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A REVIEW ON SUGAR-FREE RECONSTITUTED DRY SYRUP USING NATURAL SUSPENDING AGENT

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ABSTRACT

Reconstitutable oral dry syrups are vital pharmaceutical dosage forms designed for medications that exhibit instability in aqueous environments, most notably antibiotics such as amoxicillin, cephalexin and ciprofloxacin. These formulations consist of dry mixtures of finely divided insoluble particles, typically ranging from 0.5 to 5 in diameter, intended to be suspended in a vehicle at the time of dispensing. This review evaluates the development of sugar-free systems to accommodate pediatric, geriatric and diabetic populations while utilizing natural suspending agents like fenugreek seed mucilage (Trigonella foenum-graecum), acacia and xanthan gum. Natural agents are prioritized due to their biodegradability, non-toxicity and superior thixotropic properties compared to synthetic alternatives. The article details comprehensive preformulation, formulation and post-formulation methods. Key evaluation parameters, containing micromeritic flow properties (Angle of Repose, bulk/tapped density), sedimentation volume (F) and in-vitro dissolution kinetics, are discussed. Findings indicate that natural polymers grant excellent physical stability and dose regularity, ensuring a long shelf life of at least two years in dry form.

KEYWORDS: Dry syrup, Natural suspending agent, Sugar-free formulation.

INTRODUCTION

Oral route of administration is the most widely favored direction due to patient convenience, safety and ease of administration. However, conventional solid dosage forms such as tablets and capsules are often unsuitable for pediatric and geriatric patients due to difficulty in swallowing.[1] Liquid dosage forms overcome swallowing difficulties but frequently suffer from poor stability, microbial growth and shorter shelf life.[2] To overcome these problems, dry syrups were developed in which the drug is supplied in dry form and reconstituted with water immediately before use.[3] Antibiotics represent the largest group of drugs formulated as dry syrups because many antibiotics undergo hydrolytic degradation in aqueous media during storage.[4]

Reconstitution dry syrups offer improved chemical stability, reduced microbial contamination, ease of transport and extended shelf life compared to liquid syrups. Azithromycin dihydrate is a semi-synthetic azalide antibiotic derived from erythromycin and belongs to the macrolide class.[5] It exerts its antibacterial action by inhibiting bacterial protein synthesis through binding to the 50S ribosomal subunit.[6] Azithromycin is widely used in the treatment of respiratory tract infections, skin infections and sexually transmitted diseases. Despite its therapeutic efficacy, azithromycin dihydrate exhibits poor aqueous solubility, bitter taste and instability in liquid formulations.[7] These drawbacks necessitate formulation of azithromycin as a dry syrup to improve stability, palatability and patient acceptance, especially in pediatric therapy.[8]

Suspending agents play a vital role in reconstituted suspensions by maintaining uniform dispersion of drug particles throughout the dosing period.[9] Synthetic

suspending agents such as sodium CMC and xanthan gum are commonly used but may cause gastrointestinal irritation and are less eco-friendly.[10] Therefore, natural suspending agents obtained from plant sources are increasingly explored due to their safety and biodegradability. Fenugreek (Trigonella foenum-graecum) seeds contain a high amount of mucilage composed mainly of galactomannan polysaccharides.[11] Fenugreek mucilage exhibits excellent swelling, viscosity-enhancing and suspending properties, making it suitable for pharmaceutical use. It is biodegradable, biocompatible, non-toxic and economical, which makes it a promising substitute to synthetic polymers.[12] The increasing prevalence of diabetes has increased the demand for sugar-free pharmaceutical formulations. Sugar-free dry syrups are particularly beneficial for diabetic patients as well as pediatric patients who require long-term antibiotic therapy.[13] Hence, the present study focuses on the formulation and evaluation of a sugar-free reconstitution dry syrup of azithromycin dihydrate using fenugreek mucilage as a natural suspending agent.[14]

