Solubility and Dissolution Enhancement of Albendazole by Spherical Crystallization

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ABSTRACT :

Spherical crystallization technique combines crystallization followed by agglomeration to generate spherical crystals with improved micromeretic properties, thus obviating need for further processing by agglomeration and granulation. The present study was focused on spherical crystallization of an antihelmentic drug Albendazole (ABZ) using spherical crystallization technique. Apart from being poorly water-soluble, ABZ exhibits poor flow and compressibility owing to its needle shaped crystal habit and electrostatic charge. Spherical agglomeration was carried out in the presence of different bridging liquids (hexane, octanol, dichloromethane) and polymers (Carboxymethyl Celluose Sodium [Na CMC] and Hydroxyl propyl methyl cellulose [HPMC]), by employing different crystallization conditions such as variation of polymer type, polymer concentration, variation of bridging liquid, bridging liquid concentration, rate of stirring and stirring time. The final parameters were optimized to obtain crystals for the formulation of tablet through direct compression. The agglomerates exhibited better flow properties, higher bulk density and improved compressibility compared to pure powder drug. Spherical crystals generated in the presence of Sodium CMC and HPMC indicated better compressibility of spherical crystals than the spherical crystals prepared with organic solvents in the absence of Sodium CMC and HPMC.

INTRODUCTION:

The crystal habit and polymorphic form of a crystalline solid influences its physico-chemical, mechanical and biological performance. A number of reported studies have drawn attention to the role of polymorphism in drug discovery and development, and significance of crystal habit on processability[1,2]. The isomorphic forms, by alteration only in the crystal habit, influence the particle orientation and play a significant role in flowability, packing, compaction, syringeability of suspension stability and dissolution characteristics of a powder drug.

Highly symmetrical cubic crystals and regularly shaped spherical particles have been found to be free-flowing and exhibiting better compressibility, thus being preferred for direct compression [3,4]. Processing benefits by modification of crystal habit have been reported for tolbutamide and acetaminophen. Hence, changes in habit call upon due attention to ensure product consistency and make it imperative to study the factors influencing the crystal habit vis-à-vis its processability [5]. Solvent re-crystallization is the most commonly used approach for crystallization but, of late, other methods like spherical crystallization are gaining importance. This process leads to the generation of spherical agglomerates that are easily processable and "ready-to-use", thereby reducing validation effort of the manufacturing process.

Spherical agglomeration is the most commonly used method and involves the use of polymers and/or bridging liquids to simultaneously crystallize and agglomerate. This technique is especially useful for high dose drugs having non-optimal flow properties and compressibility. In the present study, Albendazole (ABZ) was chosen as the model drug for spherical agglomeration. Albendazole, a BCS class II drug, is a common benzimidazole anthelmintic used in the treatment of ascariasis, uncinariasi, giardiasis, trichuriasis, filariasis, neurocysticercosis, hydatid disease, enterobiasis, and more than one worm infection at a time[6,7]. It inhibits glucose uptake in the parasite, resulting in its immobilization and death. Albendazole exists in three polymorphic forms, namely, form A, B and C. Form C is the pharmaceutically and therapeutically most useful form, although the solubility of form B is highest. It exists as small acicular crystals and exhibits processing problems like poor flow, segregation tendency, poor compression and stickiness due to electrostatic charges. Owing to its poorly soluble nature, it is desirable to use micronized Albendazole, which however, can further negatively impact flow, packing and compressibility of the powder [7,8]. Therefore, the present study involved

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spherical crystallization of Albendazole containing B and C polymorphic form to improve the physico-technical properties of Albendazole.

MATERIALS & METHODS

Materials

Albendazole were purchased from Sava Pharmaceutical, Pune. Sodium Carboxymethyl

Cellulose and Hydroxypropyl methylcellulose, Colorcon Asia, (Goa). The other reagents and solvents were of analytical grade purchased from Universal Labs, Mumbai.

Methods:

Preparation of spherical Crystal by using different bridging liquid[9]

The spherical crystal is obtained through spherical agglomeration technique. Twenty one batches were prepared depending upon the change in concentration and type of bridging liquid (Table 1). Albendazole was dissolved in acetone and poured in water followed by addition of bridging liquid (Dichloromethane/ Hexane / Octanol) drop wise with different stirring speed and stirring time. The obtained precipitated agglomerates of Albendazole were dried for 24 hours at room temperature to enlarge the size of the agglomerates.

