Global Journal of Translational Medicine

*Research Article*

# Quantum Plasma Silica Nanomaterials: A Versatile Platform for Biomedical and Environmental Applications

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## ABSTRACT

This manuscript presents a comprehensive investigation into the development and multifunctional applications of proprietary silica ($SiO_2$)-based nanomaterials, including OCTA-H. We detail the significant antiviral efficacy of OCTA-H and its derivatives against Herpes Simplex Virus Type 1 (HSV-1), demonstrating superior viral inhibition. Furthermore, the virucidal potential of $NA_2SiO_3/SiO_2/TiO_2$ nanocomposites against SARS-CoV-2 is established, showing a remarkable 98.2% reduction in viral load. In oncology, these silica nanocomposites exhibit potent, targeted anticancer activity against breast and liver cancer cell lines. The multifunctionality of these engineered materials is underscored by their synthesis via a controlled quantum plasma process, yielding tailored physicochemical properties. While promising applications in environmental remediation and radiation shielding (OCTA Stone Block) are noted, this work primarily focuses on and substantiates the biomedical potential of silica nanomaterials for developing next-generation therapeutic and preventive solutions.

## Keywords

Quantum Plasma, Silica Nanomaterials, OCTA-H, $NA_2SiO_3/SiO_2/TiO_2$.

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**Received:** Januaryr 05, 2026; **Accepted:** February 16, 2026; **Published:** February 28, 2026



**Citation:** Hesham Mohamed Abdal-Salam Yehia. Quantum Plasma Silica Nanomaterials: A Versatile Platform for Biomedical and Environmental Applications. Trends Global J Transl Med. 2026;2(1):1-13.

## Introduction

The COVID-19 pandemic has been the biggest test modern global healthcare systems have ever faced. It has exposed stark inequalities and systemic problems, leaving many systems exhausted and struggling to recover. However, the pandemic has also demonstrated the effectiveness of new ways of working and digital tools in addressing some of the challenges facing the healthcare industry. It has also spurred innovation in science, pharmaceutical development, distribution, and delivery.

The challenges facing the global health and healthcare sector are set to continue in the future. Near-term issues include deteriorating mental health, healthcare workforce shortages, supply chain disruptions, climate change-related challenges, and macroeconomic instability. Long-term challenges include increasing demand for services, a growing financing gap, lack of incentives for innovation, widening health and wellness disparities, and uneven access to advanced treatments.

These complex and interconnected challenges have made the restructuring of healthcare systems a pressing global concern. This overview manuscript provides a comprehensive analysis of recent trends and advancements in the field of medical science. It highlights two specific areas of research: the evaluation of OCTA-H and Octa-Gel as potential antiviral agents against Herpes Simplex Virus Type 1 (HSV-1) infection, and the evaluation of OCTA Stone Block as an innovative radiation shielding material.

This paper focuses on the development of effective antiviral treatments for HSV-1, a common human pathogen that causes cold sores, fever blisters, and more severe infections such as herpes encephalitis and ocular herpes. The efficacy of OCTA-H and Octa-Gel in inhibiting viral replication and reducing cytopathic effects caused by HSV-1 infection is assessed. The findings suggest that OCTA-H holds promise as a potential antiviral agent for further development in the fight against HSV-1.

The aim of this paper was to address the need for efficient radiation shielding materials to manage radiation contamination resulting from nuclear accidents and industrial mishaps. Traditional shielding materials have limitations in terms of weight, cost, and implementation. The evaluation of OCTA Stone Block, a novel material, in absorbing external radiation contamination, specifically Cesium-137, is conducted. The study aims to contribute to the development of practical solutions for radiation shielding and contamination management.

Overall, this paper provides valuable insights into the ongoing research and advancements in medical science, offering potential solutions to combat viral infections and enhance radiation safety.

## DNA and RNA Viruses

Viruses are small infectious agents that can only replicate inside the living cells of other organisms, such as animals, plants, fungi, or bacteria. They are composed of a core of genetic material, either DNA (deoxyribonucleic acid) or RNA (ribonucleic acid), surrounded by a protective coat of protein called a capsid.

While all viruses share these basic characteristics, there are some fundamental differences between viruses that have DNA as their genetic material and those that have RNA. Understanding these differences is crucial for understanding viral biology, evolution, and the development of effective treatments and prevention strategies.

## Genetic Material

The primary distinction between DNA and RNA viruses lies in the nature of their genetic material. DNA viruses use DNA as their genetic code, while RNA viruses use RNA. DNA is a double-stranded molecule that can store and transmit genetic information. It is the primary genetic material in most living organisms, including humans, plants, and animals. DNA viruses, such as the herpes simplex virus and the smallpox virus, use this double-stranded DNA as their genome as depicted in Figure 1.

On the other hand, RNA is a single-stranded molecule that also carries genetic information, but it is generally less stable than DNA. RNA viruses, such as the influenza virus and the SARS-CoV-2 virus (which causes COVID-19), use this single-stranded RNA as their genetic material.

The differences in genetic material between DNA and RNA viruses also lead to distinct replication mechanisms. DNA viruses replicate their genetic material using the host cell's own DNA replication machinery. They typically enter the host cell's nucleus, where the cellular enzymes and resources are available for DNA replication. Once inside the nucleus, the viral DNA integrates with the host's DNA and uses the host's cellular machinery to produce new viral particles.

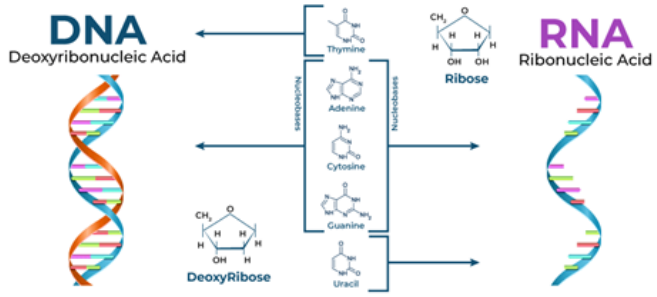


**Figure 1:** Difference between DNA and RNA Viruses.

## Replication Mechanisms

In contrast, RNA viruses replicate their genetic material within the cytoplasm of the host cell, without entering the nucleus. They use their own RNA-dependent RNA polymerase (RdRp) enzyme to make copies of their RNA genome. This process occurs in the cytoplasm, where the host cell's resources are utilized to produce new viral particles.

The replication mechanisms of DNA and RNA viruses also differ in their error rates. DNA replication is generally more accurate, with proofreading and repair mechanisms that help maintain the integrity of the genetic material. RNA replication, on the other hand, is more error-prone, as RNA polymerases lack the same proofreading and repair capabilities. This higher error rate in RNA viruses contributes to their faster evolution and adaptation to changing environments.

## Genome Size and Complexity

DNA viruses tend to have larger and more complex genomes compared to RNA viruses. The genome size of DNA viruses can range from a few thousand base pairs to over a million base pairs, allowing them to encode a wide range of proteins and functions. In contrast, the genomes of RNA viruses are generally smaller, typically ranging from a few thousand to tens of thousands of base pairs. This smaller genome size is a result of the higher error rate during RNA replication, as larger genomes would be more susceptible to mutations and potentially less viable.

The larger genome size of DNA viruses also allows for greater genetic complexity, with the ability to encode more genes and a wider variety of functions. This complexity can translate into a broader range of capabilities, such as the ability to evade host immune responses, establish persistent or latent infections, and even integration with the host's genome.

## Transmission and Host Specificity

DNA and RNA viruses can also differ in their modes of transmission

and host specificity. DNA viruses are generally more stable and can survive better in the environment outside of a host cell. This allows them to be transmitted more efficiently through various routes, such as direct contact, airborne droplets, or contaminated surfaces. Many DNA viruses, such as the herpes simplex virus and the hepatitis B virus, can also establish latent infections, where the virus remains dormant in the host's cells for extended periods before reactivating.

