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Review Article

Exploring the Therapeutic Potential of Selenium Nanoparticles in Central Nervous System Disorders: A Nanomedicine Approach

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ABSTRACT

In the realm of healthcare, Central Nervous System disorders pose a formidable challenge, affecting countless lives globally. Conditions like Alzheimer's, Parkinson's and traumatic brain injuries exact a heavy toll. However, a glimmer of hope arises from the world of nanotechnology in the shape of Selenium Nanoparticles. Selenium, a trace element, is known for its antioxidant properties, but Selenium Nanoparticles take it a step further, offering enhanced antioxidant capabilities, better absorption and the ability to deliver therapeutic agents precisely where they're needed in the brain. Oxidative stress, a major player in many Central Nervous System disorders, faces a formidable adversary in Selenium Nanoparticles, potentially offering relief to those grappling with conditions characterized by oxidative damage. Selenium Nanoparticles also exhibit anti-inflammatory prowess, valuable for tackling neuroinflammation, a common feature in these disorders. Moreover, Selenium Nanoparticles pave the way for precision drug delivery within the brain, minimizing side effects while maximizing treatment efficiency. In summary, Selenium Nanoparticles represent a promising frontier in the ongoing battle against Central Nervous System disorders, offering a glimpse of innovative solutions that could alleviate the burdens of these complex neurological conditions.

Keywords: Selenium Nanoparticles, Central Nervous System, Parkinson's disease, Alzheimer's disease.

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INTRODUCTION

Neurological disorders stand as a formidable challenge in the realm of modern medicine, impacting millions of lives annually through approximately 9 million fatalities worldwide and affecting around 276 million individuals who wrestle with physical disabilities each year. The United States, like many countries, shoulders a considerable economic burden due to these disorders, emphasizing the profound societal impact of neurological diseases. Despite extensive research endeavours, the field of neurology remains marked by one of the greatest percentages of unsuccessful drug development, highlighting the intricate and multifaceted nature of these conditions, many of which have significant ties to human actions and environments.[1]

Within the diverse landscape of CNS disorders, there is a wide array of conditions, including ischemic-reperfusion injury, neuroinflammatory disorders, demyelinating diseases, neurodegenerative disorders and psychiatric conditions. What's intriguing is that while these disorders often have a biological origin, they are also influenced substantially by human behaviors, habits and environmental factors. While inflammation certainly plays a critical role in the damage to brain neurons, other factors, such as disruptions in calcium balance, oxidative stress, protein homeostasis and nitrosative stress, are also implicated in the formation and progression of disorders like Parkinson's Disease (PD) and Alzheimer's Disease (AD).[2]

Oxidative stress, a concept rooted in a disparity within the formation of Reactive Oxygen Species (ROS) and the body's capability for neutralising those through antioxidants, emerges as a central figure in the narrative of CNS disorders. In the intricate dance of biological processes, ROS normally serve as crucial signalling molecules. However, the persistent overproduction of ROS, often exacerbated by lifestyle choices and environmental factors, can prove detrimental by inflicting damage on vital cellular components.[3] Within the CNS, where the oxygen demand is notably high and redox-active metals are abundant, oxidative stress can ultimately lead to cellular breakdown and

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neurodegeneration. Adding to the complexity, status like as Alzheimer's and Parkinson's are often characterized by decreased levels of the antioxidant Glutathione (GSH), which exacerbates the impact of oxidative stress.[4]

Neuroinflammation is another central theme that runs through the narrative of neurological disorders. It is a dynamic response to various triggers, including infections, injuries and trauma in the brain. The intriguing interplay between the brain and the immune system, driven by intricate biochemical processes, is not impervious to human influence.[5] Resident immune cells in the CNS, called microglia and astrocytes, which contribute to maintaining the brain's microenvironment, typically collaborate to quell neuroinflammation.[6] However, elevated levels of specific molecules, often influenced by lifestyle choices and genetic predispositions, can incite these guardian cells to release pro-inflammatory proteins and cytokines. This cascade of events contributes significantly to the neuroinflammatory processes observed in a spectrum of conditions, ranging from stroke and AD to multiple sclerosis and epilepsy.[7]

In essence, neurological disorders represent a complex tapestry woven from biological intricacies and influenced by human actions and choices. A comprehensive understanding of these multifaceted factors is crucial for devising effective treatments and interventions to alleviate the burden of CNS disorders. Additionally, it underscores the importance of proactive public health measures and lifestyle choices in promoting brain health and well-being.[8]

Rationale for exploring selenium nanoparticles as potential therapeutic agents

The Greek word Selene, which refers to the moon, served as the basis for the phrase "Se." With a 34 atomic weight, it is a member of Group 6 of the periodic chart. It has been found to be an outcome in the manufacture of sulfuric acid. Se, a semi-solid metal that resembles tellurium and sulphur, is typically seen as a reddish powder that is black in vitreous form and metallic grey in crystalline form.[9] Microglia and astrocytes are induced to release more pro-inflammatory factors like superoxide, nitric oxide, interleukin-1 and tumour necrosis factor, When the levels of potassium ions, or adenosine outside the cell increase.

