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# Formulation and Evaluation of Osmotic Tablet of Lovastatin

Mayuri Ashok Khobare[1], Dr. Pranav Parekh[2]
*Pharmaceutics, Dr. Babasaheb Ambedkar Technological University*

***Abstract:*** ***Lovastatin is one of the antihypertensive drug used to control the high blood pressure. Osmotically Controlled release tablet of Lovastatin was performed for reducing dosing frequency and patient compliance. Elementary osmotic tablets of Lovastatin were developed using Sodium chloride as a key ingredient which gives osmogent property which provides driving force inside the core tablet and which leads to release of drug. Microcrystalline cellulose used as a release retardant material in the present work. These formulations were evaluated for, Hardness, Flow property, Thickness, Friability, Drug content and In-vitro drug release. Tablets were coated with a semipermeable membrane using 5% w/v cellulose acetate(CA) in acetone and PEG 400(1%) used as Plasticizer. Coated Elementary osmotic tablets were drilled for delivery orifice using standard micro drill of diameter size 0.8mm. Drug release rate was increased as the increase in the concentration of sodium chloride and release rate decreased on increasing the concentration of MCC. Drug release rate was directly proportional to delivery orifice size. SEM Study carried out for detection of diameter size of delivery orifice. The FTIR studies demonstrate that there was no interaction between polymer and drug. The optimized formulation was stable for 3 months of accelerated stability study.***
***Keywords: Lovastatin Hydrochloride, Controlled release, Elementary osmotic Tablet, Semipermeable membrane, Cellulose Acetate.***

## I. INTRODUCTION

Oral drug delivery is the most accepted and used route of administration when compared to all the other routes that have been known for the delivery of drugs[1]. Conventional oral drug delivery systems release the drug immediately, in which its release of the drug cannot be controlled and cannot maintain effective concentration at the site of action or target for longer time[2]. These make the way forward for the development of other modified release drug delivery system. Most modified release delivery system classified into the followin categories:

- Delayed-release
- Extended-release
- Site-specific targeting
- Receptor targeting

All modified-release products improve the drug therapy over that achieved with their conventional counterparts.
There are several potential advantages of modified release systems over conventional dosage forms such as

- ✓ Increase patient compliance
- ✓ Employ less total drug

| Sr. No. | Name of Chemical | Name of Supplier |
|---|---|---|
| | Lovastatin | Gift Sample from Vama Pharma (Nagpur) |
| | Aerosil | Shree Sadguru Hightech Pvt Ltd, Pune |
| | NaCl | Shree Sadguru Hightech Pvt Ltd, Pune |
| | Lactose | Shree Sadguru Hightech Pvt Ltd, Pune |
| | PVP K 30 | Shree Sadguru Hightech Pvt Ltd, Pune |
| | Polyethylene oxide | Shree Sadguru Hightech Pvt Ltd, Pune |
| | Magnesium Stearate | Shree Sadguru Hightech Pvt Ltd, Pune |
| | Ethanol | Shree Sadguru Hightech Pvt Ltd, Pune |

Elementary method

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The osmotic core tablets of Lovastatin were prepared by Wet granulation method. Required amount of Lovastatin, Aerosil, Sodium Chloride, Lactose and Polyethylene oxide were weighed accurately. It was blended in blender and then passed through sieve #85. IPA was used as granulating agent. It was added slowly during the granulation process to get proper granules. PVP K-30 was used as a binder. The granules were dried in Tray drier at 50ºC
for 20-25 minutes. Then they were passed through sieve #30 to get uniform sized granules and blended with magnesium stearate and talc as a lubricant and glidant respectively. Then desired amount of granules compressed into tablets having an average weight of 200 mg using a multistation tablet-punching machine fitted with 7.2 mm standard convex punches.
The tablets were coated by conventional pan coating method. Cellulose acetate was selected as semi permeable, pH independent polymer. Coating solution was prepared by dissolving cellulose acetate in a solution of Ethanol: Acetone (50:50). PEG 400 was added as a plasticizer. The coating was carried out by a conventional pan coater. The operating condition was maintained as follows: pan size 6 inch, pan speed 30-35 rpm, spray rate 8-10 ml/min, air temperature 20–25°C, and atomization air pressure 1-1.5 bar. The coated tablets were dried at 35–40°Cfor 4 hours. The formulated coated tablets, a small orifice were drilled through one side of each coated tablet by standard mechanical drilling technique using 0.8 mm needle to obtain uniform orifice.