RNA viruses, on the other hand, are more fragile and have a shorter lifespan outside of a host cell. They are often transmitted through more direct routes, such as respiratory droplets or bodily fluids. RNA viruses, like the influenza virus and the SARS-CoV-2 virus, are known for their ability to rapidly mutate and adapt, which can lead to the emergence of new strains and outbreaks.

Additionally, DNA viruses tend to have a narrower host range, often infecting specific species or closely related groups of organisms. In contrast, RNA viruses generally have a broader host range and can more easily cross the species barrier, potentially leading to zoonotic infections (infections that can be transmitted from animals to humans).

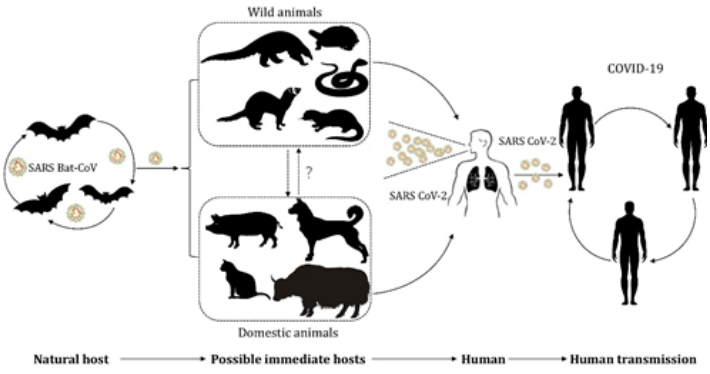


**Figure 2:** The potential transmission of SARS-CoV-2 between hosts and humans. SARS-CoV-2, the virus that causes COVID-19, is believed to have originated from a bat-borne coronavirus. Through a process of mutation and recombination, the virus was able to adapt and infect other animal species, eventually making the jump to humans. The emergence of SARS-CoV-2 is thought to be linked to wildlife trade and the close interaction between humans and wild animals. In this environment, the virus had the opportunity to cross the species barrier and infect humans, as well as domestic animals [1].

Source: Zhao, J., Cui, W., & Tian, B. P. (2020). The potential intermediate hosts for SARS-CoV-2. Frontiers in microbiology, 11, 580137. https://doi.org/10.3389/fmicb.2020.580137

## Implications for Treatment and Prevention

The differences between DNA and RNA viruses have significant implications for the development of effective treatments and prevention strategies. For DNA viruses, antiviral drugs that target specific steps in the viral replication process, such as DNA synthesis or integration, have been more successful. Examples include acyclovir, which is used to treat herpes simplex virus infections, and lamivudine, which is used to treat hepatitis B. Additionally, vaccines that stimulate the immune system to recognize and respond to specific DNA viral antigens have been widely used to prevent infections, such as the hepatitis B vaccine.

In contrast, the higher mutation rate and shorter replication time of RNA viruses make them more challenging to treat and prevent. Antiviral drugs targeting RNA viruses often have a shorter lifespan, as the viruses can quickly develop resistance. Developing effective vaccines for RNA viruses can also be more complex, as the rapid evolution of these viruses can lead to the emergence of new strains that evade the immune response.

However, the COVID-19 pandemic has highlighted the rapid development of RNA virus-based vaccines, such as the mRNA vaccines produced by Pfizer-BioNTech and Moderna. These vaccines leverage the RNA virus's ability to rapidly produce specific viral proteins, which then stimulate the immune system to generate a protective response.

In short, the fundamental differences between DNA and RNA viruses, in terms of their genetic material, replication mechanisms, genome size and complexity, transmission, and host specificity, have significant implications for their biology, evolution, and the development of effective treatments and prevention strategies.

## Herpes Simplex Virus Type 1

Herpes simplex virus type 1 (HSV-1) is a common human pathogen belonging to the Herpesviridae family as shown in Figure 3. It primarily infects the mouth, pharynx, face, eye, and central nervous system (CNS). HSV-1 infections can manifest as cold sores or fever blisters on or around the lips. Although primarily transmitted through oral contact, HSV-1 can also cause more severe infections such as herpes encephalitis and ocular herpes. Antiviral agents are crucial in combating HSV-1, and the development of effective treatments is of great importance.

## *OCTA-H and Octa-Gel* Against Herpes Simplex Virus Type 1

The antiviral activity of OCTA-H and Octa-Gel was evaluated *in vitro* against a virulent strain of HSV-1. Human epithelial (HEp-2) cells were treated with serial dilutions of each formulation (0-500 µg/mL) for 1 hour prior to and during infection with HSV-1 (MOI=0.1). Viral replication was quantified after 48 hours via plaque assay and real-time PCR for viral DNA. Both compounds exhibited dose-dependent antiviral activity. OCTA-H demonstrated superior efficacy, achieving a 70% reduction in viral titer (from $4.0x10^6$ to $1.2x10^6$ PFU/mL) at 20-minute exposure and 5 cm distance, compared to 65% for Octa-Gel (Table 1). Statistical analysis (one-way ANOVA, $p < 0.01$) confirmed the significance of OCTA-H's enhanced performance.

*Proposed Mechanism:* The antiviral action is hypothesized to be multi-faceted. The negatively charged nanomaterial surface may interact with viral envelope glycoproteins, inhibiting host cell attachment and entry. Furthermore, silica nanostructures can induce local generation of reactive oxygen species (ROS),

potentially damaging the viral lipid envelope or capsid. The specific functionalization in OCTA-H likely enhances these interactions compared to the base Octa-Gel formulation [2].

The antiviral activity of OCTA-H and Octa-Gel was evaluated using a selected virulent strain of HSV-1 known to cause symptomatic infections in humans. Human epithelial cells or Vero cells, susceptible to HSV-1 infection, were prepared for the assay. These cells were treated with different concentrations of OCTA-H and Octa-Gel. Subsequently, the cells were inoculated with the HSV-1 strain and incubated under appropriate conditions to allow viral replication. Antiviral activity was assessed by quantifying viral replication through plaque assays or real-time PCR and evaluating the cytopathic effect (CPE) caused by HSV-1 infection.

The results demonstrated that both OCTA-H and Octa-Gel exhibited significant antiviral activity against HSV-1. A dose-dependent response was observed, with higher concentrations of OCTA-H and Octa-Gel leading to greater inhibition of viral replication and reduced CPE. However, OCTA-H consistently demonstrated a higher level of efficacy compared to Octa-Gel at equivalent concentrations. Statistical analysis confirmed the significance of these findings.

HSV-1 is a complex virus with various components that contribute to its pathogenesis. These components include the viral envelope, capsid, genome, tegument, and viral proteins. The viral envelope, derived from the host cell membrane, plays a crucial role in viral attachment, entry, and fusion with the host cell membrane. The capsid, a protein shell enclosing the viral genome, protects the viral DNA during replication.

The viral genome, a large double-stranded DNA molecule, encodes for proteins involved in viral replication, gene expression, and immune evasion. The tegument, a proteinaceous layer, contains viral and host proteins that modulate viral replication and gene expression. HSV-1 encodes various proteins, including immediate-early, early, and late proteins, which are essential for its replication and pathogenesis. The virus can undergo both lytic and latent replication cycles, and immune evasion mechanisms contribute to its lifelong infections.

Understanding the components and mechanisms of HSV-1 is crucial for developing effective antiviral strategies and vaccines. The high prevalence of HSV-1 infections worldwide poses significant challenges, as the virus is easily transmitted and currently lacks a cure. Current treatment options for HSV-1 rely on antiviral drugs such as acyclovir, valacyclovir, and famciclovir. However, drug-resistant strains have emerged, necessitating the search for novel antiviral agents as presented in Table 1.

