasticizers, saliva stimulating agents, sweeteners, flavors, preservatives and colors [5]. Fast dissolving film is simply placed on the patient’s tongue or any oral mucosal tissue, instantly wet by saliva the film rapidly hydrates and adheres onto the site of application. It then rapidly disintegrates and dissolves to release the medication for oromucosal absorption or with formula modifications, will maintain the quick-dissolving aspects allow for gastrointestinal absorption to be achieved when swallowed [6].

Technology Catalysts forecasts the market for drug products in oral thin film formulations to be valued at $500million in 2007 and could reach $2 billion. More importantly, prescriptions of fast dissolving films have been now approved in US, EU and Japan which are the three major regions. These approved Rx films, have potential to dominate over other oral dosage forms of the same drugs. It seems that the value of the overall oral thin film market will grow significantly.

1.1 Special features of Fast Dissolving Films

- Thin elegant film
- Available in various size and shapes

- Unconstructive
- Fast disintegration
- Rapid release Have an acceptable taste.
- Give a pleasing mouth feel.
- Should not leave residue in mouth.

1.2 Advantages of Fast Dissolving Films [7]

- Accessibility of larger surface area that leads to quickly disintegrate and dissolution in the oral cavity within seconds.
- Fast Dissolving Film is flexible so they are not as fragile and need not any kind of special package for protection during transportation and storage as compared to FDT.
- No need of water has led to better satisfactoriness amongst the dysphasic patients.
- No fear of chocking as compared to FDT.
- The large surface area available in the film dosage form allows rapid wet by saliva then quickly disintegrates and dissolve and absorbed directly and can enter the systemic circulation without undergoing first-pass hepatic metabolism and on increase the bioavailability
- The dosage form can be consumed at any place and any time as per convenience of the individual

1.3 Disadvantages of Fast Dissolving Films [8]

- Dose uniformity is a technical challenge
- Hygroscopic in nature
- High doses cannot be incorporated
- Require special packaging for products stability and safety.

Figure 1: Fast Dissolving Film [9]

1.4 Composition of the system

An active component is included in a thin, 2–8 cm2 film known as a fast-dissolving film. A unique matrix made of watersoluble polymers allows for rapid disintegration in water or saliva. Up to 30 mg of medication can be added at a time. According to reports, formulation issues have a significant impact on the films' mechanical characteristics [10]. There is also a thorough discussion of the excipients utilized in the creation of fast-dissolving films. Any class of pharmaceutically active chemicals that may be taken orally or through the buccal mucosa can be considered an active pharmacological substance [11]. such as expectorants, antianginals, antitussives, antiulcers, antiasthmatics, antihistaminics, and antiepileptics. The dosage of the medication should be in milligrams (less than 20 mg/day) for the formulation to be effective. Examples of appropriate drug molecules that can be included in the FDF [12]

Table 1: Composition of Film Active Pharmaceutical agents

Sr. no.	**Category**	**Percentage amount%**
1	Drug (API)	1-30%
2	Polymer	40-50%
3	Plasticizer	0-20%
4	Surfactant	q.s
5	Sweetening agent	3-6%
6	Flavoring agent	0-10%
7	Coloring agent	q.s
8	Stabilizing agent or thickening agent	0-5%

1.5 The ideal characteristics of a drug to be selected [13]

- The drug should have pleasant taste.
- The drug to be incorporated should have low dose less than 30mg.
- The drugs with smaller and moderate molecular weight are preferable.
- The drug has stability and solubility in water as well as in saliva.
- It should be partially unionized at the pH of oral cavity.
- It should have the ability to permeate oral mucosal tissue

1.6 Methods of manufacture of fast dissolving films [14]

One (or a combination) of the following processes may be used to manufacture the oral films:

- Solvent casting
- Hot-melt extrusion
- Semisolid casting • Solid dispersion extrusion
- Rolling.

1.6.1 Solvent Casting

The solvent casting method, which involves dissolving water-soluble ingredients to create a clear, viscous solution and dissolving the drug and other excipients in an appropriate solvent, is the preferred method for creating fast-dissolving buccal films. The two solutions are then combined, swirled, and finally cast onto a Petri plate to be dried [15].