In addition to strengthening the immune system, ensuring the physiological function of the neurological system and preventing oxidative damage brought on by free radical species, Selenium (Se), a crucial trace element in the body, has demonstrated significant health advantages. Se plays a crucial part in the basic operation of the CNS as an important selenoprotein component. As a result, a lack of Selenium aids in the development of a number of neuropathological and neurodegenerative illnesses.[10]

Se comes in both organic and inorganic forms, with the former being preferable and safer than the former. Recent research has shown that SeNPs are a low-toxic, highly bioactive form of selenium compounds with potential applications in biomedicine. The red SeNPs are easily aggregated in aqueous suspension which makes them highly unstable and susceptible to being converted into inactive forms. Therefore, significant work has been done and different polysaccharides have been utilised to coat SeNPs increasing the stability of NPs during production, storage and use.[11]

Selenium and its Role in Neuroprotection

Importance of selenium as an essential trace element

The selenoproteins, antioxidant defence, cell signalling, immunological control and other metabolic functions all depend on selenium as a vital trace element to preserve human health.[12] Se has special physiological and pharmacological qualities that lower the risk of neurodegenerative disorders.[13]

For various elements of human biology, including immune system control, male development, thyroid function, central nervous system, cardiovascular health, the endocrine system and muscular performance, adequate levels of accessible selenium are crucial. And it also plays a very important role in the normal function of glutathione peroxidase's antioxidant action.[14]

Selenium is recognised to be crucial for normal functions of selenoproteins or selenoenzymes like Phospholipid Hydroperoxide Glutathione Peroxidase (PHGPx), Glutathione Peroxidase (GPx) and thioredoxin reductase (TrxR), involved in protective mechanisms against oxidative stress in the central nervous system and brain.[15]

Se also has been reported to have anti-inflammatory property. In a study it has been reported that selenium and its NPs act against inflammation by reducing the proinflammatory markers like TNF-α, Nf-κB and PGE2, which plays a very important role in inflammation progression.[16]

Selenium is necessary for the proper operation of the brain for a variety of factors. For instance, during selenium deprivation, the brain offers a priority supply. Additionally, the neurotransmitter turnover rate differs with selenium insufficiency. Supplementing with selenium can reduce uncontrollable epileptic episodes. Senility and cognitive deterioration in the elderly have been associated with low level of selenium. Selenium levels across the brain are lower in Alzheimer's patients than in healthy individuals. Additionally, since the brain lacks catalase, selenoenzymes, an antioxidant, must remove peroxidation byproducts such H_2O_2 and lipid peroxides.[15]

Overview of Different Forms of Selenium, Including Organic and Inorganic Compounds

While Se can be found in both inorganic and organic compounds, The organic forms of se are preferred as well as safer.

Inorganic selenium compounds

Two inorganic se compounds are sodium selenate and sodium selenite. that are frequently researched, for the prevention and diagnosis of cancer. Selenite form acts a potent chemoprotective agent and also has anti-cancer property against lung cancer cells and other deadliest cancer cells. It has been claimed selenite has a very crucial function in Natural Killer (NK) cell-based chemotherapy, by raising the sensitivity of cancer cells to NK cells. A dietary intermediate product of sodium selenite is hydrogen selenide reported to raise the cell death of cancer cells through accumulating in mitochondria.[17]

Organic selenium compounds

Organic Se compounds received more interest in the area of cancer study than inorganic Se compounds. Some of the organic Se compounds include selenium-nonsteroidal anti-inflammatory drugs, ebselen, diselenides, ethaselen, selenazofurin, selenocyantes, selenoesters, methylselenic acid, selenocarbonyl derivatives and selenoureas. By using several modes of action, such as lowering oxidative stress, initiating cell death events and boosting chemotherapeutic efficacy, these substances exhibit anticancer and chemo-preventive effect. Solid tumours can be treated using organic Se compounds that are fully capable of acting as anti-neoplastic medicines. Due to their pro-apoptotic and anti-necrotic properties, organic Se compounds are frequently used in cancer therapy because necrosis in cancer cells is associated with the host immune response and might induce therapeutic issues.[17]