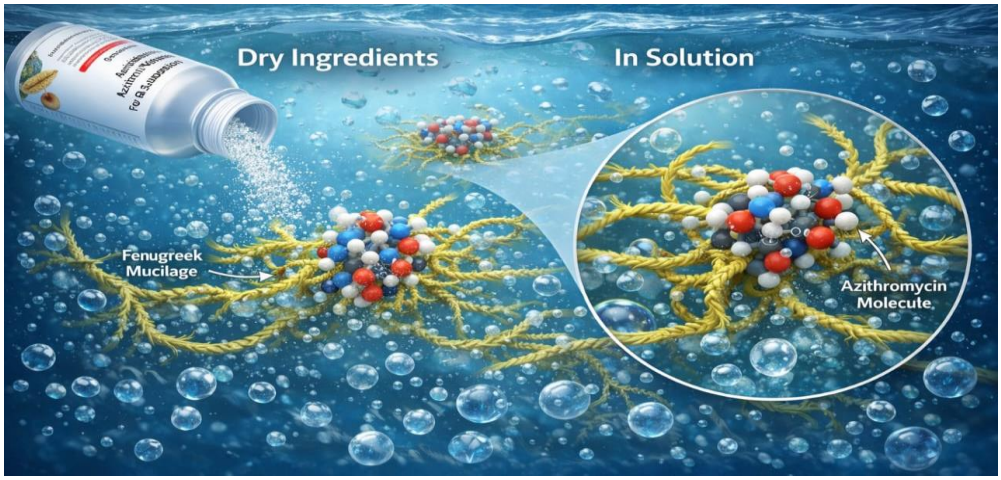

Figure 1: Schematic representation of dispersion and stabilization of Azithromycin dihydrate in aqueous medium using Fenugreek mucilage as a natural suspending agent.

ADVANTAGES

1. Sugar-free formulation is appropriate for diabetic patients as it avoids sucrose-induced hyperglycemia.[15]
2. Use of fenugreek mucilage increases formulation safety due to its natural, non-toxic and biocompatible nature.[16]
3. Dry syrup formulation improves chemical stability and shelf life of azithromycin dihydrate by preventing hydrolytic degradation.[17]
4. Natural excipients are biodegradable, eco-friendly and cost-effective compared to synthetic suspending agents.[18]
5. Improved patient compliance is achieved due to better palatability and ease of administration.[19]

DISADVANTAGES

1. Natural mucilage may show batch-to-batch variation depending on plant source and extraction conditions.[20]
2. Higher concentration of mucilage may lead to increased viscosity, affecting pourability.[21]
3. Improper reconstitution by patients may result in dosing errors.[22]
4. The reconstituted suspension has limited stability and must be used within a specified period.[23]

MATERIALS AND METHODS

MATERIALS

S.NO	MATERIALS[24]	CHARACTERS
1.	Active pharmaceutical agent (API)	Therapeutic effect.
2.	Natural Suspending agent	Increases viscosity, Retards settling.
3.	Sweeteners (Zero calories)	Masking bitterness (Zero calories).
4.	Bulking agent	Provide volume, improve flowability.
5.	Buffering agent	Maintains optimal pH stability.
6.	Preservatives	Prevent microbial growth and extend the shelf life of formulations.
7.	Stabilizer	Maintain the physical, chemical and therapeutic stability of the drug.
8.	Flavoring agent	Patient acceptability and elegance.
9.	Anticaking agent	Prevents moisture agglomeration.
10.	Wetting agent	Aids dispersion of hydrophobic drug.
11	Lubricant	Reduce friction

PREFORMULATION METHODS

IDENTIFICATION

MELTING POINT (CAPILLARY METHOD)

This method is used to determine the temperature at which a solid drug substance transitions into a liquid state, serving as a primary indicator of purity and identity. The procedure involves filling a small capillary tube (with one end closed) with a specific quantity of the drug. The tube is placed in a thermoelectric melting point apparatus, and the temperature is recorded at the moment the medication melts. A substance is considered pure if its melting point meets established pharmacopoeia standards for instance, pure cephalexin monohydrate is typically identified at a melting point of 190°C.[25]

UV ABSORPTION SPECTROSCOPY

UV Absorption Spectroscopy: This analytical technique identifies a drug by its unique light absorption pattern, specifically its absorption maximum. To determine the maximum the standard stock solution is prepared (e.g., 1 mg/ml in methanol or a buffer) and significantly diluted to a concentration range suitable for measurement, such as 2–12 µg/ml. The solution is scanned using a double-beam UV/VIS spectrophotometer across the 200–400 nm wavelength range. The resulting spectrum shows the peak absorbance wavelength, such as 271 nm for quinethazone or 232 nm for cefpodoxime proxetil, which is used for further quantitative evaluation and drug content determination.[26]

