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Formulation And Evaluation Of Colon Targeted Microsponge Of Mesalamine

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Abstract: Due to such wide significance, this drug delivery system may lead to better patient compliance and ultimate clinical output. For the treatment of inflammatory bowel colon targeting microsponges drug delivery system has been applied on the affected areas because the conventional drug therapy used to treat IBD mainly includes the use of anti-inflammatory drugs which encounters obstacle such as absorption and degradation in the upper GIT and also causes serious side effects in upper GIT. Microsponge delivery system (MDS) is the unique technique which provides targeted and controlled release of drug. Another added advantage of microsponges which contributes to their use is the ability of retaining drug on the surface of colon ensuring local and targeted action. Consequently, the lag time for drug absorption increases which makes MDS suitable for colon specific delivery and microsponge produce specific drug targeting with reduced side effects of drug.

Keywords: Colon Targeted, Microsponge, Mesalamine, Inflammatory bowel disease, Synthetic polymer

Introduction: The drug-delivery system should deliver drug at a rate dictated by the needs of the body over a specified period of time. The goal of any drug delivery system is to provide a therapeutic amount of drug to a proper site in the body, so that the desired drug concentration can be achieved promptly and then maintained. The idealized objective points to the two aspects most important to drug delivery, namely, spatial placement and temporal delivery. Spatial placement relates to targeting drugs to specific organs, tissues, cells, or even subcellular compartments; whereas temporal delivery refers to controlling the rate of drug delivery to the target site [1]. Oral drug delivery systems can be classified into three categories: immediate-release preparations, controlled-release preparations, and targeted-release preparations**.** Oral route is the most convenient and preferred route but other routes for CDDS may be used. Rectal administration offers the shortest route for targeting drugs to the colon. However, reaching the proximal part of colon via rectal administration is difficult [2]. A dosage form that allows at least a twofold reduction in dosage frequency as compared to that drug presented as an immediate-release (conventional) dosage

form. Examples of extended-release dosage forms include controlled-release, sustained-release, and long-acting drug products [3]. Targeted drug delivery into the colon is highly desirable for local treatment of a variety of bowel diseases such as ulcerative colitis, Crohn's disease, amebiosis, colonic cancer, local treatment of colonic pathologies, and systemic delivery of protein and peptide drugs. The colon specific drug delivery system (CDDS) should be capable of protecting the drug en route to the colon i.e. drug release and absorption should not occur in the stomach as well as the small intestine, and neither the bioactive agent should be degraded in either of the dissolution sites but only released and absorbed once the system reaches the colon. Targeted-release dosage forms may have either immediate- or extended-release characteristics [4]. The colon is also known as the large bowel or large intestine. It is an organ that is part of the digestive system (also called the digestive tract) in the human body. The colon is divided into the caecum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum and anal canal [5]. The site-specific targeted drug delivery negotiates an exclusive delivery to specific pre-identified compartments with maximum intrinsic activity of drugs and concomitantly reduced access of drug to irrelevant non-target cells. The targeted delivery to previously in-accessible domains, e.g., intracellular sites, virus, bacteria and parasites offers distinctive therapeutic benefits [6]. The controlled rate and mode of drug delivery to pharmacological receptor and specific binding with target cells; as well as bioenvironmental protection of the drug *en route* to the site of action are specific features of targeting. Invariably, every event stated contributes to higher drug concentration at the site of action and resultant lower concentration at non- target tissue where toxicity might crop-up [7]. The high drug concentration at the target site is a result of the relative cellular uptake of the drug vehicle, liberation of drug and efflux of free drug from the target site. Targeting is signified if the target compartment is distinguished from the other compartments, where toxicity may occur, and also if the active drug could be placed predominantly in the proximity of target site [8]. The restricted distribution of the parent drug to the non-target site(s) with effective accessibility to target site(s) could maximize the benefits of targeted drug delivery [9]. Microsponge delivery systems are used to improve the safety, effectiveness and quality of topical prescription, over-the-counter and personal care products. Microsponges can be used in variety of applications. It is used mainly for topical and now a days for oral administration. It can be used as an excipient due to its high loading capacity and sustained release ability. It offers the manufacturer a range of alternatives to develop drug and cosmetic products [10]. Microsponges are designed to deliver a pharmaceutical active ingredient efficiently at the minimum dose and they also enhance stability, reduce side effects and modify drug release. Over-the-counter products that incorporate microsponge drug delivery system include numerous moisturizers, specialized rejuvenated products, and sunscreens. Microsponges are one of the novel drug delivery systems, which were originally developed for topical delivery of drugs [11]. Mesalamine as an anti-inflammatory agent, structurally related to the salicylates and non-steroidal anti-inflammatory drugs like acetylsalicylic acid, which is active in inflammatory bowel disease. Mesalazine is one of the two components of sulphasalazine, the other being sulphapyridine. It is the latter which is responsible for the majority of the side effects associated with sulphasalazine therapy whilst mesalazine is known to be the active moiety in the treatment of ulcerative colitis. The pharmacodynamic actions of