Preparation of spherical Crystal by using Dichloromethane as bridging liquid with polymers[9,10]

The spherical crystal is obtained through spherical agglomeration technique. Five batches were prepared depending upon the change in concentration and type of polymers (Table 2). Albendazole was dissolved in acetone and poured in the mixture of water and polymer followed by addition of bridging liquid (Dichloromethane) drop wise with different stirring speed and stirring time. The obtained precipitated agglomerates of Albendazole were dried for 24 hours at room temperature to enlarge the size of the agglomerates.

The optimized spherical agglomerates of ABZ directly compressed and compared for percent cumulative drug release with marketed tablet.

Evaluation of Optimized Spherical Agglomerates

Flowability

Both loose bulk density (LBD) and tapped bulk density (TBD) were determined[11,12]. A quantity of 5g of agglomerates was lightly shaken to break any agglomerates formed and then was introduced into a 100ml measuring cylinder. It was allowed to fall under its own weight onto a hard surface from the height of 2.5cm at 2- second intervals. The tapping was continued until no further change in volume was noted. LBD and TBD were calculated using the following formulae:

$$LBD = \frac{\text{Weight of the powder}}{\text{looseVolume of the powder bed}}$$

$$TBD = \frac{\text{Weight of the powder}}{\text{Tapped Volume of the powder bed}}$$

The compressibility indices of the formulation blend were determined through Carr's compressibility index[11,12]:

$$\text{Carr's Compressibility Index}(\%) = \frac{TBD - LBD}{TBD} \times 100$$

From the mass and occupied volume respective densities were calculate, from these densities the density ratio (Hausner's Ratio[11,12]) calculated

$$HR = \frac{\text{Tapped Density}}{\text{Bulk Density}}$$

Values less than 1.25 indicate good flow (20% Carr index.) and the value greater than 1.25 indicates poor flow (33% Carr index.).

Percent drug content[13]

The optimized formulation was triturated in mortar and pestle. Powder equivalent to dose of ABZ was weighed and dispersed in to 100 ml of 0.1N HCl and sonicated using an ultrasonicator for 20 minutes. The resultant solution was filtered through whatmann filter paper no.41 and drug content was spectrophotometrically determined at 252 nm (Model-UV 1700 Shimadzu, Japan).

Solubility Analysis[13]

The optimized formulation was accurately weighed (10 mg) and mixed with 2 ml of water to make saturated solution of ABZ. The solution was placed inside orbital shaker for 48 hours followed by centrifugation in laboratory centrifuge at 300 rpm for 15 minutes. The resultant solution was then filtered through whatmann filter paper no.41 and further diluted with distilled water. Solubility was spectrophotometrically determined at 252 nm (Model-UV 1700 Shimadzu, Japan).

Dissolution Studies[14]

Drug release studies of prepared agglomerates were performed by USP Dissolution apparatus 2 (DT 60, Veego Instruments) with 900 ml of 0.1N HCl as dissolution medium at 37±0.1^{0}C. The speed of the paddle was adjusted to 100 rpm. The prepared agglomerates were packed inside muslin cloth and tied to the paddle. An aliquot of 5 ml was collected at an interval of 10 min and analyzed for the content of ABZ by UV-spectrophotometer at 252 nm after appropriate dilution. An equivalent volume (5 ml) of fresh dissolution medium was added to compensate for the loss due

Optical Microscopy:

The external morphology like, shape, size and number of spherical agglomerates was studied by optical microscopy. The sample was taken on the glass slide and is observed under 10X, 45X and 100X magnifications.

Evaluation of Formulated Tablets prepared with optimized spherical agglomerates:[15,16]

Dissolution Studies: Drug release studies of formulated tablets were performed by USP Dissolution apparatus 2 (DT 60, Veego Instruments) was used with 900 ml of 0.1N

HCl as dissolution medium at 37±0.1^{0}C. The speed of the paddle was adjusted to 100 rpm.

Friability:

Friability testing of the tablets is carried out by Roche Friabilator. Twenty tablets are placed inside of rotating drum which rotates at 25 rpm. The timer is set for 4 minutes to complete 100 rotations. The tablets are removed and % weight loss is calculated.