COMPATIBILITY STUDIES

FTIR SPECTROSCOPY

Fourier Transform Infrared (FTIR) Spectroscopy: FTIR is a powerful tool for chemical recognition and examining the interface between a drug and its carriers to ensure no deleterious interactions occur. Samples are typically prepared using the potassium bromide (KBr) pellet method, where approximately 5 mg of the sample is mixed with 50–100 mg of IR-grade KBr powder and compacted under vacuum/high pressure to form a transparent disc. The resultant disc is scanned in the infrared range of 500 to 4000 cm^{-1}. Compatibility is confirmed by comparing the spectra of the pure drug with its physical mixtures; the preservation of characteristic peaks (such as O-H or C=O stretching) and the absence of new peaks indicate that the drug and excipients are compatible.[27]

DIFFERENTIAL SCANNING CALORIMETRY(DSC)

DSC is an extensively used thermal analysis technique that measures the heat loss or gain resulting from physical or chemical changes in a sample as a function of temperature. A precisely weighed sample (e.g., 3–10 mg) is placed in a hermetically sealed aluminum pan and heated at a constant rate, such as 10°C or 20°C per minute, over a range from 50°C to 450°C. The test is conducted under a continuous stream of inert nitrogen gas to prevent oxidation. DSC thermograms provide insights into the crystalline or amorphous nature of the drug; a sharp endothermic peak corresponds to the drug's melting point, while a broad peak or the disappearance of the sharp peak may suggest a transition to an amorphous state or the formation of a complex.[28]

MICROMERITICS CHARACTERIZATION

Micromeritics predicts the flowability and fill uniformity of dry powder blends, which is essential for accurate dosing and high-speed manufacturing.

BULK DENSITY

The predetermined or pre weighed mass of the powder blend volume was measured for determination of bulk density

Bulk Density (Db) = (M) / (Vo)

Where,

M =Weight of the powder blend

Vo = Apparent volume of the powder blend.[29]

TAPPED DENSITY

The measuring cylinder which contains a powder sample was mechanically tapped. The initial volume was observed before tapping, the cylinder was mechanically tapped and volume readings were taken until little further volume change was observed.

Tapped density (Dt) = (M) / (Vf)

Where,

M = weight of the powder blend.

Vf = Final volume of the powder blend.[29]

CARR'S INDEX OR COMPRESSIBILITY INDEX

The Carr's Index or Compressibilty Index was calculated by the formula

I = Dt -Db / Dt ×100%

Where,

Db = Bulk density,

Dt = Tapped density.[29]

ANGLE OF REPOSE(θ)

The angle of repose of powder blend was determined by using employing fixed funnel method

Tan θ = h/r

Where,

h = height of the heap.

r = radius of the heap.[29]

SOLUBILITY STUDIES

Saturation solubility is determined by adding an excess amount of drug to various pH buffers (ranging from 1.2 to 6.8) and agitating the mixture for a specific period, such as 48 hours at 37°C. This study determines the drug's absorption window and its classification under the Biopharmaceutics Classification System (BCS) based on the dose solubility ratio.[30]

THRESHOLD BITTERNESS EVALUATION

This evaluation uses a panel of healthy human volunteers (typically 6–10 people) to find the minimum concentration at which a drug's bitterness is perceived. Volunteers hold varying concentrations of drug solutions

in their mouths for 20–60 seconds to establish a bitterness provocativeness threshold, which guides the extent of taste-masking required in the final formulation.[31]

SWELLING INDEX

The swelling index assesses the hydration capacity of natural gums, such as fenugreek mucilage, which serve as viscosifying agents. A precisely weighed amount (e.g., 1g) is placed in water and allowed to swell for 1 to 24 hours; a high index (e.g., 150%) indicates superior potential for retarding sedimentation via high viscosity.

Formula.