Nanotechnology and Selenium Nanoparticles

Nanotechnology

Nanotechnology involves developing novel substances, devices and methods based on atom management on a scale between 1 to 100 nm. Research in several domains, including chemistry, materials science, physics, biology, engineering and computer science, has greatly benefited from the development of nanotechnology.[18] In the past ten years, the discipline of nanotechnology has grown tremendously and numerous goods containing NPs are now employed in a variety of fields, including food science, cosmetics, pharmaceuticals and targeted or precision drug delivery.[19]

Nanoparticles

The term "Nanoparticle" (NP) relates to a particle with a single size between 1 and 100 nm. NPs display a variety of characteristics depending on their size and surface functions. Small size and huge surface area of NPs explain their widespread use in a number of industries, involving electronics, cosmetics and both therapeutic and diagnostic clinical applications.[19]

Many diverse nanostructures have been used as efficient therapeutics and drug delivery systems, in particular liposomes, polymers, metal nanoparticles, dendrimers, silicon and carbon-based nanomaterials.[9]

Advantages of selenium nanoparticles over other selenium forms

Recent research showed that Se-NPs boosted biological efficacy while lowering selenium toxicity.[20] SeNPs are preferred over other forms of Se because of their higher biological activity and lower toxicity.[21]

Elemental selenium (Se) is the least poisonous form of selenium; therefore, its nano-form has gained a lot of interest. It's interesting to note that functionalized SeNPs are less cytotoxic than inorganic Se, selenate, selenite, selenoproteins and other forms of Se. Elemental nano-sized Se might be superior to conventional Se sources in clinical trials. SeNPs have a detoxifying impact on heavy metal exposure and also has chemo preventive, anti-hydroxyl radicals, other physiological activities. They also prevent DNA damage.[22]

SeNPs exhibit many advantages over conventional organic and inorganic Se compounds, such as low toxicity, high degradability and outstanding anticancer, antibacterial and antiviral properties.[12]

Methods of Synthesizing Selenium Nanoparticles

Synthesis of SeNPs

Managing elements that might directly affect the characteristics of NPs, like shape, size, surface functioning and composition, is crucial for the development and production of SeNPs. It can be performed by using a synthesis technique, regulating the precursor concentration, reaction temperature, pH and preparation time. SeNPs can be synthesised using three diverse processes, including physical, chemical and biological ones.[23]

Physical synthesis of SeNPs

Broadlly, numerous significant pathways like microwave irradiation, hydrothermal treatments and laser ablation are among the most frequently utilised physical procedures for the synthesis of SeNPs.[23]

Laser ablation method

By using laser pulse to break polymer chains inside the irradiated volume, a reaction triggered by laser heating causes laser ablation, a technique for eliminating substances off surfaces.[24] Because of an inexpensive equipment, lack of chemical reagent contamination, simple NP collection and great stability, laser ablation offers numerous advantages over alternative approaches for the production of SeNPs.[23] In Figure 1 discusses the Laser ablation method's detailed procedure.[25]

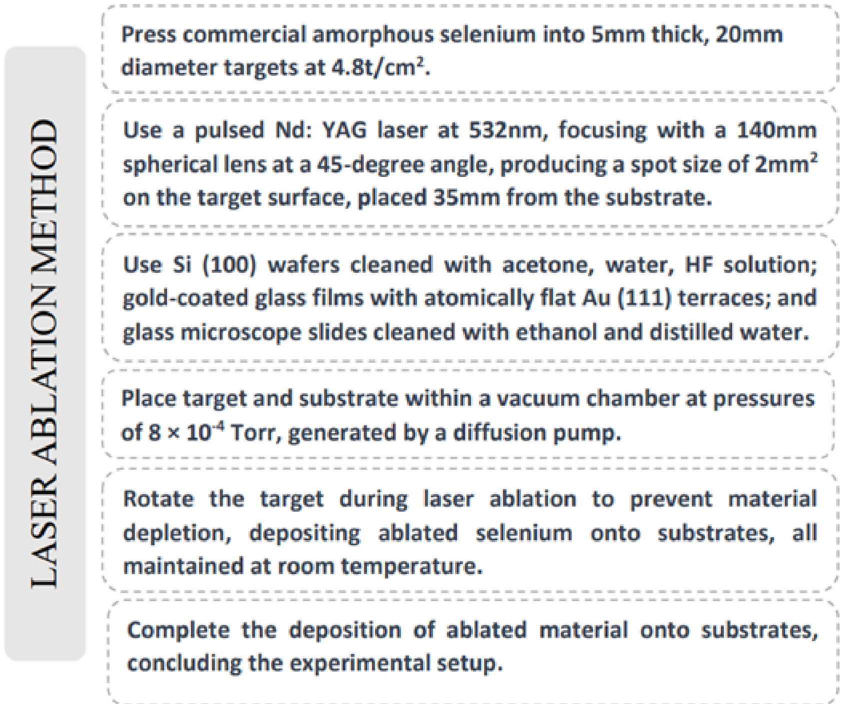

Figure 1: Synthesis of SeNPs by Laser ablation method.