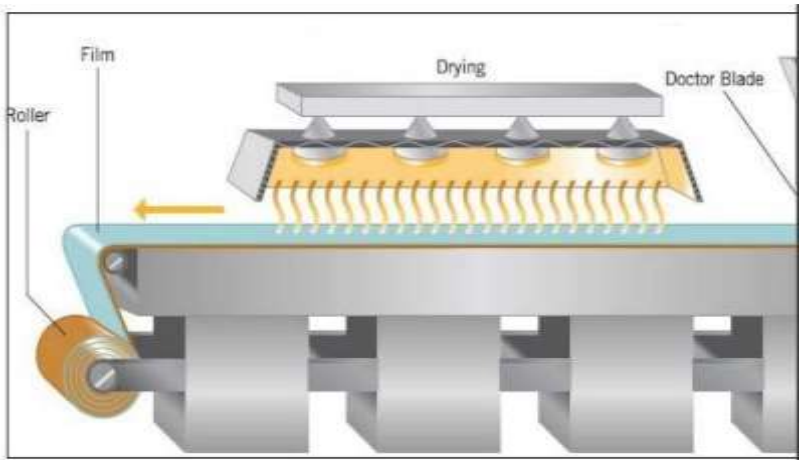

Figure 2: Solvent Casting [16]

1.6.2 Hotmelt extrusion

Granules, prolonged release tablets, and transdermal and transmucosal medication delivery devices are frequently made using hot metal extrusion. In the pharmaceutical sector, melt extrusion was first employed as a production technique in 1971.

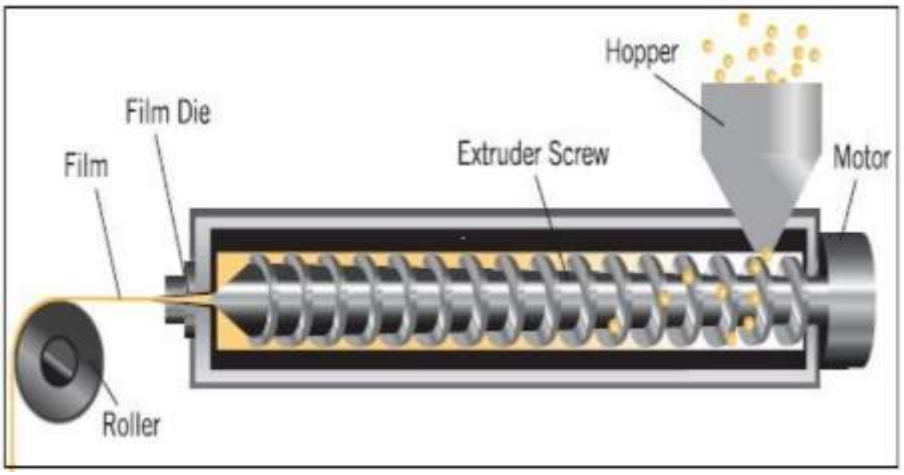

Figure 3: Hot melt extrusion [16]

Semisolid casting 17 Solution of water-soluble film forming polymer is prepared. A solution of an acid-insoluble polymer (such as cellulose acetate butyrate or phthalate) is mixed with the resultant solution. To achieve gel mass, the right amount of plasticizer is applied [17]. Finally, heat-controlled drums are used to cast the gel mass into the films or ribbons. The ideal film thickness is between 0.015 and 0.05 inches. The acid-insoluble polymer to film-forming polymer ratio need to be 1:4. Extrusion of solid dispersion The dispersion of one or more active substances in an inert carrier in a solid state while amorphous hydrophilic polymers are present is referred to as a solid dispersion [18]. A appropriate liquid solvent is used to dissolve the drug. Then solution is incorporated into the melt of polyethylene glycol, obtainable below 70◦C Finally the solid dispersions are shaped into the films by means of dies [19].