mesalazine occur in the colonic/rectal mucosae local to the delivery of drug from mesalazine tablets into the lumen. There is information suggesting that the severity of colonic inflammation in ulcerative colitis patients treated with mesalazine is inversely correlated with mucosal concentrations of mesalazine. Plasma concentrations representing systemically absorbed mesalazine are not believed to contribute extensively to efficacy [12]. The aim of proposed work is better patient compliance with effective targeting at specific site of action. Over the past three decades other dosages forms have gained much attention as preferred alternative to conventional dosage form because of the numerous advantages like administration without water, accuracy of dosage, easy portability, and ideal for pediatric and geriatric patients and rapid onset of action. Recent advances in novel drug delivery system aim to enhance safety and efficacy of drug molecule by formulating a convenient dosage form for administration and to achieve better patient compliance. One such approach is formulation of microsponges.

Material And Methods

The absorption maxima (λ max) of drug were determined by scanning drug solution in double beam UV spectroscopy. For the calibration curve of the mesalamine standard stock solution and sub stock solution of mesalamine was prepared in solution of different solutions i.e. pH 1.2, pH 6.8 and pH 7.4 Phosphate buffer and plot the graph between concentration v/s absorbance [13].

Preformulation study

Appearance: Determination of drug (meslamine) color, odor, taste etc. was made visually, against white background.

Melting point: The melting point (or, rarely, liquefaction point) of a substance is the temperature at which it changes state from solid to liquid. Melting point of meslamine was determined by capillary method. The capillary filled with drug powder was placed in Thiele tube filled with liquid paraffin. The tube was heated and the melting point of drug powder was noted when last particle melted.

Density: The drug (meslamine) powder was accurately weighed (M) and poured through a glass funnel into graduated cylinder and the volume was noted and bulk density was determined. The tapped density was determined using tapped density apparatus [14].

Particle size: The average particle size (d_{avg}) of drug (meslamine) was determined by means of optical microscope (66172/Olympus, 100 X, Olympus (India) Pvt. Ltd., New Delhi) fitted with ocular micrometer and stage micrometer. The particle size of drug powder was 15.49 μm.

Flow properties: The flow properties of drug (meslamine) powder were characterized in terms of carr's index, hausner's ratio and angle of repose. The Carr's index ((I_C)) and Hausner's ratio (H_R) of drug powders were calculating according to following equation:

$$\text{Carr's Index } (I_C) = \rho_{Tapped} - \rho_{Bulk} / \rho_{Tapped}$$

$$\text{Hausner's ratio } (H_R) = \rho_{Tapped} / \rho_{Bulk}$$

The angle of repose (θ) was measured by fixed height method. This was calculated by following equation:

$$\text{Angle of repose } (\theta) = \tan^{-1} 2\ H / D$$

Where H is the surface area of the free standing height of the powder pile and D is diameter of pile that formed after powder flow from the glass funnel [15].

Solubility determination: The solubility of drug (meslamine) was determined in various solvents (Water, 0.1 N HCl, Ethanol, Chloroform). The excess amount of drug was added to 10 ml of medium and stirred constantly overnight at 37±0.5ºC. The solubility value of drug in different medium was determined spectrophotometrically at 301.8 nm.

