Synthesis of Novel Virus-like Mesoporous Silica-ZnO-Ag Nanoparticles and Quercetin Synergize with NIR Laser for Omicron Mutated Covid-19 Virus Infectious Diseases Treatment

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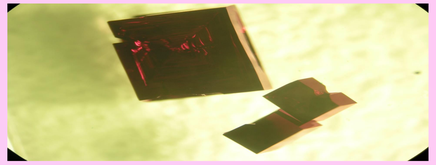

Abstract

This work shows that novel virus-like mesopore silica-zinc oxide/Ag nanoparticles (SZnOAg) synthesized and professionally collected on NIR laser irradiation with quercetin to improve their effectively eliminates the virus as a biomedical application. The properties of the nanoparticles can be tuned with respect to their core diameter, tubular length, and outer diameter. Due to their biomimetic appearance, they can rapidly transform living cells into virus-like particles, this SZnOAg nanomaterial has specific elimination effect on bacteriophage and covid-19. Using epitaxial growth, we can construct virus-like structures that can be used for biomedicine applications. These nanomaterials and NIR laser could open the way to a new range of antiviral materials, due to the low-efficiency cellular uptake of current nanoparticles, their applications in the biomedical field are limited. Herein, it is clearly shown that novel mesoporous silica nanoparticles can be easily exhibited superior cellular uptake property. In this work, uniform ease synthesized virus-like mesoporous silica-zinc oxide with Ag nanoparticles (SZnOAg) have been successfully synthesized using a single micelle epitaxial culture reaction. The nanoparticles were fully developed and exhibited uniform surface characteristics via a novel single micelle epitaxial growth approach in a low-surfactant-concern oil/water bi-phase reaction system, with the using of hexadecyltrimethylammonium bromide (CTAB) as a structural template and tetraethyl orthocarbonate (TEOC) as a precursor. The virus-like particles of mesoporous silica exhibit a uniform particle size and a well-controllable inner diameter.

Antibacterial activity

Antibacterial activity of the synthesized SZnOAg was studied by the standard disc diffusion method. The dilutions of biosynthesized ZnNPs varying from 5 mg, 10 mg and 15 mg/mL were prepared with two-fold symmetry. 30 mL of molten sterilized nutrient agar solution was poured into each Petri plates and seven organisms were grown in them. The tested organisms were inoculated in four discs (5 mm diameter), which is dipped in different dilutions of SZnOAg (5 mg, 10 mg and 15 mg/ml) solutions, and another disc was dipped in 2 mg/ ml of antibiotic Ofloxacin. Each Petri plate was loaded with four discs. The plates containing the bacteria and ZnNPs were incubated at 37°C, and then examined for confirmation appears as a clear area around the disc. The diameter of such zones of inhibition was measured using a meter ruler, and the mean value for each organism was recorded and expressed in millimeters.

Analysis

In this framework, experimental results have demonstrated that quercetin exerts strong inhibitory effects on ACE2 in vitro, and in vivo when tested in rats.33 Furthermore, the screening of a library of 150 compounds, allowed the identification of quercetin as a potent inhibitor of SARS-CoV-2 3CLpro. Taken together, these results suggest that quercetin may prevent the entry of SARS-CoV-2 in the host cell, binding the S-protein and inhibiting ACE2 receptors. Figure 1, Quercetin and virus-like mesoporous silica-ZnO-Ag nanoparticles with inner portions of the silica nanospheres consist of ZnO/Ag cubic cluster with hexadecyltrimethylammonium bromide (CTAB) as a structural template and tetraethyl orthocarbonate (TEOC) as a precursor. X-ray diffraction pattern of zinc oxide nanorod arrays as shown in Figure 2.