Table 6.3: Formula of Lovastatin Osmotically Controlled Release Tablet

| Ingredient (mg) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Lovastatin | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Aerosil | 80 | 80 | 80 | 100 | 100 | 100 | 120 | 120 | 120 |
| NaCl | 5 | 10 | 15 | 5 | 10 | 15 | 5 | 10 | 15 |
| Lactose | 60 | 55 | 50 | 40 | 35 | 30 | 20 | 15 | 10 |
| PVP K 30 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Polyethylene oxide | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Magnesium Stearate | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Talc | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Total Weight | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |

## II. COATING SOLUTION

Table 6.4: Formula of Coating Solution

| Sr. No. | Ingredient | Quantity |
|---|---|---|
| 1 | Cellulose acetate | 35 mg |
| 2 | PEG 400 | 15 mg |
| 3 | Ethanol : Acetone | 50:50 |

### *A. Micromeritic Studies of Lovastatin Tablets*

Different Parameters like Angle of repose, Density (Tapped and Bulk), flow property, Carr's compressibility Index, Hausner's ratio, Percentage yield (i.e., recovery) of Lovastatin Tablets formed were studied.

### *B. Post Compression Evaluation of Lovastatin Tablets*

Pre-compressional parameters of the prepared tablets (bulk density, tapped density, carr's index, and angle of repose) were in the range of given in official standard, indicates that the physical mixture were found to be free flowing. The post-compressional parameters of the tablets were found to be within the limits. The optimized formulation was selected for SEM and FTIR studies did not show any interaction between the drug, polymer and excipients.

*C. In-Vitro Dissolution Studies*

*In Vitro* dissolution study of formulation containing Lovastatin with different concentration of the osmogent and the polymer concentration was discussed. F6 was found to be satisfactory, where the release of the drug was found to be 96±2.08 % at24 hrs.

*D. Stability Studies*

Stability studies on selected formulations were carried out for 3 months as per ICH guidelines, ICHQ1AR: "Stability testing of new drug substances and products", 40±2°C / 75±5% RH Testing frequency: Samples were evaluated at the intervals of 0, 1, 2 and 3 months. Stability studies of the optimized formulation revealed that the selected parameters of drug content and drug release showed insignificant difference in the variation. The results revealed that the prepared formulation is stable. Hence, we can formulate the drug in different dosage forms by using these excipients in proper ratios. The selected method, i.e., Elementary method was highly suitable for formulating Lovastatin osmotic release tablet.

## III.RESULT AND DISCUSSION

*A. Drug and Polymer Compatibility Study by FT-IR*

In FTIR spectra the peaks of physical mixture was compared with the original spectra. Same peaks were observed, there is no possible molecular interaction between the drug and the polymer.