Hardness:

Hardness testing of the tablets is carried out by Monsanto hardness tester.

RESULTS & DISCUSSION:

Calibration Curve for Albendazole in Distilled Water:

10 mg of ABZ was dissolved in 100 ml distilled water with 0.5% (0.5 gm) of Sodium lauryl sulphate in 100ml volumetric flask to get 100 µg/ml. UV spectrum was recorded in the wavelength range 200-400 nm (Fig 1). Standard calibration curve was prepared for concentration of 10µg/ml to 70µg/ml at 250.5 nm. The graph of absorbance v/s concentration was plotted and data were subjected to linear regression analysis. The UV absorbance data at 252 nm and concentration estimates of pure ABZ at this wavelength showed good linearity (R^2– 0.998) over the concentration range of 10-70 µg/ml. Hence, the sample of ABZ was found to obey Beer- Lambert`s law over this range.

Calibration Curve for ABZ in 0.1N HCl:

10 mg of ABZ was dissolved in 100 ml 0.1N HCl in 100ml volumetric flask to get 100 µg/ml. UV spectrums was recorded in the wavelength range 200-400 nm (Fig 2). Standard calibration curve was prepared for concentration from 2µg/ml to 14 µg/ml at 252 nm. The graph of absorbance v/s concentration was plotted and data were subjected to linear regression analysis. The UV absorbance data at 252 nm and concentration estimates of pure ABZ at this wavelength showed good linearity (R^2– 0.9987) over the concentration range of 2-14 µg/ml. Hence, the sample of ABZ was found to obey Beer- Lambert`s law over this range.

FTIR Spectroscopy:

0.1gm of ABZ was mixed and triturated with dry potassium bromide. This mixture was placed in DRS assembly sample holder. The infrared spectrum was recorded (Fig 3) and the spectral analysis was done (Table 3).

Morphological Analysis of Albendazole by Optical Microscopy:

The Optical Microscopic images of the Albendazole shows the needle like particles which complies with the specified description of the drug (Fig 4).

Optimization of Spherical Agglomerates.

Optimization of Bridging Liquid: Batches were prepared as given in table 1, Spherical agglomerates were not obtained from batch (B 1) to (B 12). Microscopic study shows agglomerates formation is more if dichloromethane used as bridging liquid as compared to hexane and octanol. The size of the agglomerates is more spherical in (B13) batch obtained with dichloromethane as bridging liquid (Fig. 5).

Optimization of Stirring Speed (Rpm): Further batches were taken by using dichloromethane as bridging liquid to optimize the stirring speed. Microscopic study shows batch (B17) prepared through 500 rpm produces agglomerates which are ideal in size and are spherical in shape. Whereas, there is destruction of agglomerates into smaller agglomerates and formation of incomplete agglomerates in case of batches which are prepared with 800 rpm and 250 rpm respectively (Fig 6).

Optimization of Stirring Time (min.):

Further batches were prepared using DCM as bridging liquid at 500 rpm to optimize the stirring time. Microscopic study shows that batch prepared at 60 minutes leads to destruction of agglomerates and batch prepared at 15 minutes gives incomplete agglomerates. Whereas, batch (B20) prepared at 30 minutes will gives spherical agglomerates with optimal size and shape (Fig 7).

Optimization of Polymer:

B20 batch was further studied for the effects of polymer on spherical agglomerates and again three batches were formulated. Microscopic study shows that the batches which are prepared by CMC and HPMC will lead to large number of agglomerates formations which are bigger in size and have spherical in shape. Batch (B 26) gives better agglomerates which are more spherical in shape using 0.25% HPMC as compare to other batches (Fig 8).

Solubility Analysis:

The batch B13, B17, B20, B24, B25 and B26 shows suitable spherical agglomeration with optimum size particle and more spherical shape particle. So these batches are subjected to solubility analysis to determine the change in solubility of ABZ spherical agglomerates in comparison to pure ABZ.

Solubility profile shows that the solubility of batches prepared by spherical agglomeration is more than the solubility of pure drug (Table 4). The batches prepared with use of polymers shows higher solubility as compared to batches prepared with only organic solvent as bridging liquid. Thus batches (B 24, B 25 & B 26) are subjected to dissolution testing.