1.6.3 Rolling method

This process creates the film by first preparing a pre-mix, then adding an active, and finally forming a film. Make a pre-mix containing polar solvent, film-forming polymer, and additional ingredients (apart from medication) [20]. Fill the master batch feed tank with the premix. It is supplied to one or both of the first and second mixers by a first metering pump and control valve. Fill the desired mixer with the necessary amount of medication [21]. To create a consistent matrix, blend the medication with the master batch premix. The second metering pumps are then used to feed the pan a predetermined amount of uniform matrix. Ultimately, the film forms on the substrate and is removed by means of the support roller. The wet film is then dried using controlled bottom drying [22].

1.7 Characterization of fast dissolving films [23]

1.7.1 Drug-excipients interaction studies

When creating a solid dosage form, evaluating potential incompatibilities between an active ingredient and various excipients is a crucial step in the formulation process [24]. To evaluate potential drug-excipient interactions, techniques such as Fourier Transformer Infrared

Spectrum (FTIR), Differential Scalorimeter (DSC), thin-layer chromatography, and X-ray diffraction (X-RD) can be employed [25]. Because DSC displays changes in appearance, shifts in melting endotherms and exotherms, and variations in the associated enthalipies of the reaction, it enables the quick assessment of potential incompatibilities [26-30].

1.7.2 Thickness

You may use an electronic micrometer to do a thickness test. Five places (the center and four corners) should be used to measure the film sample's thickness before calculating the mean thickness. Samples that have a mean thickness variation of more than 5% and air bubbles, nicks, or rips are not included in the study [31-33].

1.7.3 Folding endurance

A strip of film is cut, then folded repeatedly at the same spot until it breaks to test folding durability [32]. The value of folding endurance is determined by how many times the film could be folded in the same spot without breaking [33].

1.7.4 Disintegration test

The time (second) at which a film dissolves when it comes into contact with water or saliva is known as the disintegrating time. The moment a film begins to shatter or dissolve is known as the disintegration time [34-36]. The physical characteristics of dissolvable films are influenced by mass and thickness. Disintegration equipment is used to perform disintegration tests. Test of dissolution [37]: The quantity of drug material that dissolves in a solution per unit of time under controlled circumstances of temperature, solvent content, and liquid/solid interface is known as dissolution. Modified USP XXIII equipment (paddle over disk) is used for in vitro release experiments [38].

1.7.5 Stability study

In accordance with ICH requirements, a stability study of rapid dissolving films is conducted for every batch. The drug concentration, disintegration time, and physical look of the films are assessed at pre-established intervals [39-41].

1.7.6 Swelling property

Each film sample is weighed and placed in a stainless-steel wire mesh that has been pre weighed. The mesh with the film sample is then immersed in 15ml medium (simulated saliva solution) in a plastic container. The weight of the film was increased at predetermined time intervals until a constant weight was observed. Swelling degree = (Wt. - W0 /W0)

1.7.7 Tensile strength

Tensile strength is the maximum stress that can be applied to a film specimen before it breaks. This test is used to determine the mechanical strength of the films. It can be calculated by dividing the applied load at cleavage by the film cross-sectional area, as shown in the equation below:
Tensile strength = (load at failure / strip thickness / strip width)
10.8 Percent elongation: When stress is applied to a film sample, it stretches, which is known as strain. Strain is defined as the deformation of a film divided by its original dimension.
Percentage elongation=length increase 100/original length.

1.8 Application of fast dissolving film

Oral mucosal delivery via Buccal, sublingual, and mucosal route by use of FDFs could become a preferential delivery method for therapies in which rapid absorption is desired, including those used to manage pain, allergies, sleep difficulties, and central nervous system disorders [42]. Dissolvable FDFs evolved over the past few years from the confection and oral care markets in the form of breath strips and became a novel and widely accepted form by consumers for delivering vitamins and personal care products [43-46].

1.8.1 Topical applications

The use of dissolvable films may be feasible in the delivery of active agents such as analgesics or antimicrobial ingredients for wound care and other applications [47].