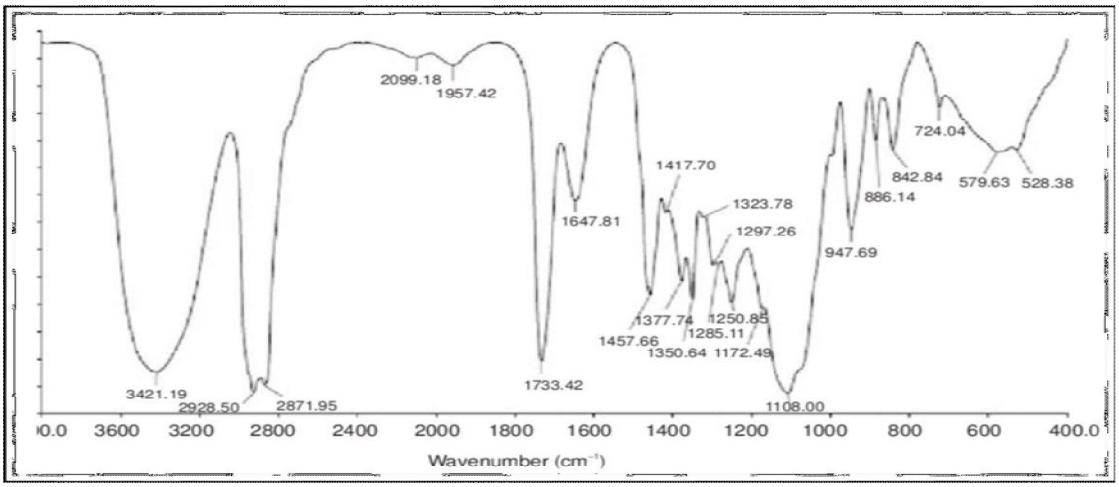



Figure No.7.3: FTIR Spectra of Lovastatin

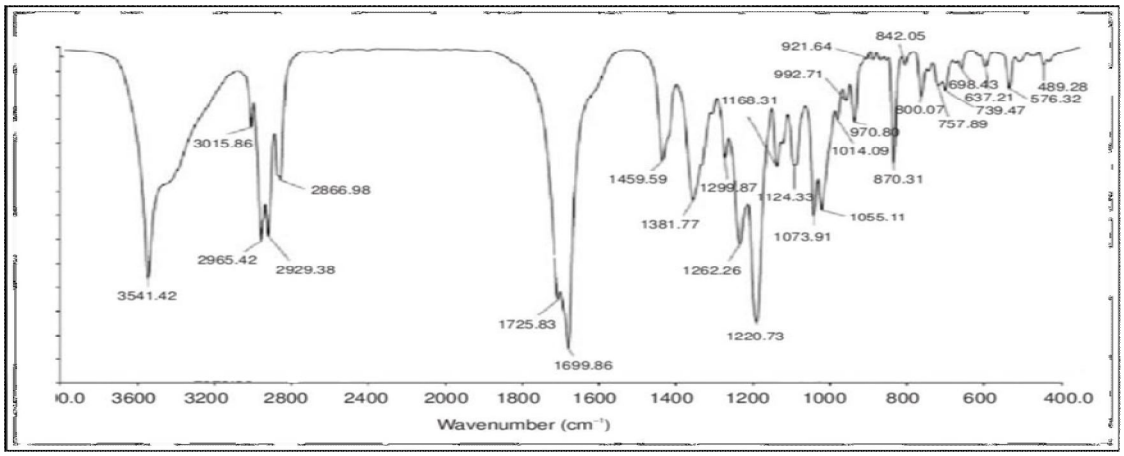



Figure No.7.4: FTIR Spectra of Lovastatin with excipients

Pure drug of Lovastatin complies with the reference sample and the combination of API with different excipients show no deviation from pure drug. Hence there was no compatibility problem between API and excipients.

*B. Evaluation of Granules*

The granules of different formulations were evaluated for angle of repose, bulk density, tapped density, compressibility index, Hausner's ratio.

Evaluation data of granules

| Formulation | Angle of Repose | Bulk Density (g/ml) | Tapped density (g/ml) | Compressibility Index (%) | Hausner's ratio |
|---|---|---|---|---|---|
| F1 | 25.71±0.14 | 0.414±0.86 | 0.487±0.58 | 16.05±0.11 | 1.18±0.18 |
| F2 | 24.78±0.17 | 0.425±0.31 | 0.478±0.96 | 12.50±0.46 | 1.14±0.36 |
| F3 | 26.57±0.16 | 0.426±0.07 | 0.502±0.19 | 16.40±0.39 | 1.19±0.20 |
| F4 | 27.48±0.19 | 0.408±0.74 | 0.479±0.26 | 15.85±0.35 | 1.18±0.47 |
| F5 | 24.31±0.29 | 0.409±0.74 | 0.477±0.26 | 13.85±0.35 | 1.18±0.47 |
| F6 | 26.57±0.27 | 0.419±0.21 | 0.517±0.62 | 10.02±0.91 | 1.24±0.50 |
| F7 | 26.48±0.14 | 0.428±0.57 | 0.525±0.80 | 18.16±0.44 | 1.23±0.16 |
| F8 | 23.97±0.89 | 0.404±0.43 | 0.509±0.69 | 19.42±0.10 | 1.27±0.09 |
| F9 | 25.77±0.93 | 0.399±0.36 | 0.464±0.78 | 15.43±0.96 | 1.17±0.87 |

## IV. DISCUSSION

The results of angle of repose and compressibility index (%) ranged from 23.97 ± 0.89 to 27.48 ± 0.19, and 10.02 ± 0.91 to 19.42 ± 0.10, respectively. The results of Bulk Density and Tapped Density ranged from 0.399 ± 0.36 to 0.428 ± 0.57 and 0.464± 0.78 to 0.525 ± 0.80, respectively. Hausner's found that this ratio was related to interparticle friction and, as such, could be used to predict powder flow properties. Generally a value less than 1.25 indicates good flow properties, which is equivalent to 20% of Carr's index.

