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SYNTHESIS AND CHARACTERISATION OF (MSNs) MESOPOROUS SILICA NANOPARTICLES

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ABSTRACT: Mesoporous silica nanoparticles are one of the widely used as carriers for drugs classified for different categories like NSAIDs, cancer, *etc*. They are synthesized by using four major materials, which include a surfactant, solvent, a silica source, and acidic or basic catalyst. By step by step, the addition of all MSNs is formed. The main part in synthesis is played by room temperature and particle size with its stability in solid form. They are characterized by using different instruments, which include ultraviolet (UV), FT-IR (Fourier transform- Infrared), SEM (Scanning Electron Microscopy).

Keywords: MSNs, Ibuprofen, Synthesis, Characterization

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INTRODUCTION: Silicon is the second abundant element in the earth's crust after oxygen. Silicon occurs as oxygen-containing compound termed Silicon dioxide (SiO_2), which is known as silica. The first mesoporous silica nanoparticles (MSN) were developed by Mobil Oil Corporation (Mobil) scientists in 1992. This was named M41S series (the Mobil 41Series), their pore diameters ranged from 15Å to 100Å [1, 2]. Mesoporous silica nanoparticles (MSNs) have been intensively explored in materials research due to their unique properties, such as high surface areas, large pore volumes, tunable pore sizes with a narrow distribution and tunable particle diameters [3, 4].

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MSNs with controlled properties can be extended to a wide range of applications, such as drug delivery, catalysts supports, adsorption and separation of proteins, cell imaging, cell labeling, enzyme adsorption and immobilization [5]. More specifically, the potential utilization of MSN materials in medical and pharmaceutical drug delivery systems is well documented [6-14].

The suitability of MSN for important biotechnological and biomedical applications is also due to their small size, which allows facile endocytosis by living animal and plant cells without any significant cytotoxicity. Mesoporous silica materials with different morphologies, such as sphere [15], fibers [16], film [17], and vesicles [18] have been developed.

However, one of the main and specific of drug delivery system using Mesoporous materials is the pore sizes which could not encounter all types of desired drugs which consist of bulky and different features.

Mesoporous silica structures have been known to materials scientists for over 40 years when the term was first coined to describe zeolite-silica gel mixtures with a well-defined and uniform porosity [19]. It was not until 1992, following the near-simultaneous discovery of organic-templated mesoporous silicas by two groups of scientists that researchers outside the field of materials engineering and petrochemicals began to take notice of these unique materials [20, 1]. The idea that mesoporous silica nanoparticles (MSNs) could be used as drug delivery devices would have to wait another 6 years until 199 when a patent was filed by Muller, Reck, and Rose stating that mesoporous silicates might contain pharmacologically active substances [21] and again speculated upon by Schuth and colleagues [22]. The first account of MSNs with the ability to release a drug molecule was published in 2001 by Balkus and colleagues using the material known as Dallas Amorphous Material-1 (DAM-1) [23].

MSN of various types and exhibiting different properties have previously been synthesized via different methods, such as plasma synthesis chemical vapor deposition, microemulsion processing, combustion synthesis, sol-gel, hydrothermal techniques, etc. Recent efforts for the preparation of nanoparticles are focused on controlling size, morphology and surface reactivity of nanoparticles [24- 34].

The Sol-gel method has been widely used and a method of choice for the preparation of nanoparticles, as it has several advantages such as synthesis may be carried out at low temperature, desired pH to yield high purity and also, the reaction kinetics of the process may be controlled by varying the composition of the reaction mixture. Mainly four ingredients are necessary for the formation of mesoporous silica materials: a surfactant, silica source, an acid or base catalyst and a solvent like ethanol or water.

Ibuprofen (IBU) [(±)-2-(4-isobutylphenyl)] propionic acid (I) is an orally administered drug belongs to a class of non-steroidal anti-inflammatory drugs (NSAIDs), which are used to reduce the pain and swelling. It is considered to be the prototype for the family of synthetic 2 -aryl propionic acids, profens, a sub-class of the non-steroidal antiinflammatory drugs (NSAIDS). In recent, they are used to treat arthritis, muscular strain, cephalalgia, and others. Some of the available profen drugs are ibuprofen, naproxen, ketoprofen, and flurbiprofen [35]. Ibuprofen is distributed over the counter and belongs to the top-ten of drugs marketed worldwide in 1989. IBU is a poorly water-soluble drug [36].