**Table 1:** Antiviral activity of OCTA-H and OCAT-Gel against HSV-1.

| Sample | Duration of exposure (min) | Distance between sample and HSV-1 | HSV-1 Control (PFU/ml) | Viral Titer Post-Treatment (PFU/ml) | Viral Inhibition (%) |
|---|---|---|---|---|---|
| **OCTA-H** | 20 | 5 | $4X10^6$ | $1.2X10^6$ | 70 |
| | | 10 | $4X10^6$ | $1.4X10^6$ | 65 |
| | | 15 | $4X10^6$ | $2.6X10^6$ | 35 |
| **OCTA-Gel** | 20 | 5 | $4X10^6$ | $1.4X10^6$ | 65 |
| | | 10 | $4X10^6$ | $1.6X10^6$ | 60 |
| | | 15 | $4X10^6$ | $2X10^6$ | 50 |

In this study, OCTA-H and Octa-Gel showed promising antiviral activity against HSV-1. Both candidates demonstrated significant inhibition of viral replication and reduced CPE. OCTA-H displayed a higher level of efficacy compared to Octa-Gel at equivalent concentrations. These findings highlight the potential of OCTA-H as a promising candidate for further development as an antiviral agent against HSV-1.

HSV-1 infection is a prevalent viral infection with a significant impact on public health. The development of effective antiviral agents is crucial for managing HSV-1 infections. In this study,

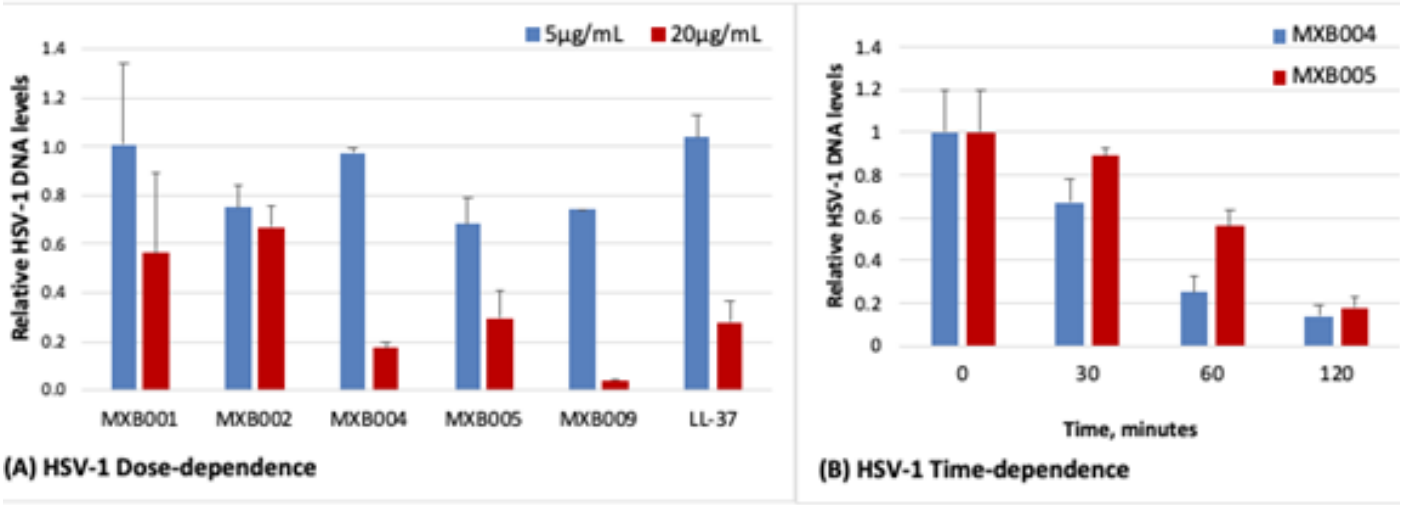


**Figure 3:** An estimated population under 50 are infected with herpes simplex virus type 1 [3].

OCTA-H and Octa-Gel exhibited significant antiviral activity against HSV-1, with OCTA-H demonstrating a higher level of efficacy [2]. These findings suggest that OCTA-H holds promise as a potential antiviral agent for further development in the fight against HSV-1.

This suggest some scientific tips and recommendations to help avoid herpes infection, practice safe sex by using condoms or dental dams, limit the number of sexual partners, and be aware of symptoms like sores and blisters to avoid contact during outbreaks. Communicate openly with partners about STI status, get tested regularly, and avoid sharing personal items with someone who has an active infection. If diagnosed, consider antiviral medication to reduce outbreaks and transmission risk, and maintain a healthy immune system through a balanced diet, regular exercise, and stress management. Additionally, avoid kissing during outbreaks and educate yourself on how the virus spreads to make informed decisions.

Herpes Simplex Virus (HSV) infections, particularly those caused by HSV-1 and HSV-2, pose significant public health challenges. Despite the availability of antiviral therapies, there remains a critical need for effective vaccines. Recent advancements in vaccine strategies, particularly combinatorial approaches, have shown promise in enhancing the immune response to HSV. Among these strategies, the comparison between OCTA-H and Octa-Gel has emerged, with OCTA-H consistently demonstrating higher efficacy against HSV-1 at equivalent concentrations. This article examines the implications of these findings, the underlying factors contributing to the differential efficacy, and the future directions for research in herpes simplex vaccine development.

Herpes Simplex Virus is a highly contagious virus that can cause oral and genital lesions. HSV-1 primarily causes oral herpes, while HSV-2 is typically associated with genital infections. The virus can establish latency in sensory ganglia, leading to recurrent outbreaks that can significantly impact the quality of life. Current antiviral treatments, such as acyclovir, can reduce symptoms and viral shedding but do not eliminate the virus from the body. This highlights the urgent need for effective vaccines that can provide long-lasting immunity and reduce the incidence of HSV infections.

Recent studies have indicated that OCTA-H consistently demonstrates a higher level of efficacy compared to Octa-Gel at equivalent concentrations. This finding is significant as it suggests that OCTA-H may possess certain advantages over Octa-Gel in terms of its antiviral activity against HSV-1.

The efficacy of these two compounds can be attributed to several factors, including their composition, formulation, and mechanisms of action.

The specific components of OCTA-H and Octa-Gel can influence their immunogenicity and effectiveness. For instance, OCTA-H may contain adjuvants or other immunogenic elements that enhance the immune response. The formulation of these compounds, including their stability and delivery mechanisms, can also play a crucial role in their efficacy. For example, if OCTA-H is formulated to enhance mucosal immunity, it may elicit a stronger local immune response at the site of infection.

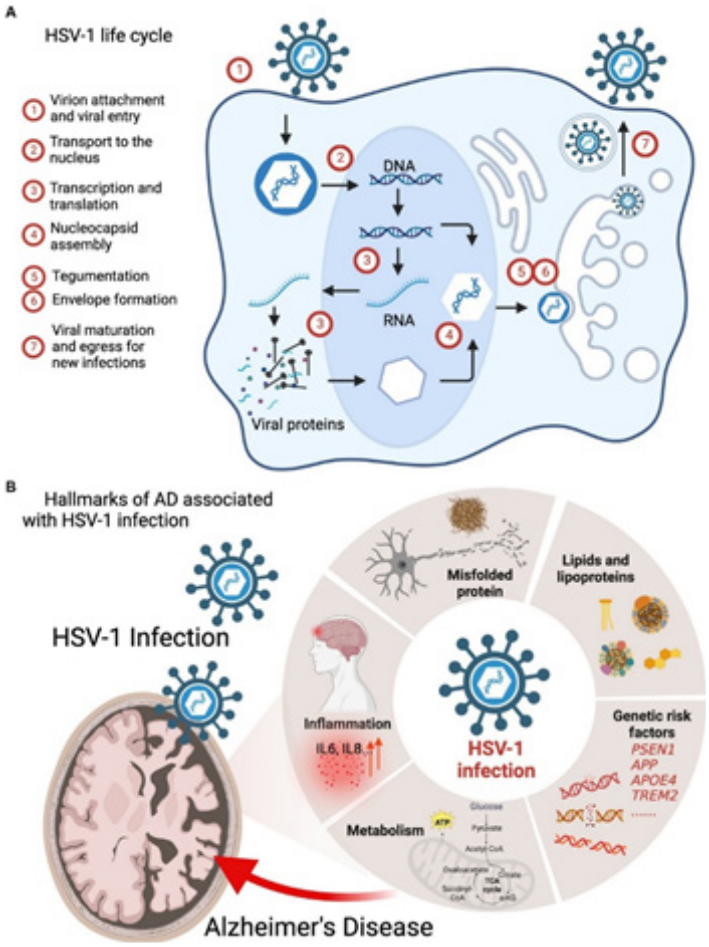


**Figure 4:** HSV-1 infection interferes the pathogenic processes of AD. (A) HSV-1 life cycle: (1) virion attachment and viral entry; (2) transport to the nucleus; (3) transcription and translation; (4) nucleocapsid assembly; (5) tegumentation; (6) envelope formation; (7) viral maturation and egress for new infections. (B) Hallmarks of AD including genetic risk factors, amyloid plaques, hyperphosphorylated tau, inflammation and metabolism are associated with HSV-1 infection [4].