Dissolution Profile:

Batch B26 provides the higher percentage cumulative release of 84.85 % as compare to other batches and pure ABZ.

Pre-Compression Assessment of Optimized Spherical Agglomerates: Spherical agglomerates were evaluated for its flow properties, porosity and drug content, results were found within the range (Table 5).

Post-compression assessment of Albendazole Tablets prepared with batch (B-26) Spherical Agglomerates:

Spherical agglomerate obtained in B 26 batch was directly compressed to obtain 200 mg tablet and evaluated for

Batch No.	ABZ (mg)	Stirring Speed (rpm)	Stirring Time (min.)	Good Solvent (ml) [Acetone]	Bad Solvent (ml) [Water]	Bridging Liquid (ml)		
						Hexane	DCM	Octanol
B1	100	250	15	5	50	—	0.5	—
B2	100	250	15	5	50	—	2	—
B3	100	250	15	5	50	—	2	—
B4	100	250	15	5	50	2	—	—
B5	100	500	30	5	50	—	—	2
B6	500	250	30	25	250	—	2	—
B7	500	250	30	2	25	—	2	—
B8	500	100	05	10	100	—	2	—
B9	500	1000	75	10	100	—	2	—
B10	500	250	15	10	100	—	8	—
B11	500	250	15	10	100	—	6	—
B12	500	250	15	10	100	—	2	—
B13	1000	250	15	10	100	—	2	—
B14	1000	250	15	10	100	2	—	—
B15	1000	250	15	10	100	—	—	2
B16	1000	250	15	10	100	—	2	—
B17	1000	500	15	10	100	—	2	—
B18	1000	800	15	10	100	—	2	—
B19	1000	500	15	10	100	—	2	—
B20	1000	500	30	10	100	—	2	—
B21	1000	500	60	10	100	—	2	—

Table: 1 Formulation of Spherical Agglomerates prepared with different bridging liquid

Batch No.	ABZ (mg)	Stirring Speed (Rpm)	Stirring Time (min.)	Good Solvent (ml) [Acetone]	Bad Solvent (ml) [Distilled Water]	Polymer with Conc.		Bridging Liquid (ml) (DCM)
						Na CMC	HPMC	
B22	500	500	30	5	100	0.5%		2
B23	500	500	30	5	100	0.25%		2
B24	500	500	30	5	100	0.1%		2
B25	500	500	30	5	100	—	0.1%	2
B26	500	500	30	5	100	—	0.25%	2

Table: 2 Formulation of spherical agglomerates using dichloromethane as bridging liquid with polymers

S. No	Frequency (cm^{-1})	Type of vibration	Functional group Present
1.	3329.70	N-H Stretch	Amine
2.	1712.67	-COOBend	Ketone
3.	2956.82	C-H Stretch	Alkane

Table No. 3. Details of FTIR spectrum of Albendazole

Formulation Code	Solubility (mg/ml)
Pure Drug	0.041
B13	3.986
B17	4.764
B20	5.140
B24	6.163
B25	6.458
B26	6.883

Table: 4. Solubility profiles of the obtained formulations and pure drug.

Formulation (Batch)	Granule density (g/cm3)	Tapped density (g/cm3)	Porosity	Hausner's ratio	Carrs index	Drug Content (%)
B26	0.294 ± 0.05	0.3448 ± 0.06	0.1470 ± 0.05	1.17 ± 0.15	14.7±0.51	98.54 ± 1.15

Table no. 5. Pre-compression assessments of Albendazole spherical agglomerates. mean ± SD (n=3)

Formulation Code	Friability† (%)	Hardness† (Kg/cm^2)	Drug Content (%)
B26-Tab.	0.458 ± 0.108	6.54 ± 0.123	98.20 ± 1.089

Table No. 6. Physical evaluation of spherical agglomerates Albendazole tablets mean ± SD (n=3)

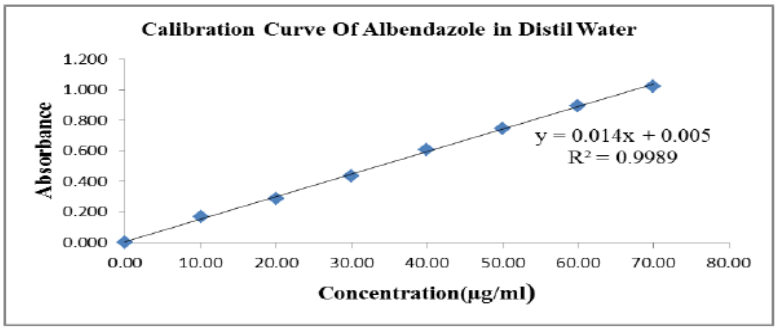

Figure: 1 Calibration Curve of Albendazole in Water (0.5% SLS).