1.8.2 Gastro retentive dosage systems

Dissolvable films are being considered in dosage forms for which water-soluble and poorly soluble molecules of various molecular weights are contained in a film format [48]. Dissolution of the films could be triggered by the pH or enzyme secretions of the gastrointestinal tract, and could potentially be used to treat gastrointestinal disorders [49].

1.8.3 Diagnostic devices

Dissolvable films may be loaded with sensitive reagents to allow controlled release when exposed to a biological fluid or to create isolation barriers for separating multiple reagents to enable a timed reaction within a diagnostic device [50-54]

1.9 Classification of fast dissolving technology

For case description, fast dissolving technologies can be divided into three broad group.

I. Lyophilized system

The technology behind these systems entails forming tablet-shaped units from a drug suspension or solution with other structural excipients using a mould or blister pack [55]. In the pack or mould, the units or tablets are frozen and lyophilized. The resulting units are extremely porous, allowing for rapid water or saliva penetration and disintegration.

II. Compressed tablet- based system

This system is made using standard tablet technology and excipients that are compressed directly. Tablet technologies vary in hardness and friability depending on the manufacturing method. When compared to a standard tablet, the speed of disintegration for fast dissolve tablets is achieved by formulating with either water soluble excipients super disintegrant or effervescent components, allowing rapid penetration of water into the core of the tablet.

III. Thin film strips

Oral films, also known as oral wafers, evolved from the confection and oral care markets in the form of breath strips over the last few years and became a novel and widely accepted form by consumers for delivering vitamins and personal care products. FDFs are now a proven and accepted technology for the systemic delivery of APIs in over-the-counter (OTC) medications, and they are in the early to mid-development stages for prescription drugs. This has been attributed to the consumer success of breath freshener products like Listerine Pocket Paks in the US consumer market. To create a 50-200 mm film, such systems employ a variety of hydrophilic polymers. The film is made in large sheets and then cut into individual dosages units for packaging in a pharmaceutically acceptable format [56].

1.10 Storage and packaging

Drug manufacturers benefit from product flexibility during the converting and packaging stages. As needed for the application, the rolled film can be die-cut into any shape or size, or slit into narrower rolls. Converters may choose to print information directly onto the film unit doses before packaging for branding purposes and to comply with industry regulations. Among the criteria that may be considered are the unit-dose packaging, barcode labelling, and content in instructions for use, child-resistant seals, and senior-friendly packaging are all required [57].

2. Conclusion

This review focused on nanosuspension preparation techniques, highlighting the importance of selecting suitable methods such as media milling and high-pressure homogenization for largescale production. Recent advances, like using emulsions or microemulsions as templates,

offer simpler alternatives with some limitations. Fast-dissolving films (FDF) have gained popularity due to their ability to bypass hepatic metabolism, improve therapeutic response, and combine the stability of solid forms with liquid applicability. FDFs are patient-friendly, cost-effective, and preferred by the pharmaceutical industry, making them a promising tool for extending the patent life of existing products.