SI\% = [(W_2 - W_1) / W_1] \times 100

Where,

W_1 = initial weight

W_2 = hydrated weight.[32]

LOSS ON DRYING(LOD)

LOD measures the moisture content in dry mixtures by heating samples (often at 105°C) until a constant weight is achieved. Maintaining low LOD values is critical to prevent caking and powder agglomeration during long-term storage.[33]

PARTICLE SIZE ANALYSIS

Using optical microscopy, the average diameter of particles is examined (typically across at least 100–200 particles) to ensure they are within the ideal range of 0.5–5 \mum. This range is vital for ensuring rapid dissolution, high homogeneity, and preventing a gritty mouthfeel upon administration.[34]

ZETA POTENTIAL

Zeta potential measures the electrokinetic nature of particles to predict the physical stability of the reconstituted suspension. A potential of more than +30 mV or more negative than -30 mV indicates a stable system, as high surface charges prevent particle aggregation and hard caking.[35]

FORMULATION METHODS

DIRECT MIXING

Direct mixing, or powder blending, is the simplest and most economical method. It involves the geometric dilution of sieved powders where excipients present in small quantities are first mixed with a portion of a major excipient to ensure even distribution.

Equipment: V-blenders, double cone mixers, and ribbon blenders.[36]

WET GRANULATION

Wet granulation is the most common process for preparing granulated dry syrups. The ingredients are mixed with a granulating fluid (usually water, isopropyl alcohol, or an aqueous binder solution) to form a wet mass. Equipment: Planetary mixers for massing and fluid bed dryers or tray ovens for drying.[37]

DRY GRANULATION(SLUGGING)

Dry granulation involves the mechanical compression of dry powder mixtures into large compacts (slugs) without the use of liquid or heat.[37]

SOLID DISPERSION

Solid dispersion is used to improve the dissolution rate and bioavailability of BCS Class II drugs (e.g., Simvastatin) by dispersing the drug in a hydrophilic carrier.

Sub-Methods

Solvent Evaporation: Dissolving drug and carrier in a common solvent followed by evaporation.

Fusion (Melting) Method: Melting the carrier and drug together, then cooling to form a solid mass.[38]

SPRAY DRYING

Spray drying is a rapid, one-step process that converts a liquid feedstock (solution or suspension) into precise dry particles.[39]

ION-EXCHANGE COMPLEXATION

This technique is primarily used for taste masking bitter drugs (e.g., Ciprofloxacin, Azithromycin). High molecular weight polyelectrolytes (resins) exchange their mobile ions with drug molecules to form a Drug-Resin Complex (DRC).[40]

HOT MELT TECHNIQUE

Hot Melt Technique Also known as melt granulation, this method involves embedding or coating drug particles with lipid carriers, waxes, or fats that are in a molten state.[41]

LYOPHILIZATION

Lyophilization is a process used to produce dry powders that are highly stable, porous, and rapidly reconstitutable.[42]

NANOPRECIPITATION

Nanoprecipitation is used to produce particles of less than 50 nm (nanosuspensions) to improve the bioavailability of potent but insoluble drugs.[43]

Figure 2: Fenugreek seeds, coarse powder and dried mucilage powder used for preparation.

EVALUATION PARAMETERS

FLOW PROPERTIES

The flow properties such as bulk density, tap density, angle of repose and porosity of the powder mixture, granulation and combination product should be carried out.

BULK DENSITY

The predetermined or pre weighed mass of the powder blend volume was measured for determination of bulk density

Bulk Density (Db) = (M) / (Vo)

Where,

M =Weight of the powder blend

Vo = Apparent volume of the powder blend

TAPPED DENSITY

The measuring cylinder which contains a powder sample was mechanically tapped. The initial volume was observed before tapping, the cylinder was mechanically tapped and volume readings were taken until little further volume change was observed.

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ANGLE OF REPOSE (θ)

The angle of repose of powder blend was determined by using employing fixed funnel method.

Tan θ= h/r,

Where,

h = height of the heap.

r = radius of the heap.

RHEOLOGICAL BEHAVIOUR

Using Brookfield viscometer, the rheological behaviour of the oral reconstituted suspensions is determined.[44]

SEDIMENTATION BEHAVIOUR

a) REDISPERSIBILITY

It is determined by studying the number of strokes required to redisperse the formed at the end of seven days of storage. Redispersibility should be at most 100 strokes.

b) SEDIMENTATION VOLUME RATIO(SVR)

It is expressed by the ratio of the equilibrium volume of the sediment (Vu) to the total volume (Vo) of the suspension.