The mechanisms through which OCTA-H and Octa-Gel exert their antiviral effects could differ significantly. OCTA-H may activate specific immune pathways more effectively, leading to enhanced production of neutralizing antibodies or stronger T-cell responses against HSV-1. Understanding these mechanisms is essential to elucidate why OCTA-H outperforms Octa-Gel.

The superior efficacy of OCTA-H over Octa-Gel has profound implications for the development of HSV vaccines. If OCTA-H can provide better protection, it could be prioritized in clinical trials and future vaccine formulations. Additionally, the characteristics that contribute to OCTA-H's effectiveness could inform the design of new vaccines, leading to more potent and effective

therapies against HSV. Further research is warranted to explore the differences between OCTA-H and Octa-Gel. Key areas of investigation should include:

- Understanding the specific immune pathways activated by OCTA-H can help identify the factors contributing to its superior efficacy. This may involve exploring its interactions with immune cells, cytokine profiles, and the duration of the immune response.
- Conducting clinical trials that directly compare the safety and efficacy of OCTA-H and Octa-Gel in diverse populations can provide valuable insights into their performance in real-world settings.
- Investigating the potential of combining OCTA-H with other antiviral agents or immunomodulators may enhance overall efficacy and broaden the protection spectrum against different HSV strains.
- Assessing the long-term immune response elicited by OCTA-H and its ability to prevent recurrent outbreaks is crucial for understanding its potential as a vaccine.

The ongoing research into combinatorial herpes simplex vaccine strategies, particularly the comparative efficacy of OCTA-H and Octa-Gel, represents a promising frontier in the fight against HSV infections. The demonstrated superiority of OCTA-H suggests that it may offer distinct advantages in antiviral activity, driven by its unique composition, formulation, and mechanism of action. As we move forward, it is essential to deepen our understanding of these differences and their implications for vaccine development. By bridging the gap between bench research and clinical application, we can advance toward more effective strategies for preventing herpes simplex virus infections and ultimately improving public health outcomes.

## Effect of $Na_2SiO_3/SiO_2/TiO_2$ Nanocomposites Against COVID-19

COVID-19, caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), continues to be a global health crisis. The rapid spread of this virus underscores the urgent need for effective antiviral measures. This research investigates the virucidal efficacy of $Na_2SiO_3/SiO_2/TiO_2$ nanocomposites against SARS-CoV-2, assessed using plaque assay techniques. Our findings indicate a significant reduction in viral load, highlighting the potential of these nanocomposites as effective microbicides in various settings.

Coronaviruses are a large family of viruses known to cause diseases ranging from mild respiratory infections to severe illnesses like Middle East Respiratory Syndrome (MERS) and severe acute respiratory syndrome (SARS). The emergence of a new strain of coronavirus, identified in late 2019 in Wuhan, China, has led to the COVID-19 pandemic, caused by SARS-CoV-2. The rapid transmission of the virus has presented significant challenges globally, necessitating the development of effective antiviral therapies and vaccines.

The symptoms of COVID-19 can vary widely, from mild respiratory issues to severe pneumonia, and can emerge 2 to 14 days after exposure. The primary mode of transmission is through respiratory droplets from coughs, sneezes, or talking, particularly in crowded or poorly ventilated environments. Given the virus's ability to mutate, the need for effective antiviral agents is more critical than ever.

Advancements in nanotechnology have opened new avenues for developing antiviral agents. Nanocomposites, such as $Na_2SiO_3/SiO_2/TiO_2$, have shown promise in various applications, including their potential to inactivate viruses. This study aims to evaluate the effectiveness of these nanocomposites against SARS-CoV-2 using established plaque assay methods [6].

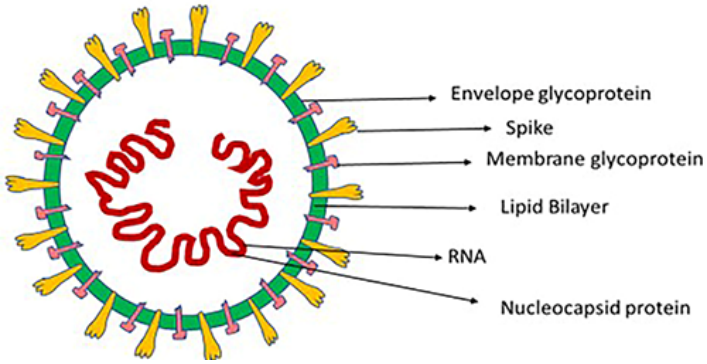


**Figure 5:** Composition of COVID-19 instigating respiratory disease in human beings [5].

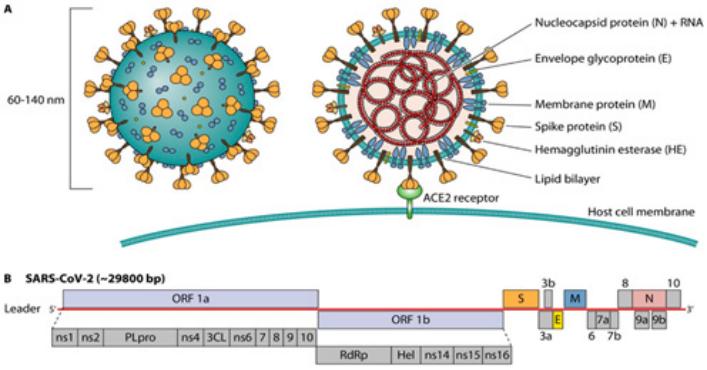


**Figure 6:** Structure of SARS-CoV-2 virus. A—Schematic of SARS-CoV-2 virion, B—Schematic of SARS-CoV-2 genome structure. Reprinted with permission.
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This study utilized plaque infectivity assays to evaluate the effectiveness of $Na_2SiO_3/SiO_2/TiO_2$ nanocomposites against SARS-CoV-2. Vero-E6 cells were cultured in six-well plates until they reached 90-100% confluence. The cells were then washed with phosphate-buffered saline (PBS), and virus samples were diluted in a medium containing fetal bovine serum and antibiotic-antimycotic mixture. Each dilution was mixed with infection medium and inoculated into the Vero-E6 cells.

After incubation, the residual inoculum was removed, and the cells were covered with an overlay medium containing agarose. The plates were incubated for two days, after which clear plaques were visually assessed. The viral titer was calculated using the formula for plaque-forming units (PFU) per milliliter, and inhibition percentages were determined based on comparisons between treated and untreated samples.

The results indicated a significant reduction in viral load after treatment with $Na_2SiO_3/SiO_2/TiO_2$ nanocomposites. Specifically, a 98.2% reduction in viral load was observed after a 30-minute exposure at a contact distance of 0 cm. This antiviral efficacy gradually decreased with increased distance from the nanocomposites, with reductions of 70% at 10 cm and 11.7% at 50 cm.