3. References

1. Mahajan, A., N. Chhabra, G. Agarwal. Formulation and Characterization of Fast Dissolving Buccal film: A Review, Der Pharmacia Sinica, 2011; 3(1); 152-165.
2. Suresh B., D. Halloran, L. James., Quick Dissolving Films: A Novel Approach to Drug Delivery, Drug Development Technology, 2006; 1- 7.
3. Priyanka, Kapil Kumar, Deepak Teotia, A Comprehensive Review on Pharmaceutical Oral Dissolving Films, Journal of Drug Delivery & Therapeutics, 2019; 9(5-s);170-174
4. Mahajan, A., N. Chhabra, G. Agarwal. Formulation and Characterization of Fast Dissolving Buccal film: A Review, Der Pharmacia Sinica, 2011; 3(1); 152-165.
5. Suresh B., D. Halloran, L. James., Quick Dissolving Films: A Novel Approach to Drug Delivery, Drug Development Technology, 2006; 1- 7.
6. Priyanka, Kapil Kumar, Deepak Teotia, A Comprehensive Review on Pharmaceutical Oral Dissolving Films, Journal of Drug Delivery & Therapeutics, 2019; 9(5-s);170-174
7. M.D. Nehal Siddiqui, Garima Garg, Pramod Kumar Sharma, A Novel Approach in Oral Fast Dissolving Drug
8. Delivery System and Their Patents, Advances in Biological Research, 2011; 291-303.
9. Juluru NS. Fast dissolving oral films: A review. Int. J. Adv. Pharm. Biol. Chem. 2013 Jan;2(1):108-12.
10. Supriya Shidhaye, Sheetal Malke, V.J. Kadam, Formulation and evaluation of Oxacarbazine fast dissolve tablets, Indian J. Pharma Sci., 2007; 211-214.
11. Galey W R, Lonsdale H K, Nacht S, The in vitro permeability of skin and buccal mucosa to selected drugs and tritiated water, J. Investigative Dermatol,1976; 713-717
12. Dixit R.P., Puthli S.P., Oral strip technology Overview and future potential, Journal of Controlled Release, 2009; 94-107.
13. Vollmer, U., P. Galfetti, Rapid Film: Oral Thin Films as an Innovative Drug Delivery System and Dosage Form, Drug Development Report, 2006; 1-5.
14. ipikaParmar,Dr. Upendra Patel, Orally Fast Dissolving Film As Dominant Dosage For Quick Releases, International Journel Pf Pharmaceutical Research And Bio Science,2012;1(3):24-41.
15. hang H, Zhang J and Streisand JB, Oral Mucosal Drug Delivery: Clinical Pharmacokinetics And Therapeutic Applications. Clinical Pharmacokinetics,2002; 41: 661-680
16. Ghodake PP, Karande KM, Osmani RA, Bhosale RR, Harkare BR, Kale BB. Mouth dissolving films: Innovative vehicle for oral drug delivery. polymer. 2013;9:20.

17. Nash R.A. Suspensions. In: Swarbrick J, Boylan J.C (Ed). Encyclopedia of pharmaceutical technology. Second edition vol. 3. New York, Marcel Dekker, 2002, p. 2045-3032.
18. Young TJ, Mawson S, Johnston KP, Henriska IB, Pace GW, Mishra AK. Rapid expansion from supercritical to aqueous solution to produce submicron suspension of water insoluble drugs. Biotechnology Progress. 2000; 16:402–7.
19. Biradar SS. Bhagvati ST, kuppasad IJ. Fast dissolving drug delivery systems; a brief review. Internet J Pharmcol. 2006; 4(2) available online on Error! Hyperlink reference not valid.
20. J.D. Smart, Buccal drug delivery, Expert Opin. Drug Deliv. 2 (2005) 507–517. 3) Lindgren S, Janzon L. Prevalence of swallowing complaints and clinical findings among 50-79 year old men and women in an urban population. Dysphagia. 1991; 6: 187-192.
21. Mishra R, Amin A. Quick API delivery. Pharmaceutical Technology Europe. 2007. Online available from http://www.ptemag.com/pharmtecheurope/Dosage +forms/QuickAPIdelivery/ArticleStandard/article/detail/464314? context CategoryId = 39142
22. Ivory AA, Rossman JM, Lee KM. Rapidly dissolving edible film compositions with cellulose film forming polymers. United states patent application publication. 2004:1-9.
23. ipikaParmar,Dr. Upendra Patel, Orally Fast Dissolving Film As Dominant Dosage For Quick Releases, International Journel Pf Pharmaceutical Research And Bio Science,2012;1(3):24-41.
24. Hang H, Zhang J and Streisand JB, Oral Mucosal Drug Delivery: Clinical Pharmacokinetics and Therapeutic Applications. Clinical Pharmacokinetics,2002; 41: 661-680
25. R.P. Dixit, S.P. Puthli: Oral Strip Technology:Overview and Future Potential. J Cont. Rele.2009;139: 94-107.
26. Bhupinder Bhyan , Sarita Jangra, Mandeep Kaur, Harmanpreet Singh: Orally Fast Dissolving Films: Innovations in Formulation and Technology. Int. J Pharm. Sci. Rev. & Res. 2011; 9:2-009.
27. Basani Gavaskar, Subash Vijaya Kumar, Guru Sharan, Y.Madhusudan Rao. Overview on Fast Dissolving Films. Int J Pharmacy and Pharm Sci; 2, 3:0975-1491.
28. Ravneet kaur,Rajni bala,Dhruv malik, a novel approach in fast dissolving drug delivery system,2012;2(1):89-104
29. Arya A and Chandra A: Fast Dissolving Oral Films: An Innovative Drug Delivery System and Dosage Form. International Journal of Chem Tech Research 2010; 2:576-583.
30. Cilruzo F and Cupone EI: Fast dissolving films made of maltodextrins. European Journal of Pharmaceutics and Biopharmaceutics 2008; 70: 895-900 17.Gohel M and Patel M: Formulation design and optimization of mouth dissolving tablet of Nimusulide using vacuum drying technique. AAPS PharmSciTech 2004; 5:45- 49.
31. Rathi V, Senthil V, Kammili L and Hans R: A brief review on oral film technology. International Journal of Research in Ayurveda and Pharmacy 2011; 2(4): 1138-1147.