The results of angle of repose (<30) indicate good flow properties of the granules. Generally, compressibility index values up to 15 % result in good to excellent flow properties. Bulk densities of granules prepared by using water alone as a granulating agent (F-1 to F-9) were found to be quite higher than those of other granules. This may be due to the presence of more fines in the granules, as water alone could not provide sufficient binding to the granules. In addition, granule density may influence compressibility, tablet porosity, dissolution and other properties. All these results indicate that the granules possessed satisfactory flow properties, compressibility.

*A. Evaluation of Uncoated Tablet of Lovastatin*

| Formulat ion code | Average weight (mg) | Thickness (mm) | Friability (%) | Hardness (kg/cm$^2$) | Uniformity of Content (%) | Porosity (%) |
|---|---|---|---|---|---|---|
| F1 | 200±3.19 | 2.00±0.06 | 0.34 | 3.8±0.08 | 95.40 ±1.18 | 13.34 |
| F2 | 200±3.21 | 2.01±0.12 | 0.3 | 3.6±0.11 | 94.50 ±1.29 | 12.65 |
| F3 | 200±3.37 | 2.01±0.15 | 0.47 | 3.2±0.20 | 97.90 ±1.04 | 16.32 |
| F4 | 200±2.27 | 2.03±0.06 | 0.32 | 3.6±0.29 | 94.90 ±1.10 | 14.55 |
| F5 | 200±2.57 | 2.01±0.1 | 0.33 | 3.3±0.15 | 93.80 ±1.47 | 17.57 |
| F6 | 200±3.06 | 2.01±0.06 | 0.32 | 3.5±0.26 | 98.00±1.28 | 18.40 |
| F7 | 200±2.75 | 2.02±0.12 | 0.58 | 3.4±0.16 | 95.20±1.58 | 15.23 |
| F8 | 200±2.75 | 2.02±0.08 | 0.8 | 3.5±0.16 | 93.8 ±1.49 | 13.24 |
| F9 | 200±2.76 | 2.02±0.08 | 0.95 | 3.3±0.27 | 95.7 ±1.16 | 14.87 |

All the formulations pass weight variation test as per IP. The range of weight variation is 200±2.27 mg to 200±3.21mg. All the osmotic tablet system had acceptable friability as none of the tested formulae had percentage loss in tablets weight exceed 1%. Friability below 1% is an indication of the good mechanical resistance of the tablets. Friability of all formulations ranges from 0.3 % to 0.95 %. This ensures that tablets could withstand to the pressure, shocks during handling, transportation and shifting processes.

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*B. Evaluation of Osmotic Tablets of Lovastatin*

After coating osmotic tablets were evaluated for Thickness of tablet, Thickness of film, weight uniformity, and dissolution test of prepared formulations.

Table No.7.8 : Post coating evaluation parameters of Lovastatin osmotic tablet

| Formulation Code | Average Weight (mg) (n=20) | Thickness of coated tablet (mm) (n=10) | ess of Film (mm) |
|---|---|---|---|
| F1 | 250.8 ± 0.4163 | 2.52 ± 0.17 | 0.2286 ± 0.004 |
| F2 | 250.4 ± 0.4988 | 2.51 ± 0.15 | 0.2953±0.005 |
| F3 | 250.5 ± 0.6046 | 2.53 ± 0.19 | 0.2468 ± 0.007 |
| F4 | 250.1 ± 0.5467 | 2.55 ± 0.13 | 0.1976 ± 0.006 |
| F5 | 250.9 ± 0.6904 | 2.52 ± 0.24 | 0.2104 ± 0.004 |
| F6 | 250.1 ± 0.500 | 2.56 ± 0.08 | 0.1860 ± 0.004 |
| F7 | 250.2 ± 0.4163 | 2.53 ± 0.26 | 0.2495 ± 0.006 |
| F8 | 250.6 ± 0.4760 | 2.54 ± 0.22 | 0.2428 ± 0.008 |
| F9 | 250.4 ± 0.6531 | 2.53 ± 0.16 | 0.2485 ± 0.004 |

All the formulations passes weight variation test. The range of weight variation is 250.1 ± 0.500 to 250.9 ± 0.6904. This ensures that tablets could withstand to the pressure, shocks during handling, transportationand shifting processes.

*C. In vitro drug release study of Lovastatin*

In vitro release rate was tested using (USP-II) paddle type dissolution apparatus, using 900 ml of pH 7.5 phosphate buffers as dissolution medium at temperature 37 ±2ºC. Samples were withdrawn at time intervals of 1, 2, 4, 8 and 16 hours and up to 24 hrs analyzed spectrophotometrically. For the final optimized formulation, the pre- compression parameter density and particle size distribution mentioned in pre- formulation studies were carried out.