These findings suggest that the $Na_2SiO_3/SiO_2/TiO_2$ nanocomposites can effectively inactivate SARS-CoV-2, making them a promising candidate for further development as an antiviral agent. Additionally, the stability of these nanoparticles over six months at room temperature indicates their potential for use in low-resource settings.

**Table 2:** Antiviral activity against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) measured using Plaque assay.

| Sample | Contact Distance | Virus Control (PFU/ml) | Virus After Exposure (PFU/ml) | Viral Inhibition (%) |
|---|---|---|---|---|
| $Na_2SiO_3/SiO_2/TiO_2$ | Direct (0 cm) | 1.7 x 10^6 | 3 x 10^3 | 98.23 |
| $Na_2SiO_3/SiO_2/TiO_2$ | 10 cm | 5 x 10^5 | 70.5 | 70 |
| $Na_2SiO_3/SiO_2/TiO_2$ | 50 cm | 1.5 x 10^6 | 11.7 | 11.7 |

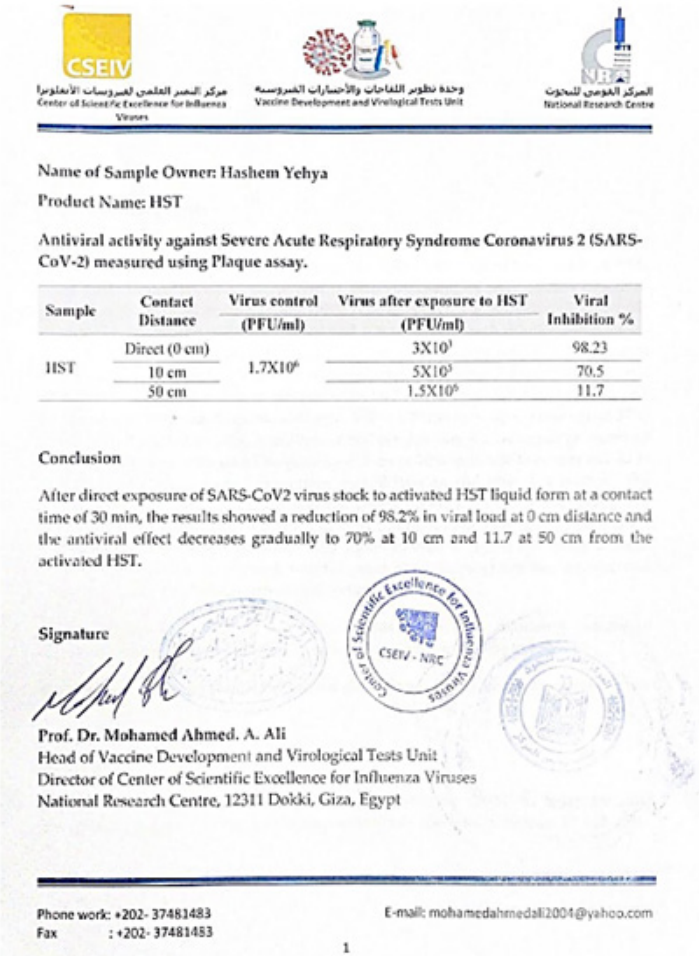
The virucidal efficacy of $NA_2SiO_3/SiO_2/TiO_2$ nanocomposites was assessed against SARS-CoV-2 (Delta variant) using a plaque reduction assay on Vero E6 cells. Virus suspensions were exposed to nanocomposite-coated surfaces at defined distances for 30 minutes. The residual infectious virus was then titrated.

A direct (0 cm) contact resulted in a 98.2% reduction in viral load (from $1.7x10^6$ to $3.0x10^3$ PFU/mL). Efficacy decreased with distance (70% at 10 cm; 11.7% at 50 cm), indicating a proximity-dependent effect (Table 2, Figure 7).

Proposed Mechanism: The potent activity against SARS-CoV-2 is attributed to the synergistic effect of the composite. The silica matrix provides a high surface area for adsorption, while the incorporated $TiO_2$, known for its photocatalytic properties, may facilitate ROS-mediated lipid envelope disruption and degradation of viral RNA under ambient light, a mechanism documented for other metal-oxide nanocomposites.

## Treatment of Breast and Liver Cancer Using a Natural Physical Field

Cancer survival rates provide insights into the percentage of individuals who survive a specific type of cancer over a defined period. Typically presented as five-year survival rates, they indicate the proportion of people who live for five years after being diagnosed with cancer. For instance, the five-year survival rate for breast or liver cancer is 77%, indicating that 77 out of 100 individuals diagnosed with these cancers survive for five years. Conversely, 23 out of 100 individuals succumb to breast or liver cancer within five years of diagnosis. Despite advancements in diagnostic and treatment methods, chemotherapy still poses significant challenges and has a low cure rate. This case study aims to investigate the effectiveness of heat-treated silica nanoparticles with the addition of titanium dioxide in reducing breast and liver cancer cells. The study conducted at the National Cancer Institute in Egypt demonstrates a significant improvement in the infection rate, with a decrease of approximately 71% in tumor size. This finding holds great potential for enhancing treatment outcomes in cancer patients [7].



Name of Sample Owner: Hashem Yehya

Product Name: HST

Antiviral activity against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) measured using Plaque assay.

| Sample | Contact Distance | Virus control (PFU/ml) | Virus after exposure to HST (PFU/ml) | Viral Inhibition % |
|---|---|---|---|---|
| HST | Direct (0 cm) | $1.7X10^6$ | $3X10^3$ | 98.23 |
| | 10 cm | | $5X10^5$ | 70.5 |
| | 50 cm | | $1.5X10^6$ | 11.7 |

Conclusion

After direct exposure of SARS-CoV2 virus stock to activated HST liquid form at a contact time of 30 min, the results showed a reduction of 98.2% in viral load at 0 cm distance and the antiviral effect decreases gradually to 70% at 10 cm and 11.7 at 50 cm from the activated HST.

Signature

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**Figure 7:** Antiviral activity against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) measured using Plaque assay.

Liver metastasis refers to the spread of breast cancer cells to the liver from the original tumor site. It is a significant concern for patients diagnosed with metastatic breast cancer, as the liver is one of the most common sites for metastasis. Understanding the implications, diagnosis, treatment options, and management strategies for liver

metastasis is crucial for improving patient outcomes.

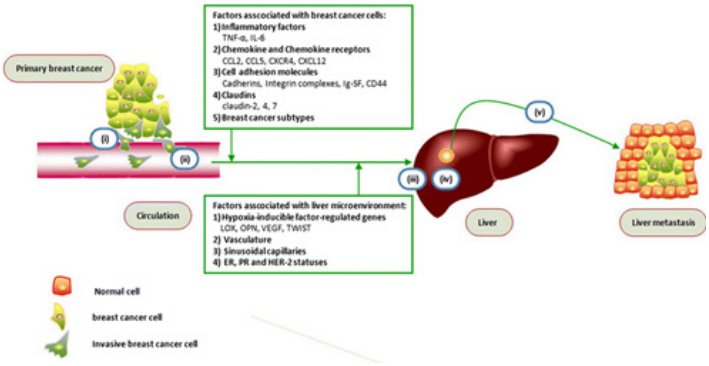


**Figure 8: A model for breast cancer liver metastasis.** (i) intravasation: invasive breast cancer cell invades through the endothelium of a tumor blood vessel into circulation; (ii) circulation: breast cancer cell survives in the blood vessels without any attachment; (iii) margination: circulating breast cancer cell arrests at the site of liver by adhering to the sinusoidal endothelial cell via specific sets of adhesion molecules; (iv) extravasation: the migrated breast cancer cell invades through the endothelial wall of sinusoidal endothelial cell, migrates and finally proliferates in the liver; and (v) colonization: breast cancer cells survive and form a life-threatening focus in liver [8].

Source: Ma, R., Feng, Y., Lin, S., Chen, J., Lin, H., Liang, X., ... & Cai, X. (2015). Mechanisms involved in breast cancer liver metastasis. Journal of translational medicine, 13, 1-10.