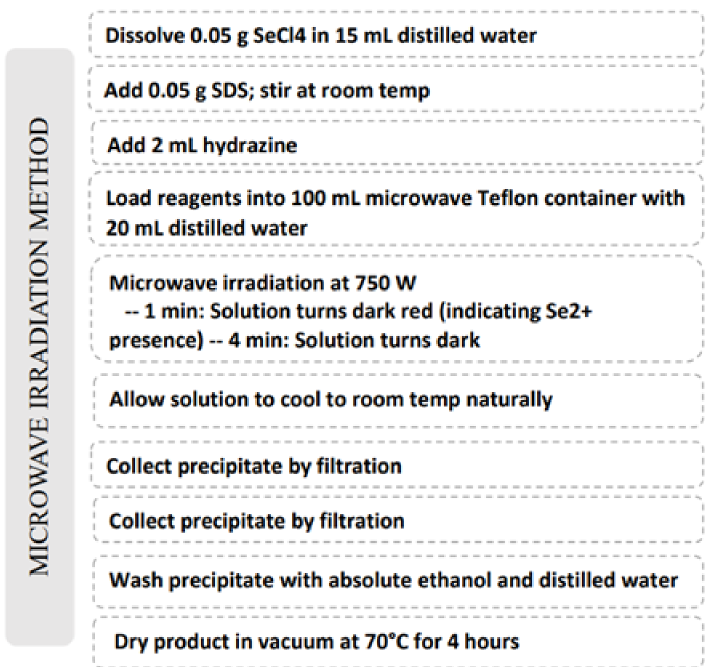

Figure 2: Synthesis of SeNPs by Microwave Irradiation Method.

Microwave Irradiation Method

When compared to traditional heating techniques, the microwave aided method for the synthesis of SeNPs shown various advantages, including quick and uniform heating, higher reaction rates, quick reaction times and energy savings.[23] The Microwave irradiation method's detailed approach is covered in Figure 2, respectively.[26]

Chemical synthesis of SeNPs

SeNPs has been synthesised chemically using a variety of methods, but chemical reduction and stabilisation through

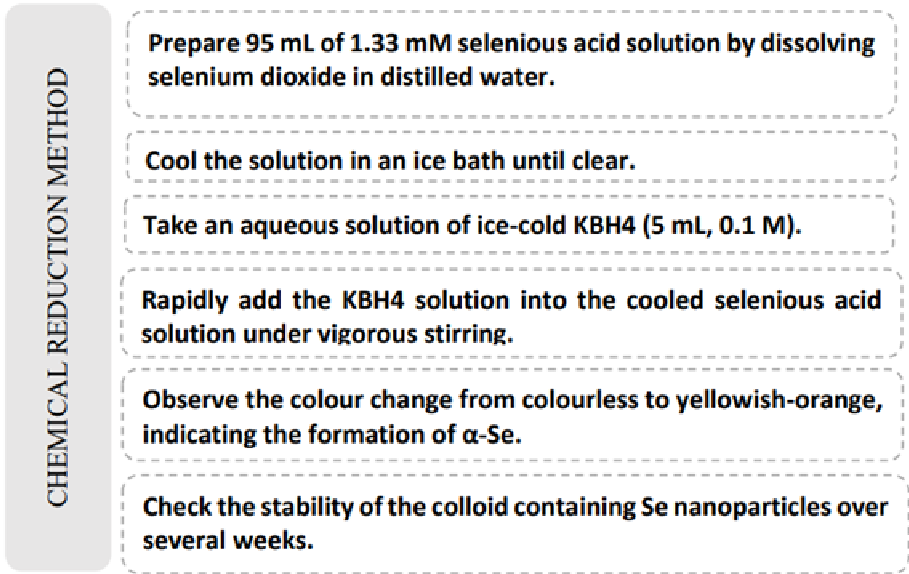

Figure 3: Synthesis of SeNPs by Chemical reduction Method.