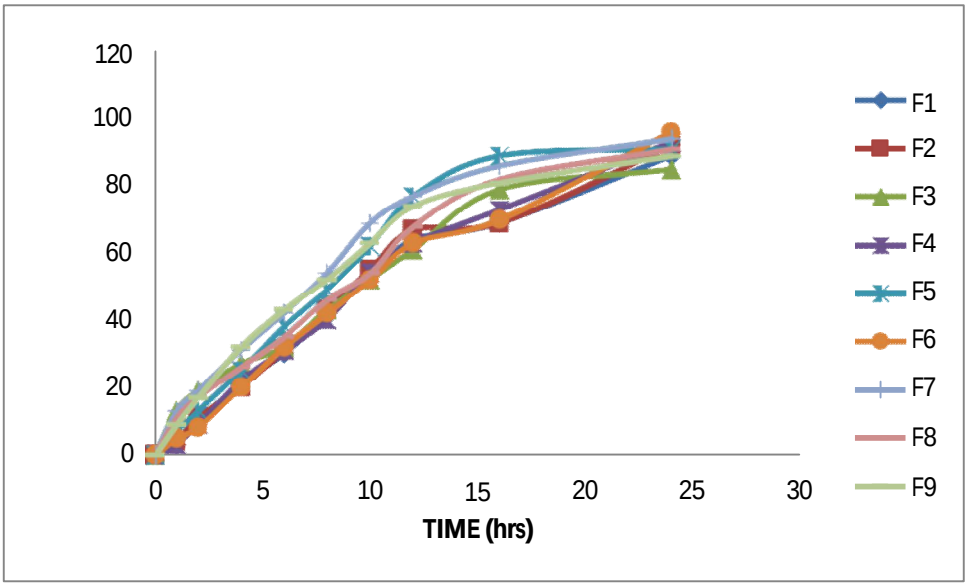



Figure No. 7.6: In vitro release profile of Lovastatin Osmotic release tablet

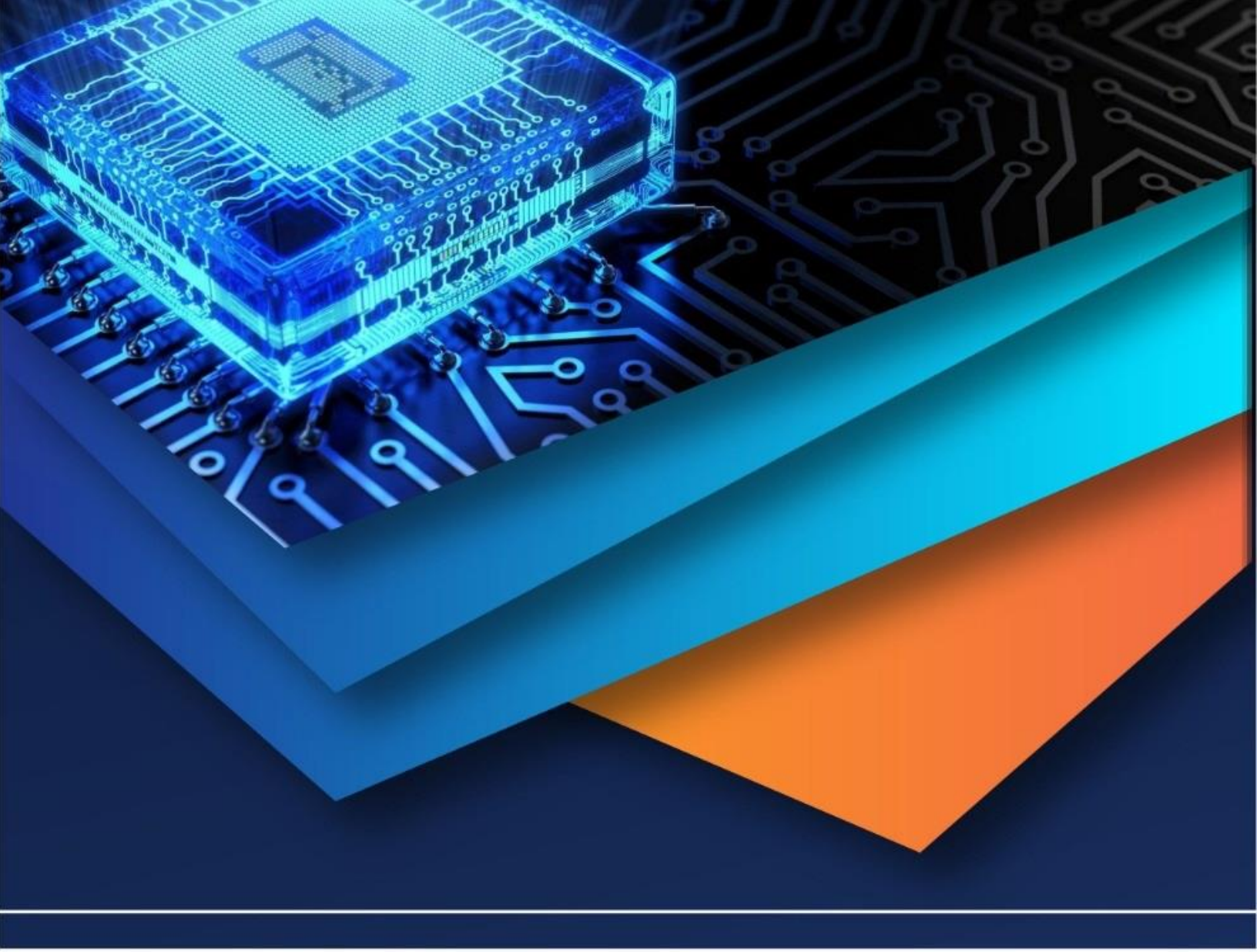
## V. CONCLUSIONS

The results of osmotic tablet studies of Lovastatin tablets proved that the granules of Lovastatin showed good flow properties, tablet evaluation tests are within the acceptable limits, IR spectral analysis proved that there was no drug-excipients interaction, the kinetic studies revealed that optimized formulation followed First order release kinetics and stability studies revealed that all the formulations were found to be stable after storing at temperature of 45ºC ± 2ºC, 75% ± 5% relative humidity for 3 months. Thus the results of the above study clearly indicated that Developed Osmotically controlled release tablet of Lovastatin provide release of drug at a predetermined rate and for a predetermined time in controlled manner.