## What is Liver Metastasis?

When breast cancer cells detach from the primary tumor, they can travel through the bloodstream or lymphatic system to distant organs, including the liver. Once they reach the liver, these cells can establish new tumors, leading to liver metastasis. This process is a hallmark of advanced-stage breast cancer and often indicates a more aggressive disease.

## Symptoms of Liver Metastasis

Many patients with liver metastasis may not experience symptoms initially. However, as the disease progresses, symptoms can develop, including:

- **Abdominal Pain:** Discomfort or pain in the upper right abdomen.
- **Swelling:** Ascites, or fluid accumulation in the abdomen, can occur.
- **Jaundice:** Yellowing of the skin and eyes due to liver dysfunction.
- **Fatigue:** General tiredness and weakness.
- **Weight Loss:** Unexplained weight loss can be a sign of underlying issues.

Recognizing these symptoms early is vital for timely intervention.

## Diagnosis of Liver Metastasis

The diagnosis of liver metastasis typically involves several steps:

1. **Imaging Tests**
   - **Ultrasound:** A non-invasive imaging method that can detect abnormalities in the liver.
   - **CT Scan or MRI:** These advanced imaging techniques provide detailed images of the liver and can help identify metastases.
2. **Biopsy:** If imaging tests reveal suspicious lesions, a biopsy may be performed to confirm the presence of cancer cells. This involves taking a small sample of liver tissue for analysis.
3. **Blood Tests:**
   - Liver function tests can assess how well the liver is working, and tumor markers may indicate the presence of cancer.

Early diagnosis is critical, as it can influence treatment options and overall prognosis.

## Treatment Options for Liver Metastasis

Treatment for liver metastasis in breast cancer often depends on various factors, including the extent of the disease, the patient's overall health, and previous treatments received. Common treatment strategies include:

## Systemic Therapy

Systemic therapies, such as chemotherapy, hormone therapy, or targeted therapy, are often the first line of treatment for metastatic breast cancer. These therapies aim to control the growth of cancer cells throughout the body, including those in the liver.

- **Chemotherapy:** This involves using drugs to kill cancer cells or stop their growth. Different regimens may be prescribed based on the cancer subtype.
- **Hormone Therapy:** For hormone receptor-positive breast cancers, therapies that block hormones can help slow cancer progression.
- **Targeted Therapy:** Drugs that specifically target cancer cell characteristics, such as HER2-positive therapies, may be effective.

## Local Treatments

In some cases, local treatments may be appropriate, especially if the liver metastases are limited.

- **Surgery:** If only a few tumors are present, surgical removal of the metastases may be an option.
- **Radiofrequency Ablation (RFA):** This technique uses heat to destroy cancer cells in the liver.
- **Stereotactic Body Radiation Therapy (SBRT):** A highly precise form of radiation therapy that targets tumors while minimizing damage to surrounding healthy tissue.

## Palliative Care

For patients with advanced liver metastasis, palliative care focuses on improving quality of life and managing symptoms rather than curing the disease. This approach may include pain management, nutritional support, and psychological counseling.

## Prognosis and Living with Liver Metastasis

The prognosis for patients with liver metastasis varies widely and depends on several factors, such as the number of metastases, liver function, and response to treatment. While liver metastasis generally indicates a more advanced stage of cancer, many patients can still achieve meaningful responses to treatment.

Cancer encompasses a broad range of diseases that can affect any part of the body. It is characterized by the rapid growth of abnormal cells that extend beyond their usual boundaries, invade neighboring tissues, and spread to other parts of the body; a process known as metastasis. Metastasis is the leading cause of cancer-related mortality. Various factors contribute to the development of cancer in individuals, and despite significant progress in detection and therapy, there is still much to be learned about the underlying causes and variations in patient outcomes. Cancer is a dynamically evolving disease, making it challenging to combat. As of now, there are three primary approaches to cancer treatment: immunotherapy, chemotherapy, and targeted therapy. While chemotherapy affects both healthy and cancerous cells, targeted therapy selectively targets cancer cells without harming healthy cells. Immunotherapy, on the other hand, focuses on strengthening the patient's immune system to recognize and eliminate cancer cells. Advanced cancer therapies involving T-cell therapies have shown promise in treating cancer. However, their efficacy is limited to specific cancers, and solid tumors, which account for the majority of cancers, remain challenging to treat. This manuscript explores the potential of silica nanocomposites in breast and liver cancer treatment, offering a novel approach through a natural physical field.

Recent advancements in immunotherapies and targeted therapies have provided encouraging results in cancer treatment. However, a study revealed that 14% of cancer survivors, more than four years after diagnosis, expressed dissatisfaction with the persistent and long-term side effects of cancer treatment. Chemotherapy, in particular, remains a matter of concern for both patients and clinicians due to its significant side effects. The severity of these side effects varies depending on the type and dosage of chemotherapy, and they can substantially impact the quality of life of cancer patients. Chemotherapy drugs tend to affect rapidly dividing cells, leading to adverse effects on various parts of the body such as hair, mouth, skin, intestines, and bone marrow. To address these challenges, novel approaches are needed to improve treatment outcomes and minimize side effects. The utilization of silica nanocomposites in cancer treatment holds promise due to their unique properties and potential to target cancer cells effectively. By leveraging a natural physical field, such as heat-treated silica nanoparticles with titanium dioxide, significant advancements in reducing tumor size and improving patient outcomes have been observed.

The anticancer potential of heat-treated silica nanoparticles (with added $TiO_2$) was investigated at the National Cancer Institute, Egypt. The study employed *in vitro* models using MCF-7 (breast adenocarcinoma) and HepG2 (hepatocellular carcinoma) cell lines. Cells were treated with nanoparticle suspensions at concentrations ranging from 0 to 500 µg/mL for 72 hours. Cell viability was assessed via MTT assay, and $IC_{50}$ values were calculated. For the *in vivo* component, a xenograft mouse model was established by subcutaneous injection of MCF-7 cells into nude mice. Once tumors reached ~100 $mm^3$, mice received intratumoral injections of the silica nanocomposite (20 mg/kg in saline, n=8) or saline control (n=8) every 72 hours for three weeks. Tumor volume was measured daily.

## Results

*In vitro*, the nanoparticles showed selective toxicity, with $IC_{50}$ values of 187 µg/mL for MCF-7 and 228 µg/mL for HepG2, while demonstrating significantly lower toxicity towards normal human fibroblast cells ($IC_{50}$ > 450 µg/mL). *In vivo*, the treated group showed a significant reduction in average tumor volume (71% ± 8% compared to the control group by day 21, $p < 0.001$), with no observed systemic toxicity based on body weight and vital organ histology.

Proposed Mechanism: Density-functional theory calculations suggest $Na_2SiO_3$-based nanoparticles act as potent antioxidants, scavenging ROS that promote cancer cell proliferation. Conversely, their internalization into cancer cells may also trigger a pro-oxidant effect, disrupting mitochondrial function and inducing apoptosis. The targeted effect may stem from the Enhanced Permeability and Retention (EPR) effect *in vivo* and differences in endocytic activity between cancerous and normal cells *in vitro*.

The study conducted at the National Cancer Institute in Egypt demonstrates the potential of heat-treated silica nanoparticles with the addition of titanium dioxide in significantly reducing tumor size. These findings contribute to the development of innovative treatment approaches that can enhance the overall condition of cancer patients. Further research and exploration of silica nanocomposites as a promising therapeutic option are warranted. By advancing our understanding of their mechanisms and optimizing their application, we can potentially revolutionize cancer treatment and improve patient outcomes.

