Journal for Research in Applied Sciences and Biotechnology

www.jrasb.com

ISSN: 2583-4053

Volume-3 Issue-3 || June 2024 || PP. 149-157

https://doi.org/10.55544/jrasb.3.3.24

Nanotechnology Based Therapeutic Approach in Alzheimer's

Md. Samiullah[1], Kajal Chauhan[1], Dr. K. Manimekalai[2], S. Hameedullah Sherief[3], Maulik K. Pandya[4], Soaib Ahmed[5], Roushan Bhaskar[6] and Jay Prakash[7*]

[1]Department of Pharmacy, Uttaranchal Institute of Pharmaceutical Sciences, Uttaranchal University, Dehradun, INDIA.

[2]Assistant Professor, Hindusthan College of Arts and Science Coimbatore, Tamil Nadu, INDIA.

[3]Assistant Professor, PG and Research Department of Microbiology, Sadakathullah Appa College, Tirunelveli, Tamil Nadu, INDIA.

[4]Department of Pharmaceutical Chemistry, Parul institute of Pharmacy & Research, Parul University, Vadodara, Gujarat, INDIA.

[5]Department of Pharmaceutical Quality Assurance, Guru Nanak Institute of Pharmaceutical Science and Technology, Kolkata, 700114, West Bengal, INDIA.

[6]Department of Pharmacology, St. Soldier Institute of Pharmacy, Jalandhar, Punjab, INDIA.

[7]Clinical Pharmacologist, Paras Health Gurugram, INDIA.

[*]Corresponding Author: jayprakashpujari@gmail.com

www.jrasb.com || Vol. 3 No. 3 (2024): July Issue

Received: 20-06-2024	**Revised:** 23-06-2024	**Accepted:** 30-06-2024

ABSTRACT

Alzheimer's disease is a neurodegenerative disorder that ultimately results from the accumulation of beta-amyloid plaques in the brain. The Alzheimer's disease cannot be prevented or cured at this time, and there is no recognised alternative. The medicinal solutions that are currently available can merely slow down its development. However, nanotechnology has demonstrated its applications in the medical field, and it demonstrates a great deal of promise in the treatment of Alzheimer's disease. In particular, it has shown significant promise in the detection of the condition and the development of an alternative technique to cure it. It is necessary for the medication delivery system to have the capability of penetrating and crossing the blood-brain barrier in order to accomplish this need. On the other hand, greater research is necessary in order to discover and overcome these limitations, which have the potential to improve drug absorption while simultaneously reducing toxicity and adverse effects. Certain nanotechnology-based techniques to treating Alzheimer's disease include regenerative medicine, neuroprotection, and stem cell regeneration. These are just few of the emerging approaches. This article's goal is to take a look at nanotechnology from every angle, including its advantages and disadvantages and how it's helping with neurodegenerative disease research and therapy.

Keywords- Nanotechnology, Alzheimer's disease, Nanoparticle, Liposome.

I. INTRODUCTION

In Alzheimer's disease (AD), the most common kind of dementia, neuritic plaques and neurofibrillary tangles are formed when amyloid-beta peptides (Aβ) accumulate in the medial temporal lobe and neocortical structures, the areas of the brain most impacted by the disease[1]. The German psychiatrist Alois Alzheimer came up with the idea for the illness, and it was named after him. The brain of Alois Alzheimer's first patient showed signs of neuronal death and amyloid plaques[2]. The patient suffered from memory loss, personality problems, and ultimately went away. Alzheimer referred to the sickness as a severe type of disease that affects the cerebral cortex. The name "Alzheimer's disease" was initially used by Emil Kraepelin to describe this medical condition in his psychiatry textbook, which was in its ninth edition at the time[3]. The slow deterioration of cognitive ability can be caused by a number of different variables coming together. Among these include cerebral illnesses such as Alzheimer's disease (AD), infections, nutritional deficiencies, a lack of vitamin B12, tumours,