## REFERENCES

[1] R.Lipp. Major advances in oral drug delivery over the Past 15 years. American Pharmaceutical Review, 2013; 16(6):__review.com/Featured-Articles/148747-Major-Advances-in-Oral-Drug-Delivery-over-the- Past-15-Years (Accessed on 11/07/2016).
[2] Kashmir Singh, Manpreet Kaur Walia, Dr. Geeta Agarwal, and Dr. S. L. Harikumar. Osmotic pump drug delivery system: a noval approach. Journal of Drug Delivery & Therapeutics, 2013; 3(5): 156-162.
[3] David B Troy, Paul Beringer and Matthew J Hauber (eds.). Remington: The Science and Practice of Pharmacy. 21st ed. Lippincott Williams & Wilkins, 2006. E-book.
[4] Gwen M Jantzen and Joseph R Robinson. Sustained- and Controlled-Release Drug- Delivery Systems. In, Gilbert S Banker and Christopher Rhodes (eds.). Modern Pharmaceutics. 4th ed. Florida: CRC Press, 2002. E-book.
[5] Oral Drug Delivery. In, Vasant V Ranade and John B Canno. Drug Delivery Systems. 3rd ed. Florida: CRC Press, 2011. E-book.
[6] Drug Delivery Systems. In, Marcos Luciano Bruschi. Strategies to Modify the Drug Release from Pharmaceutical Systems. Cambridge: Elsevier, 2015. E-book.
[7] Philip Denton. Colligative properties. In, Philip Denton and Chris Rostron. Pharmaceutics: The Science of Medicine Design. Oxford: Oxford university press, 2013. E-book.
[8] https://worldwide.espacenet.com
[9] Osmosis and Body Fluid Balance. In, Barry G Hinwood. A Textbook of Science for the Health Professions. 2nd ed. Cheltenham, UK: Nelson Thomas Ltd., 2001. E-book.
[10] Xiaoling Li and Bhaskara R Jasti. Osmotic Controlled Drug Delivery Systems. In, Design of Controlled Release of Drug Delivery Systems. USA: McGraw Hill, 2006. E-book.
[11] Stuti Gupta, Ravindra Pal Singh, Rohitashva Sharma, Renu Kalyanwat and Priyanka Lokwani. Osmotic pumps: a review. Pharmacie Globale International Journal of Comprehensive Pharmacy, 2011; *6 (01):* ISSN 0976-8157.
[12] Vishvanath pratap singh, Arpna singh, Kalpana Singh and Purnendu Kumar Sharma. Formulation and development of lansoprazole based osmotic drug delivery System. Indo American Journal of Pharmaceutical Research, 2013; ISSN NO: 2231-6876.
[13] http://wps.prenhall.com/wps/media/objects/3082/3156628/blb1305.html
[14] Oral Controlled Drug Delivery System. In, S Bharath. Pharmaceutical Technology: Concepts and applications. New Delhi: Dorling Kindersley (India) Pvt. Ltd., 2013. E-Book.
[15] Rajesh A Keraliya, Chirag Patel, Pranav Patel, Vipul Keraliya, Tejal G Soni, Rajnikant C Patel and M.M. Patel. Review Article: Osmotic drug delivery system as a part of modified release dosage form. International Scholarly Research Network, ISRN Pharmaceutics, 2012; Article ID 528079, doi:10.5402/2012/528079.