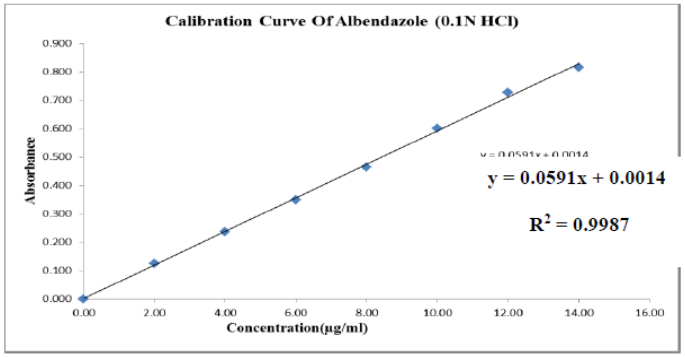

Figure: 2 Standard calibration curve of Albendazole in 0.1N HCl.

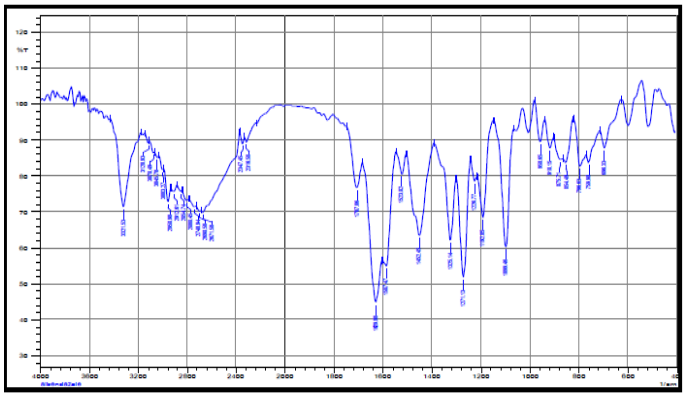

Figure: 3 FTIR Spectrum of Albendazole

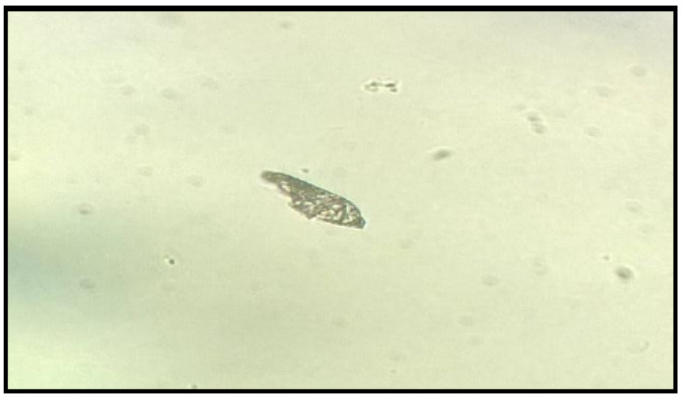

Figure: 4. Optical Microscopy of Pure Drug Albendazole

Optical Microscopic Image	B13	B14	B15
Bridging Liquid	DCM	Hexane	Octanol
Stirring Speed	250rpm	250rpm	250rpm
Stirring Time	15 minutes	15 minutes	15 minutes

Figure: 5. Optimization of Bridging Liquid

Optical Microscopic Image	B16	B17	B18
Bridging Liquid	DCM	DCM	DCM
Stirring Speed	250rpm	500rpm	800rpm
Stirring Time	15 minutes	15 minutes	15 minutes

Figure:6. Optimization of Stirring Speed (Rpm)

Optical Microscopic Image	B19	B20	B21
Bridging Liquid	DCM	DCM	DCM
Stirring Speed	500rpm	500rpm	500rpm
Stirring Time	15 minutes	30 minutes	60 minutes

Figure:7. Optimization of Stirring Time (min.)