F=Vu/Vo

F values lie between 0 to 1 for any pharmaceutical suspension.[45]

PH VALUES

The PH of the suspensions is measured with the help of PH meter.[46]

DISSOLUTION STUDIES

The dissolution studies were performed using a US Pharmacopeia XXIV type II dissolution test apparatus. The samples equivalent to 100 mg Azithromycin Dihydrate were placed in a dissolution vessel containing 900 mL of phosphate buffer (pH 6.0) maintained at 37.0 ± 0.5oC and stirred at 100 rpm. Samples were collected periodically and replaced with a fresh dissolution medium. After filtration, concentration of Azithromycin Dihydrate was determined spectrophotometrically at 215 nm.[47]

CONCLUSION

The development of sugar-free reconstitutable dry syrups using natural suspending agents like fenugreek mucilage is a robust strategy for delivering drugs susceptible to hydrolysis. Natural polymers provide superior thixotropic and suspending properties while remaining non-toxic and cost-effective. Future research scope includes the formulation of sustained-release dry syrups to reduce dosing frequency for chronic infections in pediatric care.

REFERENCES

1. Wright CT. Design and administration of medicines for paediatric and geriatric patients. Any screen. Any time. Anywhere, 804.
2. Allen Jr LV. Dosage form design and development. Clinical therapeutics, 2008 Nov 1; 30(11): 2102-11.
3. Ola M, Bhaskar R, Patil P. Dry syrup: An overview. Indian Journal of Pharmaceutical and Biological Research, 2018 Sep 30; 6(03): 30-8.
4. Jakaria SM, Budil DE, Murtagh J. Glycopeptide antibiotic drug stability in aqueous solution. AAPS open, 2022 Dec 12; 8(1): 20.
5. Egbo HA. *Quality Evaluation of a Selection of Antibiotics Distributed in Accra (Ghana) and Lagos (Nigeria)* (Doctoral dissertation, University of Ghana).
6. Scott Champney W. The other target for ribosomal antibiotics: inhibition of bacterial ribosomal subunit formation. Infectious Disorders-Drug Targets Disorders), 2006 Dec 1; 6(4): 377-90.
7. Dhaifallah HS. Azithromycin: A Pharmaceutical Studies & Mechanisms of Action.
8. Chandramouli M, Basavanna V, Ningaiah S. A Comprehensive Review of Paediatric Drug Development: An Extensive Analysis of Present Difficulties and Prospects for the Future. Biointerface Res. Appl. Chem, 2024; 14: 145.
9. Kumar RS, Yagnesh TN. Pharmaceutical suspensions: patient compliance oral dosage forms. World Journal of Pharmacy and Pharmaceutical Sciences, 2016 Oct 19; 7(12):1471-537.
10. Berninger T, Dietz N, González López Ó. Water-soluble polymers in agriculture: xanthan gum as eco-friendly alternative to synthetics. Microbial Biotechnology, 2021 Sep; 14(5):1881-96.
11. Urooj I, Muhammad G, Irfan T, Suyama TL, Hussain MA, Amin M. Galactomannan-Based Mucilage from Trigonella foenum-graecum L.: Structural Insights, Extraction Strategies, and Applications in Food and Sustainable Biomaterials. Journal of Agricultural and Food Chemistry, 2025 Oct 21; 73(44): 27855-90.