[16] Vincent Malaterre, Joerg Ogorka, Nicoletta Loggia and Robert Gurny. Oral osmotically driven systems: 30 years of development and clinical use. European Journal of Pharmaceutics and Biopharmaceutics, 2009; 73: 311–323.
[17] http://pharmaandfood.dow.com/en/pharmasolutions/products/polyox/applicatio ns
[18] Piyush Patel, Shahrzad Missaghi, Sandip B Tiwari, Thomas P Farrell and Ali R Rajabi- Siahboomi. Development of push-pull osmotic pump tablets for a slightly water soluble drug. Colorcon, 2011; CRS_2011_Missaghi_PPOP_Tabs Concept.
[19] Kunal N Patel, Dr. Tejal A Mehta. A review on oral osmotically driven systems. International Journal of Pharmacy and Pharmaceutical Sciences, 2013; 5(3): ISSN- 0975- 1491.
[20] Aditya M Kaushal and Sanjay Garg. An update on osmotic drug delivery patents. pharmaceutical technology, 2003; 38-45.
[21] R.Lipp. Major advances in oral drug delivery over the Past 15 years. American Pharmaceutical Review, 2013; 16(6)
[22] Kashmir Singh, Manpreet Kaur Walia, Dr. Geeta Agarwal, and Dr. S. L. Harikumar. Osmotic pump drug delivery system: a noval approach. Journal of Drug Delivery & Therapeutics, 2013; 3(5): 156-162.
[23] David B Troy, Paul Beringer and Matthew J Hauber. Remington: The Science and Practice of Pharmacy. 21st ed. Lippincott Williams & Wilkins, 2006.
[24] Gwen M Jantzen and Joseph R Robinson. Sustained and Controlled-Release DrugDelivery Systems. Modern Pharmaceutics. 4th ed. Florida: CRC Press, 2002.
[25] Vasant V Ranade and John B Canno.Oral Drug Delivery. Drug Delivery Systems. 3rd ed. Florida: CRC Press, 2011.
[26] Marcos Luciano Bruschi. Strategies to Modify the Drug Release from Pharmaceutical Systems. DrugXDelivery Systems. Cambridge: Elsevier, 2015.
[27] Philip Denton and Chris Rostron. Colligative properties. Pharmaceutics: The Science of Medicine Design. Oxford: Oxford university press, 2013.
[28] Barry G Hinwood. Osmosis and Body Fluid Balance. A Textbook of Science for the Health Professions. 2nd ed. Cheltenham, UK: Nelson Thomas Ltd., 2001.
[29] Xiaoling Li and Bhaskara R Jasti. Osmotic Controlled Drug Delivery Systems. Design of Controlled Release of Drug Delivery Systems. USA: McGraw Hill, 2006.
[30] Stuti Gupta, Ravindra Pal Singh, Rohitashva Sharma, Renu Kalyanwat and Priyanka Lokwani. Osmotic pumps: a review. Pharmacie Globale International Journal of Comprehensive Pharmacy, 2011; 6 (01).
[31] Vishvanath pratap singh, Arpna singh, Kalpana Singh and Purnendu Kumar Sharma. Formulation and development of lansoprazole based osmotic drug delivery System. Indo American Journal of Pharmaceutical Research, 2013.
[32] S Bharath. Oral Controlled Drug Delivery System. Pharmaceutical Technology: Concepts and applications. New Delhi: Dorling Kindersley (India) Pvt. Ltd.,