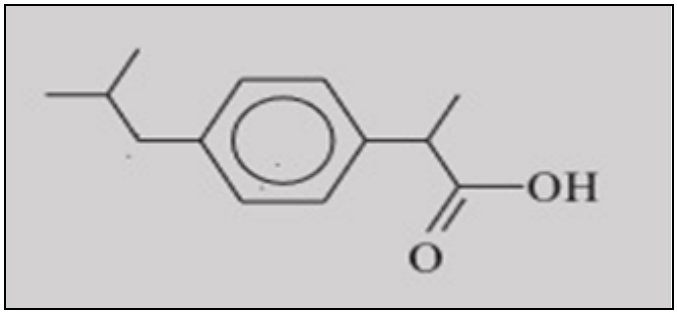

FIG. 1: CHEMICAL STRUCTURE OF IBUPROFEN

It is used to relieve the symptoms of a wide range of illnesses such as headaches, backache, period pain, dental pain, neuralgia, rheumatic pain, muscular pain, migraine, cold and flu symptoms and arthritis [37]. Ibuprofen has only 2 hr as biological half-life; this shorter biological half-life makes it a suitable drug for sustained or controlled drug delivery system development. Therefore, ibuprofen has been commonly employed as a model drug in the development of sustained/controlled releases further to this its structural feature makes it easy to accommodate into the MSNs [38].

In the present work, we studied the preparation of MSNs by using Tween 20 and 80 as surfactants and ibuprofen as a drug to be carried.

Experimental:

Materials: A surfactant such as Tween 20 (Polyoxyethylene (20) sorbitan monolaurate) was obtained from HiMedia laboratories Ltd, Mumbai, Tween 80 (Polyoxyethylene (20) sorbitan monooleate was obtained from s.d. fine- chem. Ltd., Mumbai. Silica source which is Tetraethylorthosilicate (TEOS) was obtained from Yarrowchem products, Mumbai. Sodium hydroxide (NaOH) was obtained from Hi-Tech Laboratories, Delhi. Deionized water was obtained from HiTech Laboratories, Delhi and distill water was obtained from the Innovation center, Bundelkhand University, Jhansi.

Synthesis of MSNs: General sol-gel method was employed for the synthesis of Mesoporous silica nanoparticles. MSNs were prepared by dissolving Tween 20 and Tween 80 (11g) in deionized water (490 ml), then 2M NaOH (13.5g) added at 80 °C with stirring. TEOS (15 g) was added dropwise in vigorous stirring solution at 80°C for 4 h.

FIG. 2: VOLUMETRIC FLASK CONTAINED MSNs IN SOLUTION FORM

Cooled the solution formed and filtered, then washed with ethanol (10 ml) many times.

FIG. 3: FILTERED AND WASHED

Then it was dried in a vacuum oven (63°C). For surfactant removal, calcination process at 540°C was done.

Loading of the drug in MSNs: Ibuprofen (150 mg) was dissolved in ethanol (10 ml), and to that solution, dried Mesoporous silica sample (150 mg) was added. Ibuprofen loaded MSNs were recovered by filtration followed by washing with ethanol and dried for 24 hours at 40 °C.

FIG. 4: DRIED MSNs WITH DRUG

Characterization: Here we used Ultra-Violet spectroscopy (UV) Varioskan Flash 4.00.53 (Innovation center, BU, Jhansi) to determine the λ_{max} of samples and obtain the calibration curve of IBU. Solartron Analytical FT-IR spectrometer with model number 1255B (IIT, Kanpur) for recording infrared (FT-IR) spectra of the samples. Scanning electron microscopy (SEM) Carl Zeiss EV018 (IIT, Kanpur) used to study the morphology of the MSNs synthesized for which sample preparation was done by dispersing a little amount of sample in water. A thin film of the homogenous sample solution was deposited and air dried on the reflective surfaces of silicon wafer for SEM analysis.

RESULT AND DISCUSSION:

Microscopy Observation: SEM image discloses the particle diameter of MSNs. Particle diameter was 200 µm.