12. Shoaib MH, Sikandar M, Ahmed FR, Ali FR, Qazi F, Yousuf RI, Irshad A, Jabeen S, Ahmed K. Applications of polysaccharides in controlled release drug delivery system. Polysaccharides: properties and applications, 2021 May 17: 607-56.
13. Arora R, Mukherjee U, Arora V. Erosive potential of sugar free and sugar containing pediatric medicines given regularly and long term to children. The Indian Journal of Pediatrics, 2012 Jun; 79(6): 759-63.
14. Alamgir AN. Drugs: their natural, synthetic, and biosynthetic sources. InTherapeutic Use of Medicinal Plants and Their Extracts: Volume 1: Pharmacognosy, 2017 Sep 8 (pp. 105-123). Cham: Springer International Publishing.
15. Giacaman RA, Pailahual V, Díaz-Garrido N. Cariogenicity induced by commercial carbonated beverages in an experimental biofilm-caries model. European Journal of Dentistry, 2018 Jan; 12(01): 027-35.
16. Ganesh MK, Cherian RK, Sivadasan SD, Aryan M, Madhavamenon KI. Safety assessment of a proprietary fenugreek mucilage composition (FenuMat®): Acute and subchronic toxicity studies. Toxicology Reports, 2025 Dec 18: 102187.
17. Ali FJ, Radhi IJ, Hamza NA, Abdulhussein NM, Abidalkareem A. A Study of The Stability And Kinetics of The Azithromycin Drug For Five Different Companies & Shelf Life Determine. Journals Kufa for Chamical, 2025 Jun 1; 4(2).
18. Chaudhari DB, Jaju SO, Rawat SS, Jaybhaye SS, Mundada JR. Overview of natural excipients: beneifts and application in pharmaceuticals.
19. Shahiwala A. Formulation approaches in enhancement of patient compliance to oral drug therapy. Expert opinion on drug delivery, 2011 Nov 1; 8(11): 1521-9.
20. Waghmare R, R P, Moses JA, Anandharamakrishnan C. Mucilages: Sources, extraction methods, and characteristics for their use as encapsulation agents. Critical Reviews in Food Science and Nutrition, 2022 May 12; 62(15): 4186-207.
21. Thanatcha R, Pranee AJ. Extraction and characterization of mucilage in Ziziphus mauritiana Lam. International Food Research Journal, 2011 Feb 1; 18(1): 201-12.
22. McDowell SE, Mt-Isa S, Ashby D, Ferner RE. Where errors occur in the preparation and administration of intravenous medicines: a systematic review and Bayesian analysis. BMJ Quality & Safety, 2010 Aug 1; 19(4): 341-5.
23. Bardeskar C, Geeverghese R. Reconstitutable oral suspensions (dry syrups): An overview. World Journal of Pharmaceutical Research, 2014 Dec 20; 4(3): 462-84.
24. Usman S, Fawzy KA, Beevi R, Usman A. Basis of pharmaceutical formulation. InNanoscale Networking and Communications Handbook, 2019 Jul 5 (pp. 281-319). CRC Press.
25. Darsaklis I. Identification of an Unknown Organic Compound by Determination of its Melting Point. Int. J. Sci. Res. in Chemical Sciences, 2025 Feb; 12(1).
26. Du J, Morales-Santelices J, Bisen OY, Antipin D, Morales DM, Risch M. In situ UV–Vis absorption spectroscopy study of the water electrooxidation on

