EXPLORING THE CURCUMIN LOADING CAPACITY OF SOLID SILICA NANOPARTICLES (SSN)

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ABSTRACT:

Silica nano has been extensively utilized as a possible medication carrier in medicine in recent years. The spherical, highly homogeneous solid-structured silica nanoparticles (SSN) that were successfully produced measure approximately 132.2 ± 1.7 nm in size. The characterization of the synthesized particles was confirmed via transmission electron microscopy (TEM), dynamic light scattering (DLS), nitrogen adsorption-desorption, and thermogravimetric analysis (TGA). The loading capacity and efficiency of SSN with curcumin (Cur) were 4.74 ± 0.10% and 21.11 ± 0.47%, respectively.

Keywords: solid silica nanoparticles, curcumin, drug loading efficiency, drug loading content.

1. Introduction

New nanomaterials with useful qualities have been created recently as a result of advancements in nanotechnology, and these materials hold promise for use in combination to treat cancer and other terminal illnesses. Nanomaterials can be used as drug carriers to prolong blood circulation time and reduce contact with normal cells. Put another way, by lowering drug side effects and either actively or passively targeting cancer cells, nanomaterials can improve the therapeutic efficacy of medications. The biomedical field has made extensive use of silica nanoparticles in recent years due to their many exceptional qualities, which include ease of synthesis and study, huge surface area and pore volume, and easy surface functionalization. Specifically, silica nano is more biocompatible than other nanomaterials like iron and silver nano [1-2].

One of the most widely used spices and dietary supplements is turmeric, which contains the bioactive ingredient curcumin (Cur). Recent research has demonstrated the possible pharmacological effects of Cur in the treatment of neurological illnesses, cancer, cardiovascular disease, inflammatory disorders, and Alzheimer's

disease. However, the primary disadvantages of Curcumin such as its instability, low solubility, poor bioavailability, and rapid metabolism-severely restrict its therapeutic applicability. Several nanotechnology-based delivery strategies have improved Cur's tissue-targeting capacity, biological activity, and oral bioavailability [3-4].

In this study, Curcumin was encapsulated into silica nanoparticles which provide promising results for Cur to improve its biological activities.

2. Experiment

2.1. Materials

All chemicals were of reagent grade and used without further purification: Tetraethyl orthosilicate (TEOS, 98%), curcumin was obtained from Sigma-Aldrich. Ammonia solution (NH3 (aq), 28%) was purchased from Merck, and ethanol (≥ 99.9%) was purchased from VWR Prolabo. Cellulose membrane MWCO 12-14 kDa (Spectrum Laboratories, Inc., Rancho Dominguez, CA 90220, USA).

2.2. Characterization

The morphology was imaged by transmission electron microscopy (TEM). Zetasizer nano ZS (SZ-100, Horiba) was used to determine the particle size and the zeta potential of the product. Thermal gravimetric analysis (TGA) was performed with a TGAnalyzer (Mettler Toledo, OH, USA) under a nitrogen flow. N2 adsorption-desorption isotherms were measured using a TRISTAR 3000 apparatus at 77 K under continuous adsorption conditions.

2.3. Synthesis of solid silica nanoparticles (SSN)

Solid silica nanoparticles were synthesized by the process in the previously reported research of the group [5]. This method includes alkyl silicate reagents, alcohol, water, and ammonia. First, ethanol (13.5 M), deH_2O (6.0 M) and NH3 (0.38 M) were stirred together for 30 min at 50oC. After that, TEOs solution (0.29 M) was mixed in under stirring at room temperature for 6 h. After membrane dialysis (MWCO 12-14 kDa), the obtained solution was freeze-dried.

2.4. Preparation of SSN-Curcumin and drug loading capacity

To evaluate the amount of encapsulated drug, dialysis method was utilized. Curcumin-loaded nanocarriers (SSN-Cur, 1:4 w/w) were put into dialysis membrane, then let diffuse in an appropriate media. At pre-determined intervals, samples of dialysis media were taken to quantification by UV-Vis spectrophotometry at wavelength 420 nm.

Drug loading efficiency - DLE and drug loading capacity - DLC were determined via the following equations:

$$DLE\,(\%) = \frac{\text{Amount of encapsulated drug}}{\text{Initial amount of drug for loading}} \times 100\% \quad (1)$$

$$DLC\,(\%) = \frac{\text{Amount of encapsulated drug}}{\text{Total amount of drug and carriers}} \times 100\% \quad (2)$$

3. Results & Discussion

3.1. TEM imaging

Particle morphology and size were observed by transmission electron microscope (TEM), figure 1 (a). The results shown that the formed nanoparticles were in spherical shape. According to the dynamic light scattering method (DLS), figure 1 (a') indicated that SSN had high uniformity, narrow particle size distribution and a particle size of about 132,2 ± 1,7 nm.