Journal for Research in Applied Sciences and Biotechnology

www.jrasb.com

ISSN: 2583-4053

Volume-3 Issue-3 || June 2024 || PP. 149-157

https://doi.org/10.55544/jrasb.3.3.24

anomalies in the circulatory and pulmonary systems that lower the amount of oxygen that is supplied to the brain, and intoxications[4]. According to the Alzheimer Association, between sixty and eighty percent of instances of dementia are caused by a degenerative brain condition known as Alzheimer's disease (AD). Depending on the stage of the disease, some of the symptoms that advance to influence the performance of routine activities include apathy, depression, diminished communication, disorientation, poor judgement, difficulty swallowing and walking, and behavioural changes[5]. These symptoms can also affect the ability to conduct routine activities. The length of time it takes for a spectrum of these symptoms to become apparent is determined by a number of factors, including age, heredity, and gender, among others. Because of the COVID-19 pandemic, there has been a 16% rise in the number of deaths that have been documented. Furthermore, according to the most recent estimates, the number of individuals living with Alzheimer's disease in the United States is over six million, and it is anticipated to climb to approximately 13.8 million by the year 2060. Not considering informal care, it was anticipated that an additional $355 billion would be spent on care payment for Alzheimer's disease patients and patients with disorders connected to the disease in the year 2021[6]. The accumulation of amyloid-beta (Aβ) and tau proteins leads to a steady decline in cognitive function in those who are affected by Alzheimer's disease[7]. The production of amyloid-beta (Aβ) occurs through the successive cleavage of the amyloid precursor protein (APP) by beta-secretase and gamma-secretase. When Aβ clumps together, oligomers are created, and these oligomers are detrimental to the functionality of neurons[8]. In contrast, the microtubule-associated protein tau (MAPT) gene undergoes alternative splicing, which results in the production of soluble forms of tau. In the context of Alzheimer's disease, it has been discovered that Aβ and tau are involved in various functional linkages that contribute to the breakdown of neuronal circuits and cognitive decline[9]. It is hoped that this would serve as a source of inspiration for the development of a holistic plan for the prospective therapy.

Currently, it is believed that there are fifty million individuals living with Alzheimer's disease (AD), and experts project that number will increase to 152 million by the year 2050, having doubled every five years since the year 2000[10]. Every year, the burden of Alzheimer's disease, which has an effect on individuals, their families, and the economy, is estimated to cost one trillion dollars in the United States. The only thing that treatments for Alzheimer's disease can do is lessen symptoms; there is presently no cure for the condition. The objective of this study is to provide an overview of the diagnosis, pathology, aetiology, and treatments that are currently available for Alzheimer's disease (AD)[11]. Additionally, it will bring to light the newly discovered chemicals that possess the capability to prevent or treat Alzheimer's disease by targeting a variety of pathogenic mechanisms[12]. These mechanisms include the aggregation of Aβ and tau, misfolding, inflammation, oxidative damage, and other related mechanisms[13].

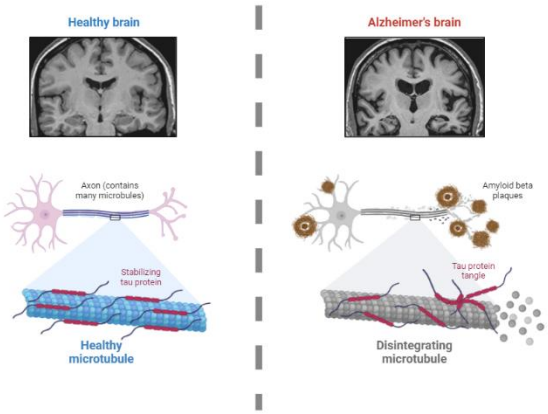

Figure 1: Difference between Healthy brain and Alzheimer's brain

II. ETIOLOGY

The gradual neurodegeneration that is characteristic of Alzheimer's disease ultimately results from the death of neuronal cells. The entorhinal cortex of the hippocampi is frequently the spot where neurodegenerative disorders begin to manifest themselves[14]. There are genetic components associated with both early-onset and late-onset Alzheimer's disease. Trisomy 21 is one of the risk factors that can lead to dementia in its early stages. Alzheimer's disease is a complicated condition that is associated with a wide range of risk factors that are now known[15]. The primary factor that contributes to the most significant component, which is age itself, is the process of ageing. An individual's risk of having Alzheimer's disease about doubles every five years beginning at the age of 65. It is well-established that both Alzheimer's disease (AD) and cardiovascular disease (CVD) contribute significantly to the progression of the disease[16]. It raises the odds of getting Alzheimer's disease and other forms of dementia, including vascular dementia and strokes. Heart disease (CVD) is a potentially treatable risk factor for Alzheimer's disease (AD), according to an increasing amount of studies.