Optical Microscopic Image	B24	B25	B26
Bridging Liquid	DCM	DCM	DCM
Stirring Speed	500rpm	500rpm	500rpm
Stirring Time	30 minutes	30 minutes	30 minutes
Polymer	0.1% Na CMC	0.1% HPMC	0.25% HPMC

Figure:8. Optimization of Polymer:

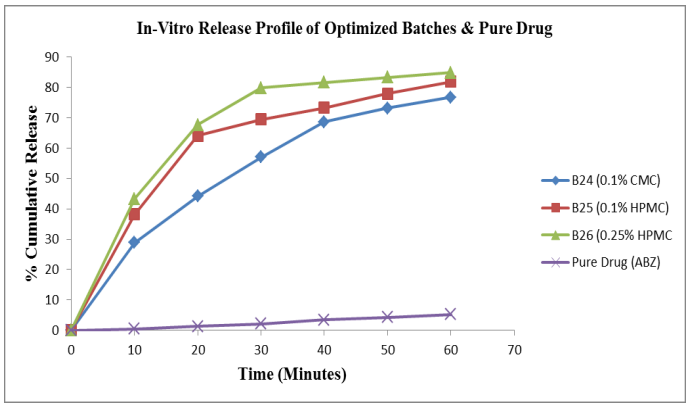

Figure: 9. Comparison of In-vitro release profile of optimized batches & pure drug.

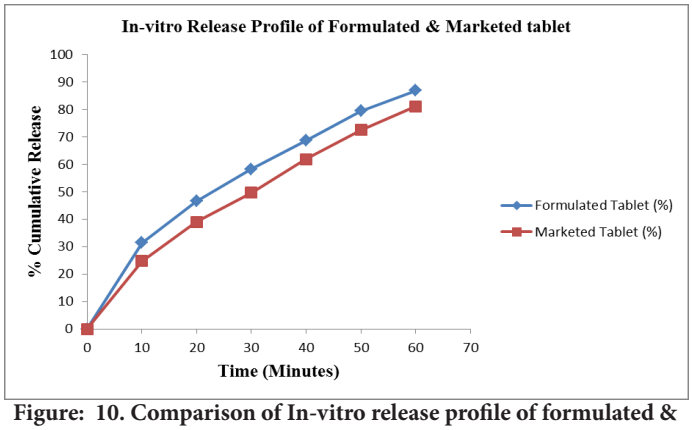

Figure: 10. Comparison of In-vitro release profile of formulated & marketed tablet.

physiochemical properties (Table 6) and dissolution studies. These agglomerates also showed improved solubility and dissolution compared to pure ABZ. Agglomerates generated using CMC and HPMC also showed significant improvement in dissolution from a value 5.61% for pure ABZ to 84.85% for the batch B 26 crystals (Fig. 9).

Comparison between Formulated Tablet & Marketed Tablet.

Dissolution Study of Formulated & Marketed Tablet: Marketed tablet of Albendazole – 200 (Intas Pharmaceutical Ltd.) were purchased and comparative dissolution profile was generated for tablet prepared with B 26 batch. The formulated tablet of ABZ and marketed tablet was found to show 86.92 & 81.05 percent cumulative release respectively (Fig 10).

Conclusion

Spherical crystallization of ABZ was carried out by Spherical Agglomeration method using good solvent, bad solvent, bridging liquids and polymers. The effect of various parameters like concentration of solvents, polymers, bridging liquids, stirring time, stirring rate and amount of drug used was studied to optimize the final conditions for spherical crystallization. Among all parameters, the drug

amount of 500 mg with acetone as a good solvent of 10 ml, water as a bad solvent of 100 ml with 0.25% HPMC and dichloromethane as a bridging liquid of 2 ml; at a stirring rate of 500 rpm and stirring time of 30 minutes is best suited to obtain the spherical agglomerates with better processability and solubility. These agglomerates also showed improved solubility and dissolution compared to pure ABZ. Agglomerates generated using CMC and HPMC also showed significant improvement in dissolution from a value 5.61% for pure ABZ to 84.85% for the batch B 26 crystals. The comparison of dissolution profile of formulated tablet and marketed tablet was done and the percent drug release at 60 minutes was found to be 86.92% and 81.05% of formulated tablet & marketed tablet, respectively. Thus finally it can be concluded that a novel method through spherical crystallization could be employed to improve the micromeritic and dissolution characteristic of Albendazole. The outcome gave a good clue to the formation of spherical crystals employing a poorly soluble active pharmaceutical ingredient. This technique would work as a lead for other active pharmaceutical ingredient too. Such a technique can successfully be employed to generate ready-to-formulate API, thus saving on time and effort at the formulator's end.