3.2. Zeta potential

Surface charges silica nanoparticles are shown by zeta potential in Figure 2. Higher electric repulsion between particles results from larger zeta potential values, which decrease aggregation

Figure 1: TEM image (a) and size distribution of solid silica nanoparticles calculated from DLS data (a')

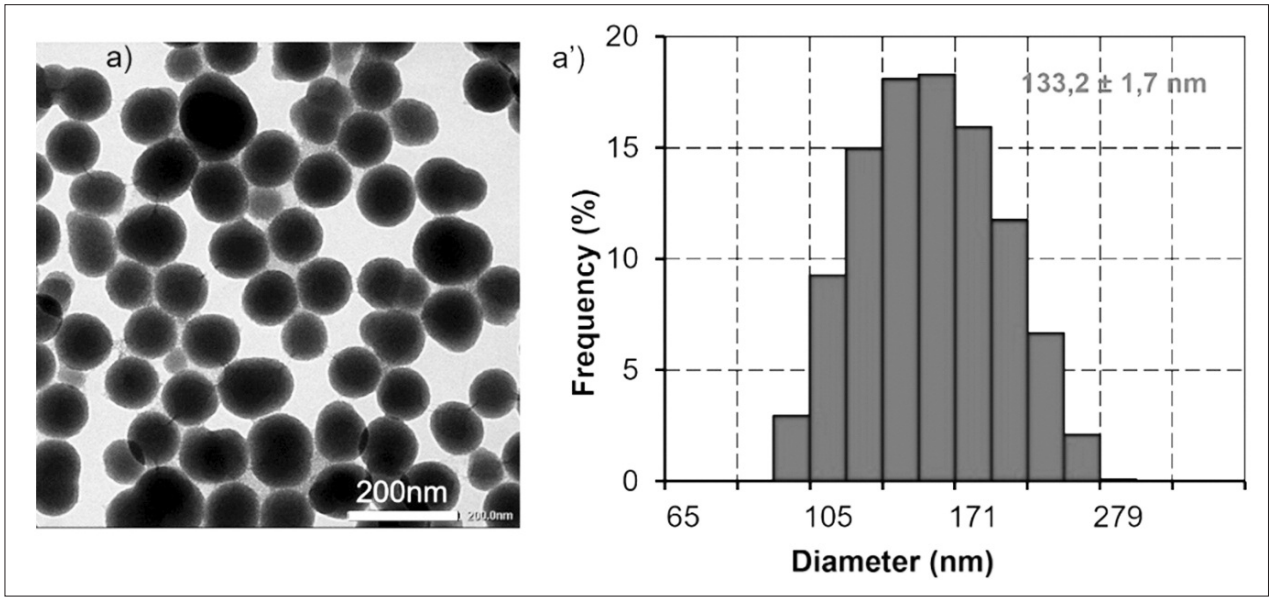
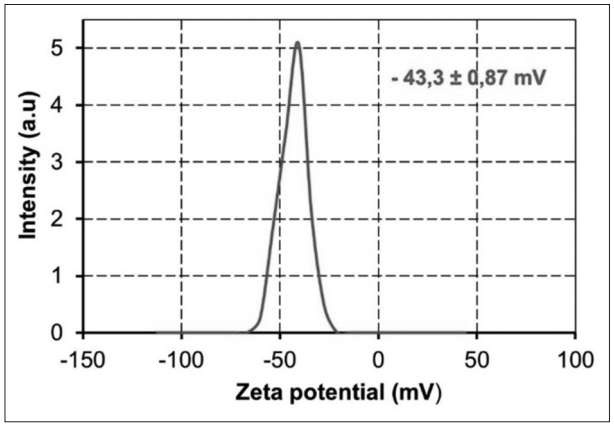


Figure 2: Zeta potential of SSN

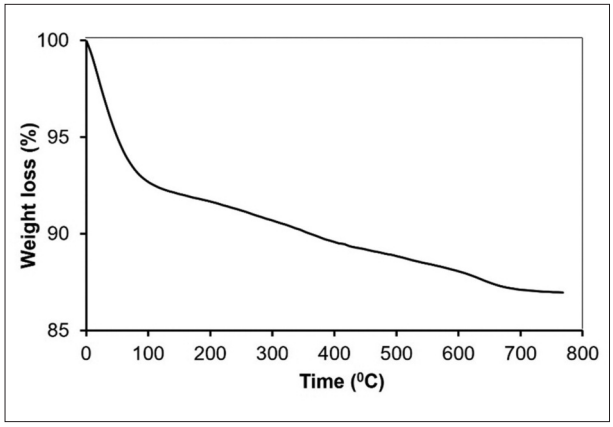


and increase particle stability and dispersion. The zeta potential of SSN was negative due to negative charges of the hydroxyl group on the surface, - 43,3.27 ± 0,87 mV.