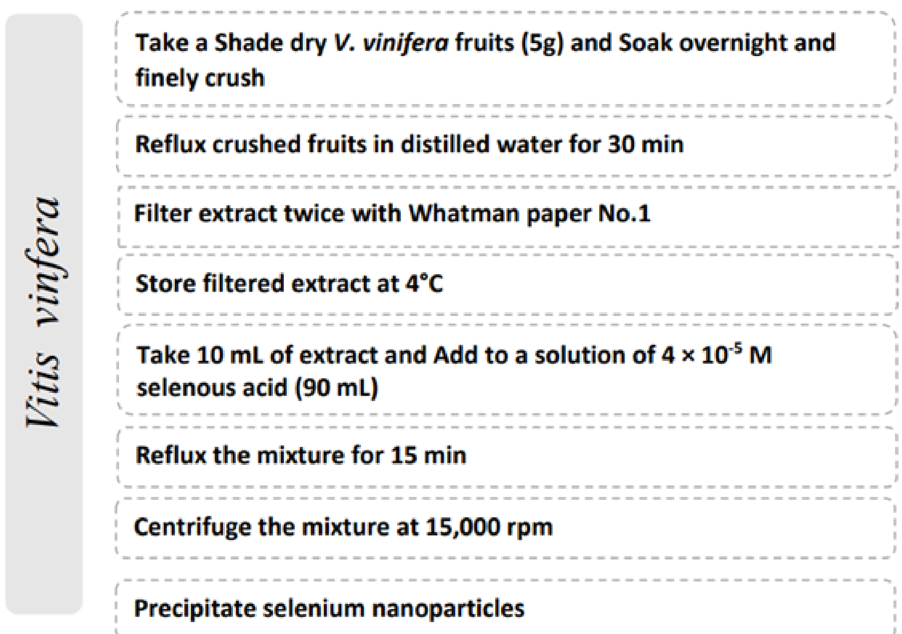

Figure 4: Synthesis of SeNPs by *Vitis vinfera* fruit.

various chemical agents is the most widely employed technique.[23] The process of chemical reduction involves the employment of chemical compounds to reduce the element, its salts, or its compounds. Growth termination reagents, such as folic acid or Polyvinylchloride (PVP), are also used to control the element's size.[22] The Detail procedure of chemical reduction method is discussed in Figure 3 respectively.[27]

Biological synthesis of SeNPs

Recent years have seen a significant increase in the popularity of biological nanoparticle synthesis because of its low toxicity, readily available raw materials, cost-effectiveness and promising applications in pharmacology. Although bacteria and other microorganisms are mostly used in the synthesis pf SeNPs, plants have also demonstrated significant potential in this regard[23].In detail procedure for synthesis of SeNPs by taking plant extract

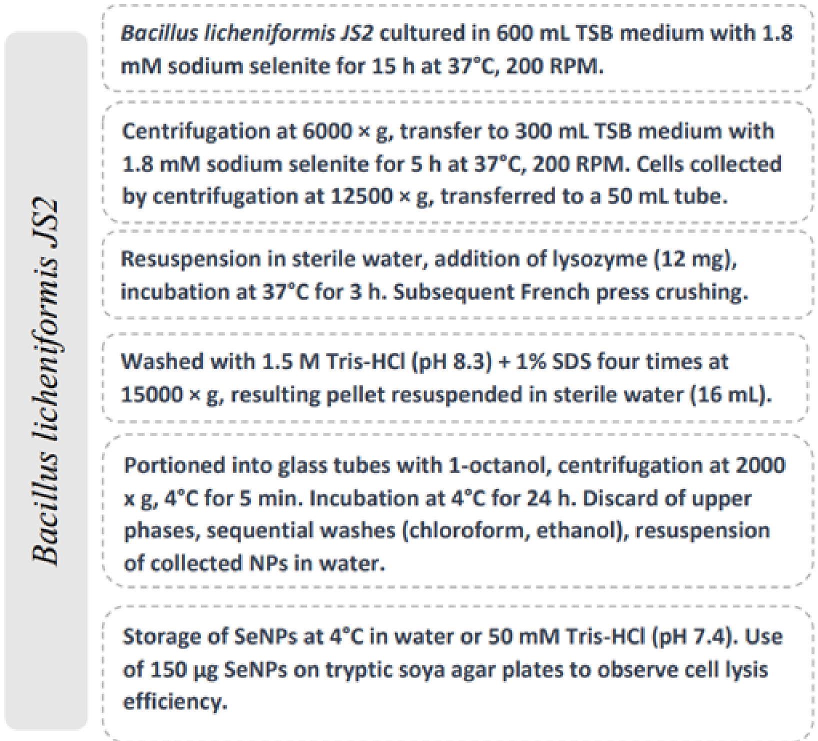

Figure 5: Synthesis of SeNPs by *Bacillus licheniformis JS2*.

