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Short Communication

Fabrication of highly stable sonication assisted curcumin nanocrystals by nanoprecipitation method

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ABSTRACT

Objectives: The present study was aimed to fabricate highly stable sonication assisted curcumin nanocrystals by nanoprecipitation method to overcome the poor aqueous solubility of curcumin.

Methods: Sodium lauryl sulfate coated curcumin nanocrystals and poloxamer 188 coated curcumin nanocrystals were prepared using nanoprecipitation method and characterized for particle size and related parameters.

Results: Poloxamer 188 coating has produced a significant size reduction in the distribution width (approximately 250 times in D 90) and in the average particle size (approximately 260 times in volume weight mean) with respect to pure curcumin. Similarly, sodium lauryl sulfate coating has produced a significant size reduction in the distribution width (approximately 1000 times in D 90) and in the average particle size (approximately 750 times in volume weight mean) with respect to pure curcumin. Sodium lauryl sulfate coated curcumin nanocrystals has shown a narrow distribution even after one week than the poloxamer coated curcumin nanocrystals.

Conclusions: The study concludes that the anionic nature of sodium lauryl sulfate has provided higher zeta potential and offered high electrostatic force which overcomes the van der Waals force of attraction and gravitational force leading to prevention of nanocrystal aggregation resulting in narrow sized high stable curcumin nanocrystals.

1. Introduction

Powdered rhizome of turmeric is very commonly used in India as a preservative for foods and traditionally being used in the treatment of various minor ailments including wound, ulcer and acne. The phytochemical responsible for the yellow colour and the therapeutic potential of turmeric is curcumin, which was first isolated by Vogel and Pelletier in 1818. Chemically, curcumin is bis-α, β-unsaturated β-diketone, named (E, E)-1, 7-bis (4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5 dione, which was first identified by Lampe et al in 1910. An extensive research have been carried out on curcumin and proven to possess diverse pharmacological activities including anti-oxidant, anti-bacterial, anti-fungal, anti-viral, anti-inflammatory and anti-proliferative properties and have significant therapeutic potential in various diseases including gastric ulcer, cataract, wound, gall stones, allergy, fever, inflammatory bowel disease, osteoporosis, psoriasis,

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scleroderma, atherosclerosis, diabetes mellitus, arthritis, pancreatitis, hypothyroidism, myocardial infarction, cystic fibrosis, Alzheimer's disease, epilepsy, Parkinson's disease, acquired immune deficiency syndrome and cancer.[1–3]

However, the clinical usefulness of curcumin is limited mainly due to lack of aqueous solubility. Many approaches have been tried to enhance the aqueous solubility including solid dispersion, co-solvent, microsphere, microcapsule, phospholipids complexes, cyclodextrin inclusion, liposome, polymer micelles, polymeric nanoparticles, solid lipid nanoparticles, magnetic nanoparticles, albumin nanoparticles and nanosponges. [4–8] Out of all approaches, nanoparticulate drug delivery system shows significant improvement in aqueous solubility of curcumin but possess a concern of aggregation, which may leads to decrease in the efficacy of the nanoformulation. Zeta potential (i.e. charges) on the nanoparticles decides the aggregation. Zeta potential more than ±60 mV exhibit significant stability to the nanoformulation and value around ±30 mV are quite physically stable but value below ±20 mV will undergo pronounced aggregation.[6] Hence, the present study was aimed to fabricate highly stable sonication assisted curcumin nanocrystals by nanoprecipitation method.

2. Material and methods

2.1. Materials

Curcumin and poloxamer 188 were purchased from Sigma–Aldrich, India. Sodium lauryl sulfate was purchased from S.D. Fine Chemicals, India. HPLC grade ethanol was purchased from Brampton, Canada.

2.2. Fabrication of sonication assisted curcumin nanocrystals

Sonication assisted fabrication of curcumin nanocrystals were prepared by nanoprecipitation method[9] using sodium lauryl sulfate and poloxamer 188 as stabilizers.

2.2.1. Fabrication of sodium lauryl sulfate coated curcumin nanocrystals

About 100 mg of curcumin was dissolved in 20 ml of 60% ethanol, which was then added to aqueous phase containing 100 mg sodium lauryl sulfate in 20 ml of distilled water under sonication at 40 kHz (Lark, India). Nanocrystals were formed spontaneously and turned the solution slightly turbid. However, sonication process was continued up to 60 min to evaporate residual ethanol. Prepared nanoformulation was subjected to centrifugation (Remi, India) at 19,000 rpm for about 45 min at −20 °C. Sodium lauryl sulfate coated curcumin nanocrystals were separated, washed and re-suspended in distilled water, which was stored at room temperature for about a week and characterized for particle size and related parameters.

2.2.2. Fabrication of poloxamer 188 coated curcumin nanocrystals

About 100 mg of curcumin was dissolved in 20 ml of 60% ethanol, which was then added to aqueous phase containing 100 mg poloxamer 188 in 20 ml of distilled water under sonication at 40 kHz (Lark, India). Nanocrystals were formed spontaneously and turned the solution slightly turbid. However, sonication process was continued up to 60 min to evaporate residual ethanol. Prepared nanoformulation was subjected to centrifugation (Remi, India) at 19,000 rpm for about 45 min at −20 °C. Poloxamer 188 coated curcumin nanocrystals were separated, washed and re-suspended in distilled water, which was stored at room temperature for about a week and characterized for particle size and related parameters.

2.2.3. Particle size and related parameter characterization of curcumin nanocrystals

The average particle size, distribution width, surface area and uniformity were measured using Mastersizer (Malvern, UK), which function based on laser light scattering principle. Briefly, prepared curcumin nanocrystals formulation was added drop-wise in to the distilled water of sample dispersion unit of particle size analyzer, which was equipped with a single shaft pump and stirrer to disperse the nanocrystals and re-circulate continuously through the measurement zone of particle size analyzer and reconfirmed using transmission electron microscopy (Hitachi H7500). However, zeta potential was measured using Zetasizer (Malvern, UK).

3. Result and discussion

3.1. Fabrication of sonication assisted curcumin nanocrystals

In nanoprecipitation method, organic phase containing curcumin in 60% ethanol was added at once into the aqueous phase containing stabilizer resulting in rapid miscibility of ethanol with water leading to increase in ethanol polarity,

Table 1 – Particle size and related parameters of curcumin nanocrystals.

Code	Distribution width (nm)			Mean particle size (nm)		Surface area (m^2g^{-1})	Zeta potential (mV)	Uniformity
	D 10	D 50	D 90	VWM	SWM			
Cu	21,512	65,399	219,909	126,531	46,528	0.129	–	1.37
SLS	63	117	219	166	104	57.9	−49.8	0.712
P 188	70	149	846	474	135	44.5	−9.0	2.53

D: distribution width; VWM: volume weight mean; SWM: surface weight mean; SLS: sodium lauryl sulfate; P 188: poloxamer 188; Cu: curcumin.