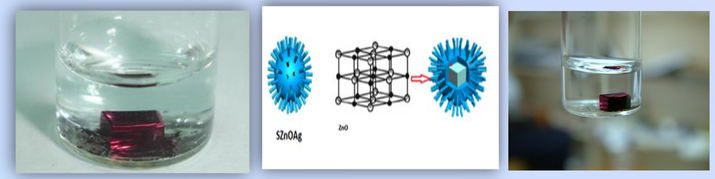

Figure 1: Quercetin and virus-like mesoporous silica-ZnO-Ag nanoparticles with inner portions of the silica nanospheres consist of ZnO/Ag cubic cluster with hexadecyltrimethylammonium bromide (CTAB)

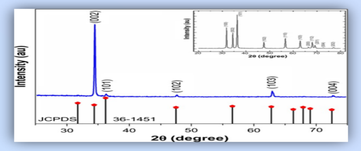

Figure 2: X-ray diffraction pattern of zinc oxide nanorod arrays.

Omicron virus-like nanomaterials and NIR-Laser system

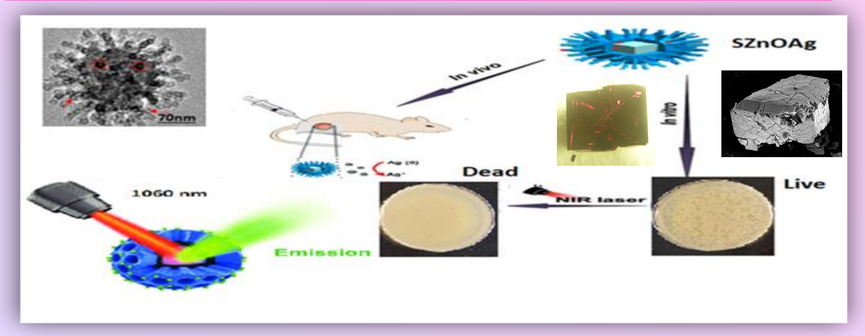

Figure 3: Schematic description of photothermal effect of the quercetin and SZnOAg under NIR laser irradiation (1060 nm) and its synergistic antiviral effects.

The oil phase was adopted in the upper of the beaker to be a (TEOC) solution in hydrophobic organic solvent (such as cyclohexane), while the bottom water phase was an aqueous solution of cationic surfactant (CTAB) as a template and NaOH as a catalyst. Quercetin exerts strong inhibitory effects on ACE2 in vitro, and in vivo when tested in rats. Furthermore, the screening of a library of 150 compounds, allowed the identification of quercetin as a potent inhibitor of SARS-CoV-2 3CLpro. Taken together, these results suggest that quercetin may prevent the entry of SARS-CoV-2 in the host cell, binding the S-protein and inhibiting ACE2 receptors.

Materials Wild-type T7 bacteriophage (4.8 × 1012 pfu ml-1) was prepared by using a T7 select packaging kit (Novagen). Zinc oxide (purity = 95%), SiO_2 (purity = 99.99%), Zn nanomaterial was synthesized with (purity =98.5%). The measured temperature of the solutions (away from the laser beam) at 1 min intervals by using a mercury thermometer. 2.5. Temperature assay We irradiated solutions of complex (300 μg ml-1) in PBS (1 ml) by using a 1060 nm laser (5 W) as shown in Figure 3.

Morphology, crystallinity, particle size distribution

Transmission electron microscopy (TEM) (Figure 4) images of the obtained mesoporous silica nanoparticles clearly show a unique virus-like morphology with a uniform particle size of ~120 nm. Quercetin is one of the most important flavonoids and belongs to the class of flavanols. The resulting nanoparticles exhibited uniform particle size and good mono-dispersibility. Synthesized ZnO nanoparticles generated spherical cluster shapes up to 3 μm with an average size was 48.3±3.5 nm in diameter with a narrow size distribution.

Figure 4: Left, temperature curves for a solution of NIR laser-induced exothermicity of SZnOAg and quercetin SZnOAg-virus complex (concentration = 300 μg ml−1) , right TEM image of mesoporous silica-zinc oxide nanomaterials.