3.2. TGA curve analysis

The SSN's TGA curve is shown in figure 3. The SSN sample was heated between 30°C and 800°C at a rate of 10°C per minute. As the processing temperature rises, the examined sample loses weight. Because of the partial dehydration (dehydroxylation) of silanol groups on the material surface and the evaporation of physically bound water, the associated weight loss is approximately 11% at temperatures below 170°C. The following 5% loss at 170°C-500°C was due to the evaporation of physically bound water, the loss of organic impurities from the starting material, or, in part, the dehydration of silanol groups within the material structure. At temperatures over 500, slight weight loss is associated with the dehydration of silanol groups inside the structure. The silanol group is not destroyed as evidenced by the heating process to 800°C.

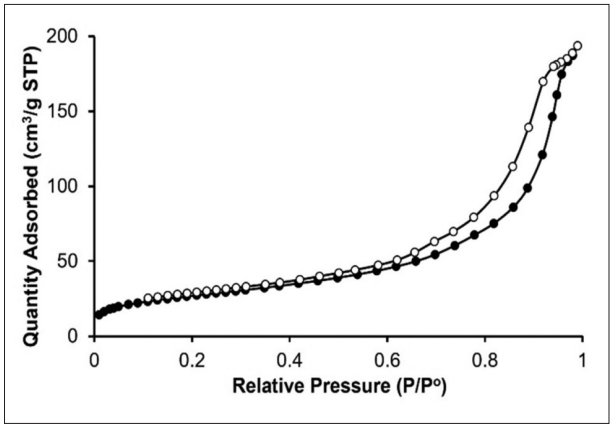
Figure 3: TGA curve of SSN



3.3. Surface area via BET method

The surface area of the material was evaluated by nitrogen adsorption-desorption and BET method (Barrett-Emmet-Taller) to be 97 m2/g. The adsorption-desorption isotherm shape can be either type I or type II based on the synthesis process [6,7]. As can be seen from figure 4, the nitrogen adsorption-desorption isotherms of SSN belong to type II, according to IUPAC classification. Furthermore, the graph displays a quite broad hysteresis loop in the desorption branch, which may be due to the gaps formed at the surface between spherical nanoparticles.

Figure 4: Nitrogen adsorption-desorption isotherms of SSN



3.4. Drug loading efficiency and capacity

With the greatest absorption wavelength at 420 nm, UV-Vis ultraviolet-visible spectroscopy was used to evaluate the Dox concentration of the nanocarrier system. To create a standard curve, pure Dox was dissolved in deionized water at concentrations ranging from 0 to 5 µg/ml.

DLE and DLC are crucial values in the design of drug delivery systems since they have a direct impact on the effectiveness of the system. Using the abovementioned equations, these parameters were determined directly from the quantity of Curcumin contained within the particles. The DLE and DLC of synthesized SSN were 21.11 ± 0.47% and 4,74 ± 0.10 %, respectively.

4. Conclusion

In this study, solid silica nanoparticles were successfully synthesized via the Stober method. TEM imaging showed that the synthesized particles had spherical and high drug loading capacity. Scientists are currently interested in using nanoparticles as "carriers" to transport medications to the appropriate region. The analysis above's findings indicate that silica nanoparticles promise a potential material for medication delivery systems ■

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KHẢO SÁT KHẢ NĂNG MANG TẢI CURCUMIN CỦA NANO SILICA CẤU TRÚC RẮN (SSN)

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TÓM TẮT:

Trong những năm gần đây, vật liệu nano silica được sử dụng rộng rãi như một chất mang thuốc trong y học. Các hạt nano silica cấu trúc rắn (SSN) được tổng hợp thành công có dạng hình cầu với độ đồng nhất cao (SSN), kích thước hạt tạo thành khoảng 132,2 ± 1,7 nm. Hình thái, đặc trưng tính chất vật liệu được đánh giá thông qua kính hiển vi điện tử truyền qua (TEM), tán xạ ánh sáng động (DLS), hấp phụ - khử hấp phụ khí N_2 và phân tích nhiệt khối lượng (TGA). Hiệu suất và khả năng mang tải Curcumin (Cur) của SSN lần lượt là 4,74 ± 0,10 % và 21,11 ± 0,47%.

Từ khóa: Hạt nano silica cấu trúc rắn, Curcumin, hiệu suất mang thuốc, khả năng mang thuốc.