Partition coefficient: The partition coefficient of drug (meslamine) was determined in n-octanol: phosphate buffer pH 7.4 solution. An exactly weighed (100 mg) amount of drug was added into 25 ml each of an n-octanol and buffer phase in a separating funnel. The mixture was shaken, separated and collected separately, filtered. The amount of drug solubilized determined by measuring the absorbance at 330.0 nm for by UV spectrophotometer. The partition coefficient of drug was calculated from the ratio between the concentrations of drug in organic and aqueous phase using following equation.

$$\text{Log P (oct / }_{\text{pH 7.4}}\text{)} = \text{Log (C }_{\text{Oct}} / \text{ C }_{\text{pH 7.4}}\text{) equilibrium}$$

Preparation of microsponge: Microsponges were prepared by quasi-emulsion solvent diffusion method. The External phase was prepared by dissolving polyvinyl alcohol in warm distilled water with continuous stirring at 200 rpm. Now, ethyl cellulose E426 (Polymer) and Di-butyl Phthalate (plasticizer) was dissolved in Ethanol (organic solvent) to form the internal phase. The drug mesalamine was added to the internal phase with gradual stirring (1000 rpm). Then inner phase was incorporated drop wise into outer phase with constant stirring at 500 - 1000 rpm for 12 hours to remove and diffuse ethanol completely from reaction vessel. The mixture formed was centrifuged at 3000 rpm for 30 minutes and formed microsponges are separated by filtration. Microsponges were dried in oven at 40 °C for 12 hours and collected [16].

Table 1: Composition of various formulations of micro sponges of mesalamine

Ingredients	MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7
Mesalamine (mg)*	500	500	500	500	500	500	500
Ethyl cellulose (mg)*	100	100	100	100	100	100	100
Eugradit RL 100	10	20	30	40	50	60	70
Ethanol (mg)*	5	5	5	5	5	5	5
Di-butyl Phthalate (mg)*	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Poly vinyl alcohol (mg)*	50	50	50	50	50	50	50
Distilled water (ml) *	200	200	200	200	200	200	200

Evaluation of Microsponges:

Flow Properties: Flow properties of microsponge were investigated by determining the following standard procedures.

A. Bulk Density: Bulk density was determined taking a known weight of dried microsponge in a measuring cylinder and tapping 3 times from 1 inch height at 2 second interval. The bulk volume is noted and the bulk density was calculated from the following equation.

$$\text{Bulk Density} = \frac{\text{Weight of microsponge}}{\text{Bulk volume of microsponge}}$$

B. Tapped Density: Tapped density is the ratio of mass of microsponge to the volume occupied by the same mass of the powder after a standard tapping of a measure. Weighed quantity of microsponge was taken in a cylinder and tapping 300 times from 1 inch at 2 second interval. The tapped volume is noted and the tapped density was calculated from the following equation.

$$\text{Tapped Density} = \frac{\text{Weight of microsponge}}{\text{Tapped volume of microsponge}}$$

C. Hausner's Ratio: Hausner's ratio of microsponge is used for predicting the flow characteristics.

$$\text{Hausner's ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

D. Compressibility Index: Compressibility index of microsponge was determined using bulk density and tapped density

$$\text{Compressibility index (\%)} = \frac{\text{Tapped density} - \text{Bulk density} * 100}{\text{Tapped density}}$$

E. Angle of Repose: A funnel was fixed to a stand and the bottom of the funnel was fixed at a height of 3 cm from the plane. Microsponge were placed in funnel and allowed to flow freely and the height and radius of the heap of microsponge was measured.

$\tan \theta = h/r$

Where, 'h' is the height of heap and'r' is the radius of heap of microsponge

Particle Size Analysis: The average particle size of the prepared mesalamine magnetic microsponge for intra-arterial administration was measured by optical microscopy using a calibrated Eye piece micrometer and was compared to that of microspheres without drug and also with those microspheres prepared without drug and magnetite. The average size of 100 particles was determined by the equation.

Size of individual particle (µm) = Number of divisions on eye piece × Calibration factor

Sum of Size of Individual Particles

Average Particle Size (µm) = Number of particles

Shape and surface morphology studies using Scanning Electron Microscope: The shape and surface morphology of magnetic microsponge were investigated using scanning electron microscopy (SEM). The samples for SEM study were prepared by lightly sprinkling the formulation on a double-adhesive tape stuck to an aluminum stub. The stubs were then coated with gold to a thickness of ~300 Å under an argon atmosphere using a gold sputter module in a high vacuum evaporator. The coated samples were then randomly scanned and photomicrographs were taken with a scanning electron microscope [17].

Percentage Yield: Microsponge were weighed and the percentage yield was calculated by taking into consideration the total weight of the drug and excipients used for preparation of microsponge.

$$\text{Percentage Yield} = \frac{\text{Practical yield} * 100}{\text{Theoretical yield}}$$

Estimation of Drug Content and Entrapment Efficiency: 50mg of microsponge was weighed and dissolved in 2.5 ml of 0.1N HCl and suitably diluted with phosphate buffer saline pH 7.4 in 50 ml standard flask. The solution was kept for 24hrs and filtered to separate the fragments. Drug content was analyzed after suitable dilution by UV spectrophotometer at a wavelength of 330.0 nm against phosphate buffer saline pH 7.4 as blank.