32. Bhyan B, Jangra S, Kaur M and Singh H: Orally fast dissolving films: innovations in formulation and technology. International Journal of Pharmaceutical Sciences Review and Research 2011; 9(2): 50-57.
33. Gavaskar B, Vijayakumar S, Sharma G and Rao YM: Overview on fast dissolving films. International Journal of Pharmacy and Pharmaceutical Sciences 2010; 2(3): 2933
34. Arya A, Chandra A, Sharma V and Pathak K: Fast dissolving oral films: an innovative drug delivery system and dosage form. International Journal of Chem Tech Research 2010; 2(1): 576-583.
35. Vishwakarma DK, Tripathi AK, Yogesh P and Maddheshiya B: Review article on mouth dissolving film. Journal of Global Pharma Technology 2011; 3(1): 1-8.
36. Fulzele SV, Sattuwar PM, Dorle AK. Polymerized rosin: novel film forming polymer for drug delivery. Int J Pharma. 2002; 249: 175 -184
37. Ketul P, Patel K, Patel M, Patel N. Fast dissolving films: A Novel approach to oral drug dilivery. safety. 2013;4:6.
38. Adachi, Y., Arii, S., Funaki, N., Higashitsuji, H., Fijita, S.,Furutani, M., Mise, M., Zhang, W., Tobe, T. (1992)Tumoricidal activity of Kupffer cells augmented by anticancerdrugs. Life Sci. 51: 177–183Akers, M. J. (2002) Excipient–drug interactions in parenteralformulations. J. Pharm. Sci. 91: 2283–2300
39. Allen, T. M. (1997) Liposomes: opportunities in drug delivery.Drugs 54: 8–14Aungst, B. J. (1993) Novel formulation strategies for improvingoral bioavailability of drugs with poor membrane permeationor presystemic metabolism. J. Pharm. Sci. 82: 979– 986
40. Aungst, B. (2000) Intestinal permeation enhancers. J. Pharm.Sci. 89: 429–442Aungst, B. J., Nguyen, N., Rogers, N. J., Rowe, S., Hussain, M.,Shum, L., White, S. (1994) Improved oral bioavailability of anHIV protease inhibitor using Gelucire 44/14 and Labrasolvehicles. B.T. Gattefosse 87: 49–54
41. Benet, L. Z., Izumi, T., Zhang, Y., Silverman, J. A., Wacher, V. J.(1999) Intestinal MDR transport proteins and P-450 enzymes asbarriers to oral drug delivery. J. Control. Release 62: 25–31
42. Blunk, T., Hochstrasser, D. F., Sanchez, J. C., Mu¨ller, B. W.(1993) Colloidal carriers for intravenous drug targeting:Plasma protein adsorption patterns on surface-modified latexparticles evaluated by two-dimensional polyacrylamide gelelectrophoresis. Electrophoresis 14: 1382–1387
43. Blunk, T., Hochstrasser, D. F., Lu¨ ck, M. A., Calvo¨ r, A., Mu¨ller,B. W., Mu¨ller, R. H. (1996) Kinetics of plasma protein adsorp-tion on model particles for controlled drug delivery and drugtargeting. Eur. J. Pharm. Biopharm. 42: 262–268
44. Bodmeier, R., McGinity, J. M. (1998) Solvent selection in thepreparation of poly (DLlactide) microspheres prepared bysolvent evaporation method. Int. J. Pharm. 43: 179– 186Breitenbach, J. (2002) Melt extrusion: from process to drugdelivery technology. Eur. J. Pharm. Biopharm. 54: 107–117
45. Buchmann, S., Fischli, W., Thiel, F. P., Alex, R. (1996) Aqueoussuspension, an alternative intravenous formulation for animalstudies. Eur. J. Pharm. Biopharm. 42: S10Bucolo, C., Maltese, A., Puglisi, G., Pignatello, R. (2002) Enhanced ocular antiinflammatory activity of ibuprofen car-ried by an Eudragit RS 1001 nanoparticle suspension.Ophthalmic Res. 34: 319–323