REFERENCES

1. Kawashima Y, Niwa T, Takeuchi H, et al., Characterization of polymorphs of Tranilastanhydrate and Tranilast monohydrate when crystallization by two solvents changes spherical crystallization technique, Jr.Pharm.Sci: 1991, 80(5), 472-78.
2. Chelakara L. Viswanathan, Sushrut K. Kulkarni, et al, Spherical Agglomeration of Mefenamic Acid and Nabumetone to Improve Micromeritics and Solubility: A Technical Note, AAPS PharmSciTech: 2006, 7 (2), 132-143.
3. Kumar S, Chawla G, Bansal AK, Spherical crystallization of mebendazole to improve processability, Pharmaceutical Development and Technology: 2008, 13(6), 559-568.
4. Nokhodchi A. and Maghsoodi M., Preparation of Spherical Crystal Agglomerates of Naproxen Containing Disintegrant for Direct Tablet Making by Spherical Crystallization Technique, AAPS PharmSciTech: 2008, 9(1), 322-339.
5. Yadav VB, Yadav AV, Effect of Different Stabilizers and Polymers on Spherical Agglomerates of Gresiofulvine by Spherical crystallization technique, International Journal of PharmTech Research: 2009, 1(2), 149-150.
6. Mishra RK, Chitlange SS , Probiotics: A Review on Formulation Aspects of Probiotics, International Journal of Pharmaeutical Sciences Review and Research: 2014,29(2), 251-256.
7. Gokul R. Ghenge, S.D. Pande, et al, An overview to Spherical Crystallization and its Evaluation, International Journal of Applied Pharmaceutics: 2011, 3(3), 41-59.
8. Patil PB, Gupta VRM, Udupi RH, et al, Spherical agglomeration – direct tabletting technique. IRJP: 2011, 2 (11), 30 – 35.
9. Kovacic B, Vrecer F, Planincek O. Spherical crystallization of drugs, Acta Pharm: 2012, 5(62), 1-14.
10. Chouracia MK, Jain A, Valdya S and Jain SK, Utilization of spherical crystallization for preparation of directly compressible materials. Indian Drugs: 2004, 41(6), 319-29.
11. Nandgude TD, Bhise KS, Gupta VB. Characterization of Hydrochloride and Tannate Salts of Diphenhydramine. Ind. J. Pharm. Sci. Aug. 2008, 483-487.
12. Gohle MC, Parikh RK, Shen H, Improvement in flowability and compressibility of Ampicilline Trihydrate by spherical crystallization, Ind. J. Pharm. Sci: 2003, 6(13), 634-37.
13. Yadav VB, Yadav AV, Designing of pharmaceuticals to improve physicochemical properties by spherical crystallization technique, Journal of Pharmacy Research: 2008, 1(2), 105-112.
14. Ueda M, Nakamura Y, Makita H, Imasato Y, Kawashima Y, Particle design of Enoxacin by spherical crystallization technique II, Characteristics of agglomerated crystals, Chem.Pharm.Bull: 1991, 39(5), 1277-1281.
15. Rane DR, Gulve HN, Patil VV, et al, Formulation and evaluation of fast dissolving tablet of Albendazole, ICPJ: 2012, 1(10), 311-316.
16. Nandgude TD, Maria S, Bhise KS. Formulation and evaluation of fast disintegrating tablet of Diphenhydramine Tannate. *Asian J. of Pharmaceutics.* Oct-Dec 2006, 1(1), 41-45.
17. Anusha V., Palanichamy S., Sugumar M., Rajesh M., Parasakthi N., et al., Formulation and characterization of albendazole chewable tablets, Pelagia Research Library: 2012, 3(2), 211-216.