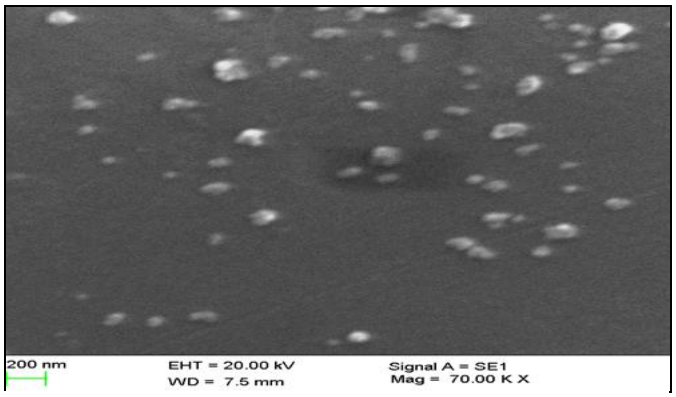

FIG. 5: SEM IMAGE SHOWING PARTICLE DIAMETER

λ_{max} of the pure drug as well as ibu loaded nanoparticle were taken by UV spectroscopy. The drug-loaded silica shows similar absorbance spectrum with ibuprofen in liquid media at the peak around 264 nm.

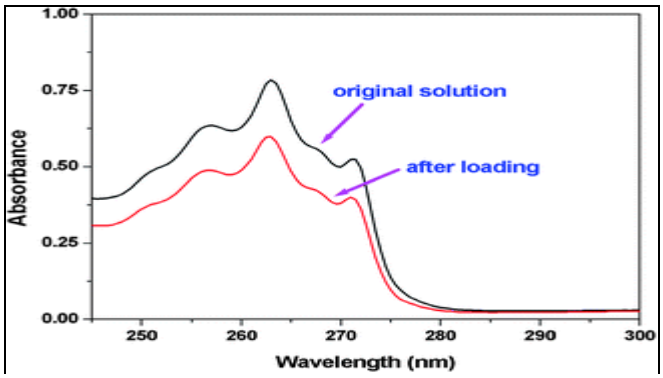

FIG. 6: UV SPECTRA OF PURE IBU WITH MSN LOADED IBU

FT-IR spectra represent the MSNs loaded drug. The ibu loaded silica in this figure the bands at around 1720 cm^{-1} is proved the presence of carboxyl group vibration, and the vibration bands from 2950–2850 cm^{-1} is proved the presence of C–H stretching vibrations of Ibu. These bands provide the information of ibuprofen loading into the silica. Remaining bands from 795 and 465 cm^{-1} were attributed to Si–O–Si, and the band at 964 cm^{-1} is for Si–OH.

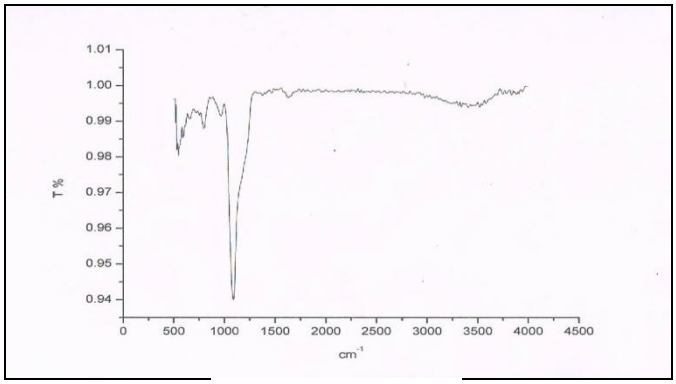

FIG. 7: IR SPECTRA

CONCLUSION: In our present study, we synthesized Mesoporous silica nanoparticles with tween 20 and 80 as surfactant and ibuprofen as a drug for loading. The nanoparticles obtained were in Mesoporous silica nanoparticles range, *i.e.*, 50 – 500 nm and the wavelength at which peaks were obtained of pure drug and MSN loaded with the drug was 264 nm. So, we can say that the MSNs formed by using Tween 20 and 80 with Ibuprofen as a drug to be loaded was successful.

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CONFLICT OF INTEREST: Nil

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