and microorganisms is depicted in Figure 4 and Figure 5 respectively.[28,29]

Characterization

Various methods were used to characterise the Se NPs. The NPs' ability to absorb light was evaluated using a UV-visible spectrophotometer with a wavelength of 1 nm. The distribution of particle sizes design of the total cell debris suspension, include Se NPs and refined NPs, were identified by Zetasizer MS2000. To perform Transmission Electron Microscopy (TEM), a small amount of the aqueous suspension including Se NPs was dropped on carbon-coated copper TEM grids and allowed to dry over an IR lamp. Micrograph has been created with a TEM that was operating at a high voltage of 80 volts. In order to analyse the NP superficial properties and find out the elemental composition of NPs, a wavelength Dispersive X-ray (EDX) microanalysis connection was attached to a Scanning Electron Microscope (SEM). NPs have been mounted on specimen's stubs for SEM analysis after being plated with gold in a sputter coating instrument. The samples were examined using a SEM running at 16 kV and the spectrum of EDX was collected by focusing on a collection of NPs. The crystalline structure of the Se NPs is being investigated using an X-ray diffractometer over the scanning range of Bragg angles from 20 to 80.[30]

Antioxidant properties of selenium nanoparticles

Se is a necessary nutritional trace element that has exceptional antioxidant properties. It is vital for maintaining good health. As one Se atom is completely necessary at the active site of all selenoenzymes in the type of the 21st amino-acid selenocystein, it can block a variety of inflammatory cell mechanisms through antioxidant selenoenzymes. Selenoenzymes are GPx, PHGPx and TrxR. These are vital in sustaining intercellular reducing conditions, notably in the brain.

Studies have shown that SeNPs have antioxidant characteristics, suggesting that they could be used to make specialised anti-oxidative medications. Furthermore, oxidative damage builds up in ageing cells. SeNPs have been found to be effective at scavenging free radicals in both *in vitro* and *vivo* in the size range of 5 to 200 nm. The use of biologically produced SeNPs with a diameter is below 100 nm as food additives with antioxidant qualities is a possibility.[31]

Anti-Inflammatory Properties of Selenium Nanoparticles

According to accessible data, selenium controls the inflammatory response through a number of diverse routes. The effect that selenium has on immune cells, particularly macrophage signalling pathways, determines how effective it is at reducing inflammation.[24] Among selenium's other anti-inflammatory properties, we can point to its influence on monocyte adherence to endothelial cells and tissue penetration as a means of controlling the inflammatory response.[25]

The mitogen kinase active protein pathways, supplements containing Se have decreased the endotoxin of gram-negative bacteria's lipopolysaccharides and decreased the gene production of key inflammatory cytokines like cyclooxygenase II and TNF-α. In restraint. Leukocyte transit across the endothelium is facilitated by TNF-α because it has been demonstrated to be a potent inducer of adhesion molecules. As a result, leukocyte adherence to the endothelium decreases following Se administration due to the decrease in TNF-α.[25]

In addition, Se facilitates monocyte adhesion to endothelial cells and subsequent migration to several regions. L-selectin has been established to play an essential function for the immune system's main players in inflammation, the binding of monocytes to vascular endothelium and their distinction into macrophages. In actuality, monocyte adhesion to endothelial cells is inhibited by L-selectin. SeNPs can be utilized as micronutrients and as an alternative to anti-inflammatory and antioxidant medications. According to other reports, selenium lessens apoptotic signals linked to the NF-kB system. The mRNA expression of pro-inflammatory cytokines such inducible TNF-α, Nitric Oxide Synthase and IL-1is downregulated by SeNPs, which also lessens inflammation.[26]

Applications of Selenium Nanoparticles in Cns Disorders

Alzheimer's Disease (AD)

As NPs can pass across the Brain-Blood Barrier (BBB), many studies have suggested using them to treat AD. Several substances have been utilised to stabilise NPs, to lessen their cytotoxicity and to diminish amyloid aggregation with regard to the role of SeNPs in AD investigations. By interfering with hydrophobic and electrostatic interactions during amyloid nucleation, SeNPs coated with specific peptides have demonstrated the ability to bind and suppress A40 fibril development in AD. *In vitro* AD models have employed other SeNPs modified with chondroitin sulphate to prevent aggregation and guard against the cytotoxicity of AD. Additionally, polyphenols, which are widely known for their antioxidant, anticancer, antibacterial, antimicrobial and antiviral effects but which have also been linked in multiple studies to neurogenic qualities, can be coated on SeNPs. For instance, the central nervous system is stimulated by polyphenols like chlorogenic acid, kaempferol, catechins, which also has

Table 1: Various clinical trials conducted report.