Characterization techniques

Scanning electron microscopy (SEM) image of mesoporous shows interior spherical mesoporous silica cores with a diameter of ~110 nm; (ii) separated peripheral silica nanotubes perpendicular to the core surface with a length of ~35 nm and outside/inside diameters of 10/2.5 nm, respectively. The size of the mesoporous silica cores can be tuned from ~60 to 160 nm by changing the feeding amount of the surfactant (CTAB) as in Figures 5 and 6.

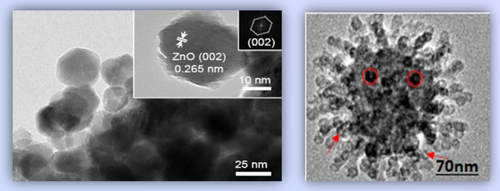

Figure 5. FE-TEM images with crystallinity and electron diffraction.

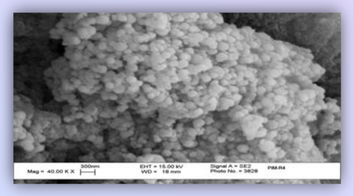

Figure 6: SEM image of mesoporous silica-zinc oxide nanomaterials

Structure and (DLS) Analysis

The instrument can measure the particle size of samples suspended in liquids in the range of 0.1 nm to 12.3 μm with sample suspension concentrations from 0.00001% to 40%, plus a sensitivity for molecular weight to as low as 250 Da. Dynamic light scattering is a widely used technique for the determination of particle size in colloidal solution. The average size of the particles, size distribution, and polydispersity index (PDI) of the synthesized zinc oxide nanoparticles were determined by this technique and the results are shown in Figure 7. The resulting particle size of zinc oxide nanoparticles exhibits the size distribution starting from 78 to 145 nm.

The XRD patterns of SZnOAg exhibit the face-centered cubic structure corresponding to the reflection peaks are observed with 2θ values and indexed crystal planes are shown in Figure 8.

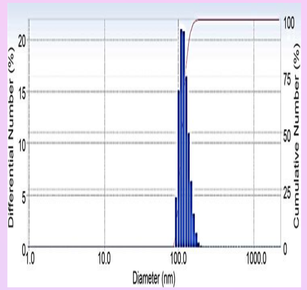

Figure 7. Size distribution of SZnOAg

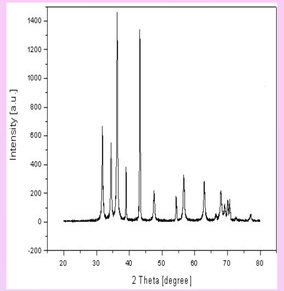

Figure 8. XRD diffraction pattern of the SZnOAg

Aim of the Work

Inhibit virus spreading by using omicron virus-like nanomaterials and NIR-Laser system. Uniform virus-like mesoporous silica-zinc oxide nanoparticles can be synthesized in a bi-phase reaction system with a low surfactant concentration, which allows the assembly of reactants to take place at the oil−water interface for continuous interfacial growth. The virus-like nanoparticles' rough surface morphology results mainly from the mesoporous silica nanotubes spontaneously grown via an epitaxial growth process. The biomimetic morphology, the virus-like nanoparticles show greatly superior cellular uptake properties (invading living cells in large quantities within few minutes, <5 min), unique internalization pathways, and extended blood circulation.

Conclusions

The high-efficiency cellular uptake of synthesized nanomaterial quercetin-SZnOAg-virus complex with excellent applications in the biomedical field was verified. The novel mesoporous silica nanoparticles can be easily synthesized and exhibited superior cellular uptake property, which on NIR laser irradiation effectively eliminates the virus. These results strongly suggest that functional nanomaterials could soon be produced that exhibit photo-exothermic elimination of harmful viruses, such as HIV, SARS, and avian influenza virus. The present work makes important progress for biomedical applications of nanomaterials in the field of omicron mutated Covid-19 antiviral material.

References

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Acknowledgments

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