The drug content of each formulation was calculated using the following equation

$$\text{Percentage Drug Entrapment Efficiency} = \frac{\text{Actual Drug Content} * 100}{\text{Theoretical Drug Content}}$$

Drug Loading Capacity: Drug loaded microsponge were mixed in 2.5ml of 0.1N HCl and suitably diluted with phosphate buffer pH 7.4 at room temperature and kept for 24 h. After filtration and suitable dilution, Mesalamine present in the solution was determined.

$$\%\ \text{Drug Loading} = \frac{\text{Quantity of the drug present in the microsponge} * 100}{\text{Weighed quantity of microsponge}}$$

Swelling studies: The degree of swelling of the microsponge was investigated in PBS pH 7.4 without enzymes. A dialysis membrane 9 cm long was activated by immersion in 50ml of distilled water regulated at 90°C for 1 h and then washed with distilled water. A known weight of microsponge was placed in the activated dialysis membrane which was tied at both ends and immersed in a beaker placed on a

thermostated bath maintained at 37°C. At fixed intervals the membrane was removed from each medium, dried with filter paper and weighed. The degree of swelling (H) was calculated using the formula:

$$H = \frac{\text{Final weight of microsponge - Initial weight of microsponge}}{\text{Initial weight of microspheres}}$$

In-Vitro Drug Release Study: The in-vitro release profile of the entrapped drug from the microsponge was studied by the in-vitro dissolution study. The microsponge was kept in tea bags and placed in basket of IP dissolution rate test apparatus (apparatus type II, 50 rpm, 37±0.5 ºC). The basket was immersed in a beaker containing 0.1 N HCl (900 ml) for 2 h as the average gastric emptying time is about 2 h, then the dissolution medium was replaced with phosphate buffer pH 7.4 for 3 h as the average small intestinal transit time is about 3 h. The susceptibility of gum combination coats to the colonic environment was assessed by then replacing the dissolution medium by phosphate buffer pH 6.8 (900 ml) saline to maintain colonic pH condition Aliquots were withdrawn periodically and analyzed for mesalamine content by UV Spectrophotometer at 230nm [18].

Results And Discussion

The absorption maxima (λ max) of drug were determined by scanning drug solution in double beam UV spectroscopy. The absorbance at pH 1.2, pH 6.8 and pH 7.4 Phosphate buffer are 301.8 nm, 330.8 nm and 330.0 nm, respectively. The physical appearance of drug (Meslamine) color was white yellow, odourless and bitter in taste. Melting point of meslamine was determined by capillary method and it was 147°C. The Bulk and tapped densities of drug are to be 0.226 gm / cm^3 and 0.231 gm / cm^3, respectively. The particle size of drug powder was 15.49 µm. The flow properties of drug (Meslamine) powder were characterized in terms of carr's index, hausner's ratio and angle of repose. The Carr's index ((I_C)) and Hausner's ratio (H_R) of drug powders were showed good flow in nature. The partition coefficient of drug (Meslamine) was determined in n-octanol: phosphate buffer pH 7.4 solution and it was shown that drug was hydrophilic in nature. The compatibility i.e. drug-excipients interaction studies are helpful for dosage form design. For compatibility studies drug / excipients ratio are selected and investigated based on the reasonable drug / excipient ratio in the final product and results was showed that there was no interaction between and polymers used for the formulations.

Characterization of microsponges: The flow properties of microsponge were investigated by determining in terms of bulk density, tapped density, Hausner's ratio, Compressibility index and Angle of Repose (Table 2). Particle size results revealed that average particle size of microsponges increased with increasing polymer concentration. Higher concentration of polymer produced a more viscous dispersion with larger droplets and consequently larger microsponges were formed. The particle size of microsponges was found in the range of 34.3 to 46.85 µm.In general, less than 5µm size is used for intravenous route, less than 125 µm is used for intra-arterial route. Particles of this size can be administered easily by suspending them in a suitable vehicle and injecting them using a conventional syringe with an 18 or 20 gauge needle. The percentage yield of microsponges was found in the range of 79.490 to 94.783 % w/w. The results indicated that the formulation containing Ethyl Cellulose and Eugradit RL 100 combination (1: 1 ratio) yields better