Study Title	Interventions	Conditions	Phase	Identifier
31P-MRS imaging to assess the effects of CNM-Au8 on impaired neuronal redox state in Parkinson's disease (REPAIR-PD).	Drug: Gold Nanocrystals	Parkinson's Disease	Phase 2	NCT03815916
Study of APH-1105 in patients with mild to moderate Alzheimer's disease.	Drug: APH1105 Other: Placebo	Dementia AlzheimerDisease1 AlzheimerDisease2 AlzheimerDisease3.	Phase 2	NCT03806478
A Phase I trial of nanoliposomal CPT-11 (NL CPT-11) in patients with recurrent high-grade gliomas.	Drug: Nanoliposomal CPT-11	Glioblastoma Gliosarcoma Anaplastic Astrocytoma Anaplastic.	Phase 1	NCT00734682
Therapeutic nanocatalysis to slow disease progression of Amyotrophic Lateral Sclerosis (ALS).[39]	Drug: CNM-Au8 Drug: Placebo.	Amyotrophic Lateral Sclerosis.	Phase 2	NCT04098406
Exploratory study using nanotechnology to Detect Biomarkers of Parkinson's Disease from Exhaled Breath.	Other: collection of exhaled breath.	Parkinson's Disease Parkinsonism.	-	NCT01246336
AGuIX nanoparticles with radiotherapy plus concomitant Temozolomide in the treatment of newly diagnosed glioblastoma (NANO-GBM).[40]	Drug: Polysiloxane Gd-Chelates based nanoparticles (AGuIX) Radiation: radiotherapy Drug: Temozolomide.	Glioblastoma	Phase1 Phase 2	NCT04881032

cardioprotective, anti-inflammatory, anti-obesity and free radical scavenger characteristics. These factors suggest that polyphenol surface functionalization of SeNP may help in reduction of Aβ aggregation.[32]

Parkinson's Disease (PD)

After Alzheimer's, Parkinson disease is the second most common CNS condition. One of the main contributing reasons to this illness is oxidative stress, which results in apoptosis and neuronal death. As a result, reducing oxidative stress can help PD patients with their behavioural problems. The neuroprotective impact of glycine-nano-selenium on oxidative stress was assessed in preclinical experiments using the PD rat approach and oxidative stress is generated in rats using 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine. Selenium has antioxidant capabilities. It was discovered that intragastric glycine nano-selenium administration reduced oxidative stress in the PD rat approach, which in turn reduced the neurobehavioural impairments in rats.[33] Se supplementation has been demonstrated to increase glutathione and GPx levels in both humans and animals, which slows neuronal deterioration and prevents the depletion of dopamine. As a result, it is considered a crucial micronutrient for PD as well.[34]

Epilepsy

Other CNS conditions, like epilepsy, can also benefit from the usage of SeNPs. Because of its wide antioxidant, anti-inflammatory and neuromodulatory effects, SeNPs may possibly have anticonvulsant action. SeNP can be used as an effective treatment for epilepsy since it reduces the duration of tonic, myoclonic and generalised seizures.[35] SeNP may successfully cross the BBB, making it possible to employ it to improve the administration of antiepileptic and other CNS medications in to the brain.[36] A nanosized particle is necessary for drug delivery to pass the BBB and enable the drug to enter the brain. SeNPs are crucial to the control of Neurodegenerative Disorders (NDs) in this regard.

Overview of Relevant *in vitro* and *in vivo* Studies using Selenium Nanoparticles.

SeNPs for targeted stroke therapy through modulation of inflammatory and metabolic signalling

In laboratory studies, it was discovered that nanoparticles primarily targeted the cell nucleus. Additionally, research revealed that SeNPs played a significant role in promoting the survival of neurons. This effect was achieved by their interaction with various cellular signalling pathways that govern cellular metabolism, the defense system against oxidative stress, responses to inflammation, processes related to cellular self-digestion and programmed cell death involving key molecules like Mst1, ULK1, Bax, Caspase-3 and TORC2.[13]

SeNPs and metformin ameliorate streptozotocin-instigated brain oxidative-inflammatory stress and neurobehavioral alterations in rats