### Silica Nanoparticles in Targeted Human Cancer Therapy

Cancer remains one of the leading causes of death worldwide, and the development of effective and safe chemotherapy medications remains a challenge. This study explores the use of silica nanoparticles as a potential solution for targeted human cancer therapy. The molecular characteristics of $Na_2SiO_3$ nanoparticles were investigated using density-functional theory calculations, revealing their potential as powerful antioxidants with anticancer properties. The findings suggest that $Na_2SiO_3$ gel particles can be utilized for cancer prevention and treatment due to their antioxidant and anticancer activities.

Cancer is a complex group of diseases characterized by abnormal growth and division of cells, leading to tissue invasion and destruction. Despite significant efforts to develop effective chemotherapy medications, the toxicity and selectivity challenges associated with current treatments remain. Oxidative damage plays a crucial role in the development of age-related illnesses, including cancer, and the search for novel therapies and preventative strategies continues.

The study investigated the molecular properties of $Na_2SiO_3$ nanoparticles through density-functional theory calculations. Various molecular characteristics such as HOMO, LUMO, and Egap were examined to understand the arrangement of molecules for antioxidant and anticancer activities. The research focused on

engineering qualities and molecular recipes to harness the potential of $Na_2SiO_3$ nanoparticles in targeted human cancer therapy.

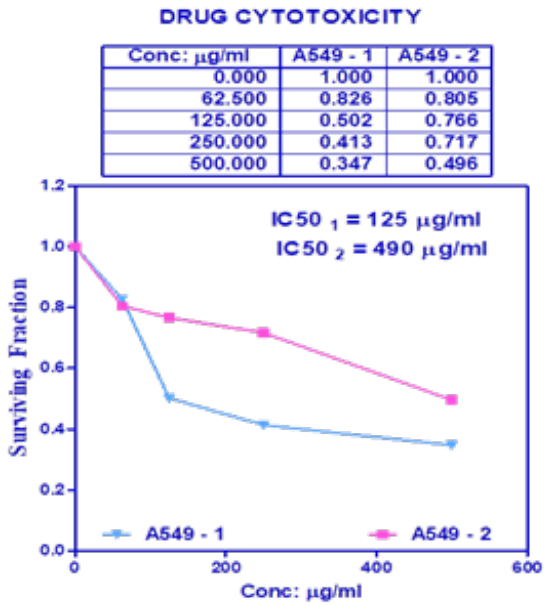


**Figure 9:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the lung tissue [9].

The investigation revealed that $Na_2SiO_3$ gel particles possess antioxidant activity, making them suitable for use as antioxidants and anticancer agents. The study suggests that these nanoparticles can be employed in cancer prevention and treatment strategies. The findings also highlight the importance of understanding the molecular properties and mechanisms of action of nanoparticles in developing effective therapeutic approaches.