2013.
[33] Rajesh A Keraliya, Chirag Patel, Pranav Patel, Vipul Keraliya, Tejal G Soni, Rajnikant C Patel and M.M. Patel. Review Article: Osmotic drug delivery system as a part of modified release dosage form. International Scholarly Research Network, ISRN Pharmaceutics, 2012.
[34] Theeuwes F. Elementary osmotic pump. J. Pharm. Sci. 1975; 64: 1987-1991.
[35] Jerzewski RL, Chien YW. Osmotic drug delivery in: A. Kydonieus, Treatise on Controlled Drug Delivery: Fundamentals, Optimization, Application, Marcel Dekker, New York. 1992; 225- 253.
[36] Wong PSL, Barclay B, Deters JC, Theeuwes F. Osmotic device with dual thermodynamic activity. US patent 4,612,008, 1986.
[37] Cortese R, Theeuwes F. Osmotic device with hydrogel driving member. US patent 4,327,725, 1982.
[38] Swanson DR, Barclay BL, Wong PSL, Theeuwes F. Nifedipine gastrointestinal therapeutic system. Am. J. Med. 1987; 83: 3-9.
[39] Kunal N Patel, Dr. Tejal A Mehta. A review on oral osmotically driven systems. International Journal of Pharmacy and Pharmaceutical Sciences, 2013; 5(3)
[40] Zentner GM, Rork GS, Himmelstein KJ. The controlled porosity osmotic pump.
[41] J. Control. Release. 1985; 1: 269-282
[42] Zentner GM, Rork GS, Himmelstein KJ. Osmotic flow through controlled porosity films: An approach to delivery of water soluble compounds. J. Control. Release. 1985; 2: 217-229.
[43] Zentner GM, Rork GS, Himmelstein KJ. Controlled porosity osmotic pump. US patent 4,968,507, 1990.
[44] Schultz P, Kleinebudde P. A new multiparticulate delayed release system. Part
[45] Dissolution properties and release mechanism. J. Control. Release. 1997; 47: 181-189.
[46] Schultz P, Tho I, Kleinebudde P. A new multiparticulate delayed release system. Part II. Coating formulation and properties of free films. J. Control. Release. 1997; 47: 191-199.
[47] Cardinal JR, Herbig SM, Korsmeyer RW, Lo J, Smith KL, Thombre AG. Use of asymmetric membranes in delivery devices. US patent 5,612,059, 1997.
[48] Cardinal JR, Herbig SM, Korsmeyer RW, Lo J, Smith KL, Thombre AG. Asymmetric membranes in delivery devices. US patent 5,698,220, 1997.
[49] Herbig SM, Cardinal JR, Korsmeyer RW, Smith KL. Asymmetric membrane tablet coatings for osmotic drug delivery. J. Control. Release. 1995; 35: 127- 136.
[50] Thombre AG, Cardinal JR, DeNoto AR, Herbig SM, Smith KL. Asymmetric membrane capsules for osmotic drug delivery I. Development of a manufacturing process. J. Control. Release. 1999; 57: 55-64.
[51] Thombre AG, Cardinal JR, De Noto AR, Gibbes DC. Asymmetric membrane capsules for osmotic drug delivery II. In vitro and in vivo drug release performance. J. Control. Release. 1999; 57: 65-73.
[52] Dong L, Shafi K, Wan J, Wong P. A novel osmotic delivery system: L-OROS Softcap, in: Proceedings of the International Symposium on Controlled Release of Bioactive Materials. Paris, 2000; CD ROM.
[53] Espinal S, Dong L, Wong P,. L OROS HARDCAP: A new osmotic delivery system for controlled release of liquid formulation. San Diego 2001; CD-ROM.
[54] Theeuwes F, Wong PSL, Burkoth TL, Fox DA. Osmotic systems for colon- targeted drug delivery, Marcel Dekker, New York. 1993; p. 137-158.
[55] Liu L, Ku J, Khang G, Lee B, Rhee JM, Lee HB. Nifedipine controlled delivery by sandwiched osmotic tablet system. J. Control. Release. 2000; 68: 145-156.
[56] Aditya M Kaushal and Sanjay Garg. An update on osmotic drug delivery patents. Pharmaceutical technology, 2003; 38-45.
[57] McClelland GA, Sutton SC, Engle K, Zentner GM. The solubility modulated osmotic pump: In vitro/in vivo release of diltiazem hydrochloride. Pharm. Res. 1991; 8: 88-92.
[58] Zentner GM, McClelland GA, Sutton SC. Controlled porosity solubility- and resin modulated osmotic drug delivery systems for release of diltiazem hydrochloride. J. Control. Release. 1991; 16: 237-244.



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