The beneficial impacts of SeNPs on diabetes-induced alterations in neurobehavioral and biochemical factors are linked to enhanced natural antioxidant mechanisms. These include reduced levels of lipid damage, the alleviation of oxidative and inflammatory stress, as well as a decrease in acetylcholinesterase activity. Most notably, SeNPs also contribute to the regulation of Nrf2, caspase-3 and parvalbumin proteins, which serve as molecular indicators of oxidative stress and tissue injury.[37]

Clinical Trials

While numerous experiments, both in the lab and in living organisms, have explored the potential benefits of NPs and drug delivery systems based on nanoparticles, there have been only a limited number of clinical trials that have used these nanocarriers to target neurodegenerative diseases. These clinical trials were primarily designed to assess the effectiveness, safety and metabolic impacts of NPs, either on their own or in combination with other treatments, for conditions like AD, PD, glioma and for their potential role in diagnosing and managing dementia in clinical settings. Despite the fact that the results of these clinical trials may not have been published or deemed sufficient, this has not discouraged researchers from continuing their clinical investigations into the use of SeNPs.[38] The various clinical trials reports are mentioned in the Table 1.

Safety Issues of Selenium Nanoparticles

Due to selenium's vital function in the body, its antioxidative qualities, its anti-inflammatory properties and its significance in nutrition and medicine, one could anticipate nanotoxicity for SeNPs. Se has one of the narrowest gaps between nutritional deficit and hazardous levels, though. For an adult who is healthy, the lower daily intake for selenium is 40 μg, but toxicity effects start to manifest at 10 times greater concentrations. Se's inorganic form, selenite, is thought to be the most hazardous, with selenomethionine and selenocysteine being less harmful. Biochemical thiols quickly react with selenite and other inorganic Se compounds, forming ROS as a result. The inhibition of thiol-containing proteins and enzymes as a result of Se's resemblance to sulphur, which may lead to the nonspecific substitution of sulphur in proteins, is another potential cause of Se toxicity.[41] Garlic breath, hair and nail loss, thicker and brittle nails, tooth deformation, skin lesions and a drop in haemoglobin are typical signs of Se poisoning, also known as selenosis, in humans. Numerous researches has suggested that Se in nanoparticulate form is less hazardous.[42] For instance, in treated mice, folate-conjugated SeNPs showed roughly three times less acute liver damage than selenite or selenomethionine and remarkable selectivity in growth inhibition between cancer and normal cells.[43]

Dosing Protocols

Se has a small window between dangerous and advantageous dosages, though. Se should be taken in doses of 70 μg for men and 60 μg for women daily, according to the Expert Group on Vitamins and Minerals (EVM). Doses exceeding 400 μg are harmful and can cause selenosis, a condition. SeNPs are widely used in the field of therapeutics and have attracted attention due to their remarkable health effects. Compared to inorganic Se, SeNPs are less toxic, more effective against free radical species and have a tolerable bioavailability. SeNPs' toxicity is also rated as being lower than that of other organic and inorganic substances including selenate, selenite and selenomethionine based on experimental data.[10]

CONCLUSION

In conclusion, this review has highlighted the burgeoning potential of SeNPs as a promising avenue in the treatment of CNS disorder. These debilitating conditions, involving Parkinson's, Alzheimer's and traumatic brain injuries continue to challenge the field of healthcare. SeNPs, with their enhanced antioxidant capabilities, anti-inflammatory properties and precise drug delivery mechanisms within the brain, offer a multifaceted approach to addressing the complex nature of CNS disorders. By countering oxidative stress and potentially alleviating neuroinflammation, SeNPs present an exciting prospect for more effective, targeted and minimally invasive therapeutic strategies.

As we delve into the realm of nanotechnology, the innovative utilization of SeNPs provides a glimpse into a future where intricate neurological conditions may find relief through novel interventions. However, it's essential to acknowledge that further research, rigorous clinical studies and safety assessments are imperative to fully realize the therapeutic potential of SeNPs in CNS disorder management. Nevertheless, SeNPs stand as a testament to the relentless pursuit of innovative solutions in our ongoing commitment to ease the burden faced by those affected by these formidable disorders. This review underscores the significance of continued exploration and highlights the promise that SeNPs hold as a crucial component of future CNS disorder therapies.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

SeNPs: Selenium Nanoparticles; **PHGPx:** Phospholipid hydroperoxide glutathione peroxidase; **GPx:** Glutathione peroxidase; **TrxR:** Thioredoxin reductase; **TNF-α:** Tumour Necrosis Factor alpha; **Nf-κB:** Nuclear factor kappa B; **PGE2:** Prostaglandin E2.

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