cobalt oxide catalysts. Electrochimica Acta, 2025 Feb 1; 512: 145489.
27. Valente PA, Mota SI, Teixeira A, Ferreiro E, Sarmento H, Cipriano I, Campos JR, Rama L, Oliveira PJ. Fourier Transform Infrared (FTIR) Spectroscopy as a Tool to Characterize Exercise and Physical Activity: A Systematic Review. Sports Medicine, 2025 Feb; 55(2): 459-72.
28. Zuo CJ, Zhang CY. Standardizing differential scanning calorimetry (DSC) thermal decomposition temperatures at various heating rates of an energetic material as a threshold one. Energetic Materials Frontiers, 2025 Jun 1; 6(2): 189-94.
29. Singh A, Jezerska L, Gelnar D, Sinha MK, Kumar R. Detailed Micromeritics and Rheological Study of Mild Steel Grinding Chips: A Sustainable Feedstock for Additive Manufacturing. Journal of Materials Engineering and Performance, 2025 Mar 7: 1-3.
30. Sinha A, Bharti A, Munshi P. A Review on Solubility Studies of Industrially Important Compounds in Supercritical CO2. ChemistrySelect, 2025 Oct; 10(38): e02648.
31. Khalighi H, Mortazavi H, Anbari F, Eftekhari MS, Mohammadnia N, Mirzaei H, Nashibi S. Gustatory thresholds and obesity: a comparative study of five main tastes. BMC nutrition, 2025 Jul 21; 11(1): 142.
32. Letif M, Bahar R, Mezouar N. The use of machine learning models and SHAP interaction values to predict the soil swelling index. Periodica Polytechnica Civil Engineering, 2025; 69(1): 239-50.
33. Kiricenko K, Klinken S, Kleinebudde P. Proof of a LOD prediction model with orthogonal PAT methods in continuous wet granulation and drying. Journal of Pharmaceutical Sciences, 2025 Jan 1; 114(1): 176-84.
34. Hossein F, Errigo M, Cheng S, Materazzi M, Lettieri P, Arcucci R, Angeli P. Acoustic emission and machine learning algorithms for particle size analysis in gas-solid fluidized bed reactors. Particuology, 2025 Jun 1; 101: 155-65.
35. Yang B, He J. New insights into selective depression mechanism of Tamarindus indica kernel gum in flotation separation of fluorapatite and calcite. Separation and Purification Technology, 2025 Feb 19; 354: 128787.
36. Sankhla AM, Patel KM, Makhesana MA, Giasin K, Pimenov DY, Wojciechowski S, Khanna N. Effect of mixing method and particle size on hardness and compressive strength of aluminium based metal matrix composite prepared through powder metallurgy route. journal of materials research and technology, 2022 May 1; 18: 282-92.
37. Ranjan OP, Kumbhar AP. Dry and wet granulation. InPolymers for Oral Drug Delivery Technologies, 2025 Jan 1 (pp. 463-494). Elsevier Science Ltd.
38. Koo J, Jeon H, Cheong J, Joo Y, Han S, Kim H, Oh J, Lee D, Oh KT. Modern approaches to quality by design for amorphous solid dispersion product development: a narrative review. Journal of Pharmaceutical Investigation, 2026 Jan 19: 1-9.
39. Poozesh S, Connaughton P, Sides S, Lechuga-Ballesteros D, Patel SM, Manikwar P. Spray drying process challenges and considerations for inhaled biologics. Journal of Pharmaceutical Sciences, 2025 Feb 1; 114(2): 766-81.
40. Serrano S, O'Day PA, Vlassopoulos D, García-González MT, Garrido F. A surface complexation and ion exchange model of Pb and Cd competitive sorption on natural soils. Geochimica et Cosmochimica Acta, 2009 Feb 1; 73(3): 543-58.
41. Crowley MM, Zhang F, Repka MA, Thumma S, Upadhye SB, Kumar Battu S, McGinity JW, Martin C. Pharmaceutical applications of hot-melt extrusion: part I. Drug development and industrial pharmacy, 2007 Jan 1; 33(9): 909-26.
42. Tashish AY, Shahba AA, Alanazi FK, Kazi M. Adsorbent precoating by lyophilization: A novel green solvent technique to enhance cinnarizine release from solid self-nanoemulsifying drug delivery systems (S-SNEDDS). Pharmaceutics, 2022 Dec 30; 15(1): 134.
43. Zaibudeen AW. Recent advances in different nanoprecipitation methods for efficient drug loading and controlled release. Journal of Nanotechnology and Nanomaterials, 2025 Jul 3; 6(1): 12-25.
44. Sharma AK, Tiwari AK, Dixit AR. Rheological behaviour of nanofluids: A review. Renewable and Sustainable Energy Reviews, 2016 Jan 1; 53: 779-91.
45. Nalluri C, Alvarez EM. The influence of cohesion on sediment behaviour. Water science and technology, 1992 Apr 1; 25(8): 151-64.
46. Rodríguez-López L, Santás-Miguel V, Núñez-Delgado A, Álvarez-Rodríguez E, Pérez-Rodríguez P, Arias-Estévez M. Influence of pH, humic acids, and salts on the dissipation of amoxicillin and azithromycin under simulated sunlight. Spanish Journal of Soil Science, 2022 May 25; 12: 10438.
47. Huynh DT, Hai HT, Hau NM, Lan HK, Vinh TP, De Tran V, Pham DT. Preparations and characterizations of effervescent granules containing azithromycin solid dispersion for children and elder: Solubility enhancement, taste-masking, and digestive acidic protection. Heliyon, 2023 Jun 1; 9(6).