percentage of mesalamine microsponges. The content of active ingredients of various formulations was analyzed using UV spectrophotometer at 230 nm. The percentage of drug content ranged from 69.964 to 86.369% w/w. The formulation MMS7 found to have higher drug content. The Drug loading capacity of various formulations was analyzed using UV spectrophotometer at 230 nm. The drug loading capacity ranged from 17.289 – 28.209 %w/w and from the result it is clear that the drug loading capacity increases with increase in drug:polymer ratio. The swelling ability of various microsponges formulations in PBS pH 7.4 was determined. The swelling ratio of microsponges was found in the range of 0.200 to 0.380. The data revealed that the SR of microspheres increases with decrease in drug content since water molecules cannot acquire much space in MM7 with higher drug entrapment. The in- vitro release study of microsponges results indicated that formulation with lesser drug–polymer ratio shows faster drug release. All formulations from MMS4 to MMS6 showed a burst release of 50+5% in 2h itself. It is observed that the formulations MMS7 containing polymer mixture (Ethyl Cellulose and Eugradit RL100 in the ratios 1:1, 1:2, and 1:3 respectively) was able to protect the formulation from premature drug release when compared to those formulations containing pectin alone (namely, MMS4, MMS5 and MMS6).The results also indicates that the Ethyl Cellulose and Eugradit Rl 100 microspheres substantially retarded the drug release and showed the best result for the one with medium (MMS7). It is observed that the formulation MMS7 containing polymer mixture was able to protect the formulation from premature drug release when compared to those formulation containing pectin alone (MMS4).The results also indicates that the Ethyl Cellulose and Eugradit RL 100 microspheres substantially retarded the drug release upto 9 hours. The inter polymer complex that could be formed between carboxyl groups of Eugradit Rl 100 and the OH groups of Ethyl Cellulose, may be responsible for such delayed drug release.

Conclusion: A various formulation of Mesalamine loaded colon targeted microsponges were successfully developed by quasi emulsion technique. The developed formulations were found to be spherical with tiny pores on the surface. In these formulations polymer combination of Ethyl cellulose and Eudragit R L100 was used in different proportion of Eudragit RL 100 used as a pH sensitive polymer having threshold pH value above 6, which bypassed the upper GIT and showed targeted and controlled release at colonic pH as revealed by in vitro drug release study. The in vivo studies also revealed better therapeutic outcomes as compared to free mesalamine .Thus the results of all formulation suggested that loaded micro sponges in having combination of ethyl cellulose and Eugradit RL 100 was valuable polymeric combinational approach for colon targeted drug delivery system. That's why results of all formulation indicate that microsponges may be considered as a promising drug delivery system for treatment of inflammatory bowel disease.

References:

1. Cetinkaya A, Bulbuloglu E, Kurutas EB, Ciralik H, Kantarceken B, Buyukbese MA. Beneficial effects of N-acetylcysteine on acetic acid-induced colitis in rats. The Tohoku Journal of Experimental Medicine. 2005;206(2):131–139. [PubMed]
2. Asghar LF, Chandran S. WQE formulations approach to colon specific drug delivery: current perspectives. J Pharm Pharm Sci 2006; 9:327-38.
3. Cooper J, Gunn C. Powder flow and compaction. In: Carter SJ, editor. Tutorial pharmacy, New Delhi: CBS Publishers and Distributors; 1986. p. 211-33.
4. Gandhy SU, Kim K, Larsen L, Rosengren RJ, Safe S. Curcumin and synthetic analogs induce reactive oxygen species and decreases specificity protein (Sp) transcription factors by targeting microRNAs. BMC Cancer. 2012;12, article 564
5. Devrim B, Canefe K. Preparation and evaluation of modified release ibuprofen microspheres with acrylic polymers (Eudragit) by quasi emulsion Solvent diffusion method: effect of variables. Acta Pol Pharm 2006; 63:521-34.
6. Jelvehgari M, Siahi-Shadbad MR, Azarmi S, Martin GP, Nokhodchi A. The micro sponge delivery system of benzoyl peroxide: preparation, characterization and release studies. Int J Pharm 2006; 308:124-32.
7. Barollo M, Medici V, D'Incà R, et al. Antioxidative potential of a combined therapy of anti TNFα and Zn acetate in experimental colitis. World Journal of Gastroenterology. 2011;17(36):4099–4103.
8. Comoğlu T, Gönül N, Baykara T. Preparation and in vitro evaluation of modified release ketoprofen microsponges. Farmaco 2003; 58:101-6.
9. Jostins L, Ripke S, Weersma RK, Duerr RH, McGovern DP, Hui KY, et al. Host-microbe interactions have shaped the genetic architecture of inflammatory bowel disease. Nature 2012; 491:119-24.
10. Goyal N, Rana A, Ahlawat A, Bijjem KR, Kumar P. Animal models of inflammatory bowel disease: a review. Inflammopharmacology 2014; 22:219-33.
11. Kruis W, Bar-Meir S, Feher J, Mickisch O, Mlitz H, Faszczyk M. The optimal dose of 5-aminosalicylic acid in active ulcerative colitis: a dose-finding study with newly developed mesalamine. Clin Gastroenterol Hepatol 2003;31; 1:36-4.
12. Nokhodchi A, Jelvehgari M, Siahi MR, Mozafari MR. Factors affecting the morphology of benzoyl peroxide microsponges. Micron 2007; 38:834-40.
13. Jain V, Singh R. Design and characterization of colon-specific drug delivery system containing paracetamol microsponges. Arch Pharm Res 2011; 34:733-40.
14. Kandhare AD, Raygude KS, Ghosh P, et al. Effect of hydroalcoholic extract of Hibiscus rosa sinensis Linn. leaves in experimental colitis in rats. Asian Pacific Journal of Tropical Biomedicine. 2012;2(5):337–344.PMC free articl

15. Jelvehgari M, Siahi-Shadbad MR, Azarmi S, Martin GP, Nokhodchi A. The microsponge delivery system of benzoyl peroxide: Preparation, characterization and release studies. Int J Pharm 2006; 308:124-32.
16. Loftus EV Jr, Sandborn WJ. Epidemiology of inflammatory bowel disease. Gastroenterol Clin North Am 2002; 31:1-20.
17. Louis P, Hold GL, Flint HJ, 2014. The gut microbiota, bacterial metabolites and colorectal cancer. Nature Reviews Microbiology; 1-12.
18. Orlu M, Cevher E, Araman A. Design and evaluation of colon specific drug delivery system containing flurbiprofen microsponges. Int J Pharm 2006; 318:103-17.

Table 2: Flow properties of mesalamine microsponge

F. code	Bulk density(g/ml)	Tapped density(g/ml)	Compressibility index (%)	Hausner's ratio	Angle of repose (°)
MMS1	0.335± 0.013	0.427 ± 0.035	21.11 ± 4.189	1.270± 0.065	26.31± 2.257
MMS2	0.316 ± 0.008	0.366 ± 0.013	13.52± 1.753	1.156± 0.023	29.3± 1.892
MMS3	0.297 ±0.00	0.337 ± 0.007	12.04± 1.676	1.137± 0.024	27.281± 0.571
MMS4	0.467 ± 0.009	0.523± 0.017	10.203± 1.566	1.112± 0.023	29.55± 1.536
MMS5	0.385 ± 0.011	0.427± 0.009	7.550± 3.954	1.108± 0.028	27.36± 0.953
MMS6	0.33 ± 0.012	0.363± 0.005	6.38± 3.008	1.069± 0.036	28.16± 1.076
MMS7	0.415 ± 0.011	0.448± 0.016	6.775± 1.994	1.07± 0.022	26.57± 0.844

Table 3: Physical properties of mesalamine microsponge

Formulation	Mean Particle Size	Theoretical yield (g)	Practical yield (g)	Percentage yield (% w/w)	Drug Content (%w/w)	Drug Loading (%)	Swelling Ratio (SR)	Drug Content (%w/w)
MMS1	35.95	1.24	0.983	79.49	85.058	17.289	12.4	85.058
MMS2	39.55	1.87	1.66	85.876	84.393	22.828	26	84.393
MMS3	40.7	1.877	1.677	94.783	72.157	29.093	18	72.157
MMS4	41.3	1.86	1.635	88.453	85.698	29.131	25.1	85.698
MMS5	43.15	1.866	1.597	89.449	78.127	21.667	21	78.127
MMS6	46.85	1.88	1.734	92.69	70.601	19.131	21.5	70.601
MMS7	34.3	1.865	1.688	91.33	86.369	47.54	40.2	86.369