46. Chowdhary, K. P., Reddy, G. K., Rao, S. (2003) A novelapproach for controlled release of nifedipine through cyclo-dextrin complexation. Proceedings of the InternationalSymposium on Innovations in Pharmaceutical Sciences andTechnology Vol. 5, Controlled Release Society – IndianChapter, pp 133 (abstr. 55)
47. Constantinides, P. P., Scarlart, J. P., Smith, P. L. (1994) Formulation and intestinal absorption enhancement evalua-tion of water in oil microemulsions incorporating medium-chain triglycerides. Pharm. Res. 11: 1385–1390
48. Constantinides, P. P., Lancaster, C., Marcello, J., Chiossone, D.,Orner, D., Hidalgo, I., Smith, P. L., Sarkahian, A. B., Yiv, S. H.,Owen, A. J. (1995) Enhanced intestinal absorption of a RGDpeptide from w/o microemulsion of different composition andparticle size. J. Control. Release 34: 109–116
49. Dressman, J. B., Amidon, G. L., Reppas, C., Shah, V. P. (1998) Dissolution testing as a prognostic tool for oral drug adsorp-tion: immediate release dosage forms. Pharm. Res. 15: 11–22
50. Dupont, B. (2002) Overview of the lipid formulations of ampho-tericin B. J. Antimicrob. Chemother. S1: 31–36Eccleston, G. M. (1992) Microemulsions. In: Swarbrick, S.,Boylan, J. C. (eds) Encyclopedia of pharmaceutical tech-nology. Vol. 9, Marcel Dekker, New York, pp 375–421
51. Floyd, A. G. (1999) Top ten considerations in the developmentof parenteral emulsions. Pharm. Sci. Technol. 4: 134–143
52. Gregoriades, G. (1995) Engineering liposomes for drug delivery:progress and problems. TIBTECH 13: 527–537
53. Horter, D., Dressman, J. B. (2001) Influence of physicochemicalproperties on dissolution of drugs in the gastrointestinal tract.Adv. Drug Deliv. Rev. 46: 75–87
54. Illum, L., Davis, S. S., Wilson, C. G., Thomas, N. W., Frier, M.,Hardy, J. G. (1982) Blood clearance and organ disposition ofintravenously administered colloidal particles. Effect of parti-cle size, nature, and shape. Int. J. Pharm. 2: 135–136
55. Heer D, Aggarwal G, Kumar SLH. Pharmacophore. 2013;4(1):1–9.
56. Mandeep K, Rana AC, Nimrata S. Fast Dissolving Films : An Innovative Drug Delivery System. 2013;2(1):14–24.
57. Pradesh A. FORMULATION AND EVALUATION OF TRAMADOL HYDROCHLORIDE ORAL THIN FILMS. 2018;9(4):1692–8.