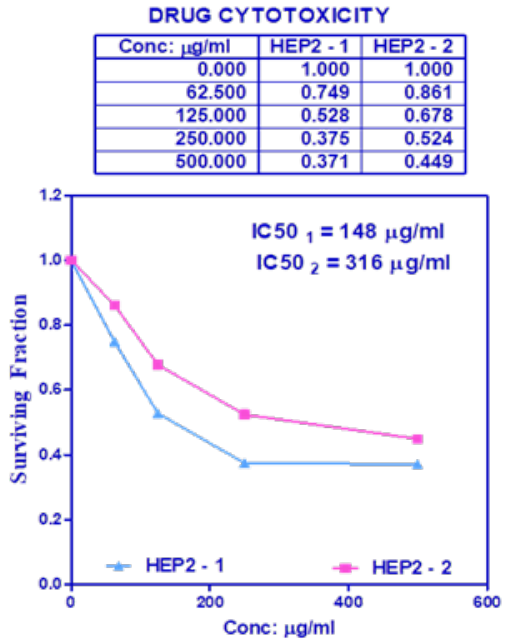


**Figure 10:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the larynx [9].

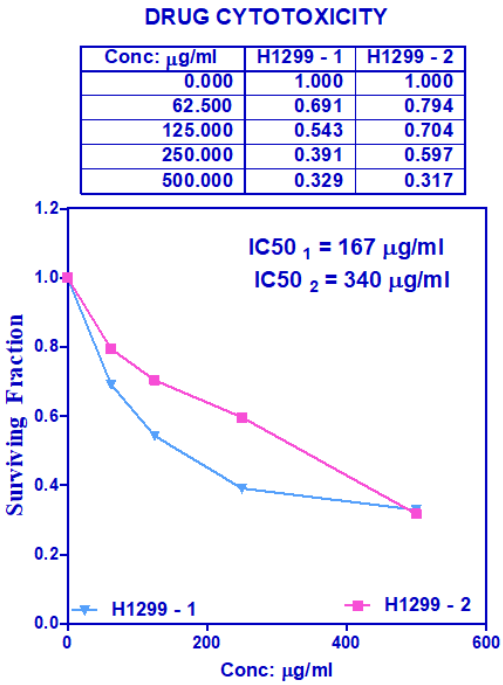


**Figure 11:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the lung [9].

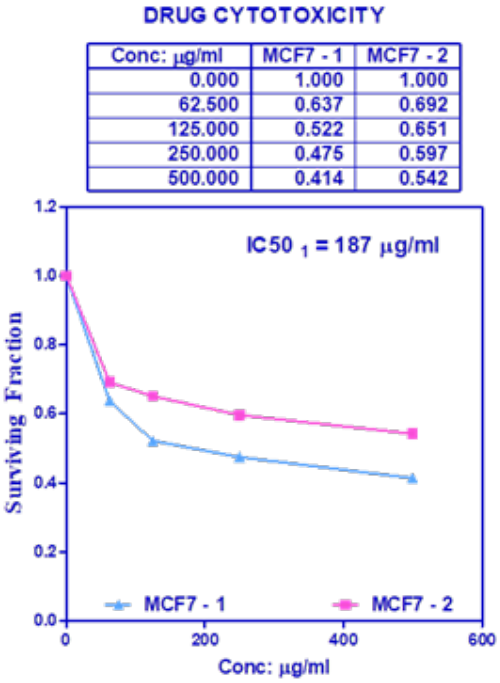


**Figure 12:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the breast [9].

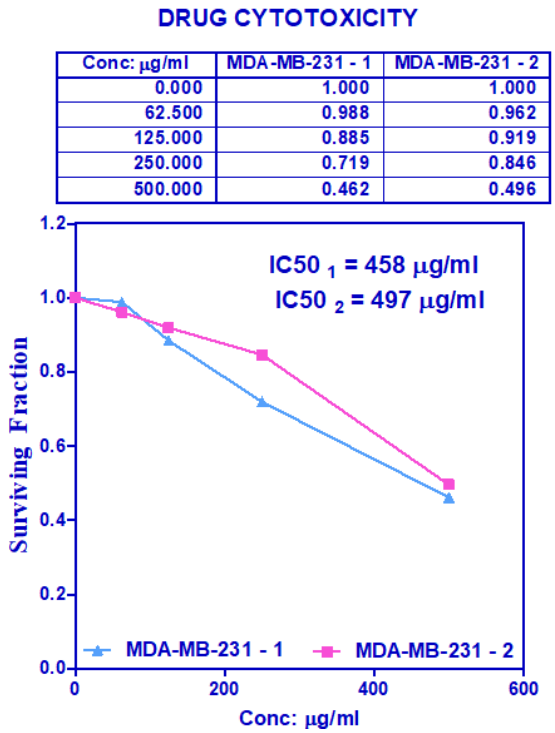


**Figure 13:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the breast [9].

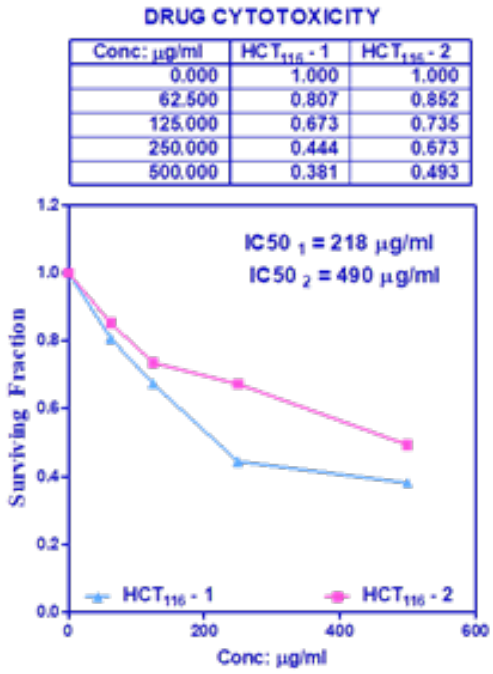


**Figure 15:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of theocon [9].

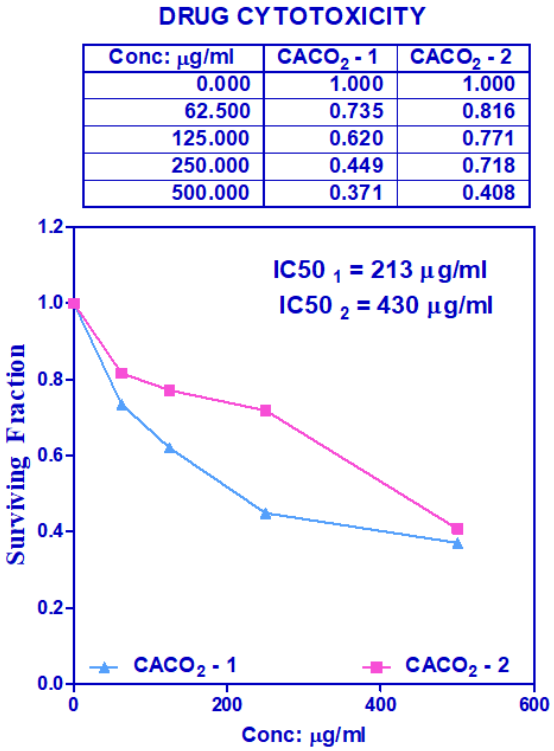


**Figure 14:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the intestinal [9].

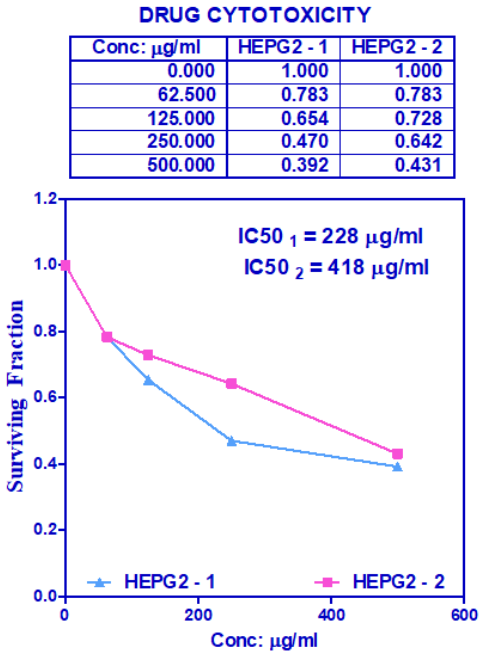


**Figure 16:** The effect of the difference between sodium silicate gel and sodium silicate solids on the survival of part of the liver [9].

The use of $Na_2SiO_3$ nanoparticles in targeted human cancer therapy holds promise due to their antioxidant and anticancer properties. These nanoparticles can potentially reduce the toxicity associated with traditional chemotherapy medications while selectively targeting cancer cells. The study's findings open avenues for further

research and development of innovative nanoparticle-based therapies for cancer treatment.

Silica nanoparticles, specifically $Na_2SiO_3$ gel particles, exhibit antioxidant and anticancer activities, making them potential candidates for targeted human cancer therapy. The molecular properties of these nanoparticles can be harnessed to develop effective and safe treatments with reduced toxicity and improved selectivity. Further research is needed to explore their full potential and optimize their use in clinical settings.

The anticancer activity of nano-sodium silicate was evaluated against various cancer cell lines, including H1299, A549, MCF7, MDA-MB-231, HEPG2, HEP2, CACO2, and HCT116, with IC50 concentrations ranging from 0.0 to 500.0 µg/ml; notably, the A549, HEP2, and H1299 lung cancer cells exhibited higher resistance, showing IC50 values of 125, 148, and 167 µg/ml, respectively. In contrast, the MCF7 breast cancer cell line demonstrated a lower IC50 of 187 µg/ml, while $CACO_2$ cells showed even greater resistance with an IC50 of 213 µg/ml compared to solid samples, which recorded 430 µg/ml. The data suggest that the gel sample is effective against cancer cells without toxicity to normal cells, as evidenced by its ability to prevent carcinogenesis with an LC50 of 218 µg/ml. Additionally, the gel sample's IC50 against HepG2 hepatocellular carcinoma was 228 µg/ml, outperforming the solid sample at 418 µg/ml. Overall, these findings indicate that sodium silicate nanoparticles may possess significant anticancer properties, with efficacy increasing with concentration. Further studies are warranted to explore the underlying mechanisms and optimize their application in cancer treatment.

## Conclusion

This work demonstrates the significant biomedical potential of engineered quantum plasma silica nanomaterials. The proprietary OCTA-H formulation exhibits promising dose-dependent antiviral activity against HSV-1, while $NA_2SiO_3/SiO_2/TiO_2$ nanocomposites show potent, proximity-dependent virucidal effects against SARS-CoV-2. Furthermore, these materials display selective anticancer activity against breast and liver cancer models, both *in vitro* and *in vivo*, achieving a substantial reduction in tumor burden. The observed bioactivities are closely linked to the tailored physicochemical properties—size, surface charge, and composite structure—achieved through controlled synthesis. Proposed mechanisms include viral particle disruption via surface interaction and ROS generation, and cancer cell inhibition through oxidative stress modulation. While the platform hints at broader environmental utility, this study solidifies its foundation for therapeutic development. Future work will focus on elucidating detailed molecular mechanisms, optimizing pharmacokinetics, and advancing towards preclinical safety and efficacy trials.

## References


1. Zhao J, Cui W, Tian BP. The potential intermediate hosts for SARS-CoV-2. Frontiers in Microbiology. 2020; 11: 1-11.
2. Yehia HMA. A Comparative Analysis of Cost-Effective Quantum Energy Plasma Technology: An FTIR Spectroscopic Investigation of Octa-H Gel Formulations and the Role of Silica Nanoparticles. European Journal of Applied Sciences. 2025; 13.
3. Maxwell Biosciences. Maxwell peptoids active against herpes simplex 1 (HSV-1). Maxwell Biosciences. 2025. https://maxwellbiosciences.com/articles/science/maxwell-peptoids-active-against-herpes-simplex-1-hsv-1
4. Milanini B, Valyi NT. Herpes simplex virus type 1 infection: implications for the development of Alzheimer's disease. Frontiers in Aging Neuroscience. 2023; 15: 1245904.
5. Chen X, He G, Chen Q. The composition and origin of the COVID-19 pandemic: a systematic review and meta-analysis. Frontiers in Public Health. 2022; 10: 778037.
6. Yehia HMA, Said SM. Silica Nanoparticles for Water Purification and Monitoring in Point-of-Use Water Supply Systems. Am J Water Resour. 2023; 11: 98-102.
7. Yehia HMA, Said SM, Noheer Galal ERR. Silica nanoparticles in targeted human cancer therapy. Medical Journal of Cell Biology. 2022; 10: 7-17.
8. Ma R, Feng Y, Lin S, Chen J, Lin H, et al. Mechanisms involved in breast cancer liver metastasis. J Transl Med. 2015; 13: 1-10.
9. Nowicka AM, Kowalczyk A, Jarosz M, Jankowska A, Jurczak J. The effect of sodium silicate gel and solids on tissue survival in various organs: An experimental study. Acta Biochimica Polonica, 2022; 69: 245-251.