Obesity and diabetes are major risk factors for Alzheimer's disease, and they are also controllable. Owing to its effects on glucose tolerance, obesity raises the chance of acquiring type II diabetes[17]. Because it encourages the buildup of beta-amyloid (A-beta) and neuroinflammation in the brain, chronic hyperglycemia can induce cognitive impairment. Obesity considerably raises the chance of developing diabetes because it causes an increase in insulin resistance and stimulates the release of cytokines that promote inflammation. There are a number of other risk factors for Alzheimer's disease, including a higher mother age at birth, smoking, raised homocysteine levels, a family history of dementia,

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traumatic brain injury, depression, cardiovascular and cerebrovascular disease, APOE e4 allele status, and other risk factors. Having an Alzheimer's disease in a first-degree relative increases the probability of developing the disease by 10% to 30%. Having two or more diagnosed siblings increases a person's risk of having late-onset Alzheimer's disease by a factor of three compared to the general population. Many of the factors that have been discovered may be responsible for a reduced risk of developing Alzheimer's disease (AD). A healthy diet, regular aerobic exercise, a higher level of education, the use of oestrogen in women, anti-inflammatory drugs, and recreational activities such as reading or playing an instrument are some of the items that fall into this category[18].

III. PATHOGENESIS OF ALZHEIMER'S DISEASE

To better understand the causes of Alzheimer's disease (AD), it's crucial to pinpoint the regions that need immediate attention when the disease is in its early stages and reversible changes are still possible[19]. Neurofibrillary tangles within cells and amyloid plaques outside of cells are telltale signs of early-stage Alzheimer's disease. Features seen in histopathology include aneuploidy, degradation of synapses, and loss of neurons in the hippocampus. In the initial phases of Alzheimer's disease, a multitude of pathophysiological alterations occur[20]. A malfunctioning brain lymphatic system, neuroinflammation, oxidative stress, microbiome infection, and mitochondrial dysfunction are all components of these alterations[21]. The progression of Alzheimer's disease is influenced by various physiological mechanisms, which are summarised in Figure 2. Factors that hasten the onset of Alzheimer's disease include a person's lifestyle choices as well as the natural ageing process. The following sections will outline these components so that you can gain a better understanding of the pathophysiology of Alzheimer's disease[21].

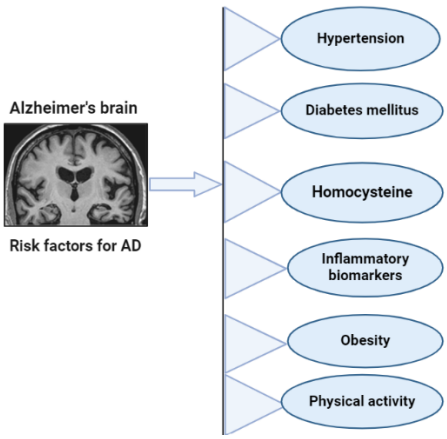

Figure 2: The lifestyle and age related factors involved in Alzheimer's disease

Hypertension

Among the characteristics that put senior people at risk for Alzheimer's disease, hypertension is the one that is most strongly associated to the condition and is reliant on age[22]. Chronic hypertension may have an effect on Alzheimer's disease (AD) through the connection of cerebrovascular pathology, despite the fact that the processes involved in this correlation are challenging to understand[23]. One suspected component of the pathophysiology of Alzheimer's disease (AD) is hypertension, or high blood pressure, since research has linked it to an increase in brain plaque formation[24].

Diabetes Mellitus

Diabetes mellitus is associated with the onset of Alzheimer's disease, according to recent studies. MA-[D-leu-4]-OB3, which is typically used to treat obesity and diabetes, has also shown promise in reducing Alzheimer's disease symptoms, according to studies[25]. Regarding the link between the two conditions, one study found that caveolin-1 deficiency in type 2 diabetic mellitus (T2DM) can cause Alzheimer's disease to develop. Theoretically, there is evidence linking the two diseases, and novel strategies for preventing Alzheimer's disease in diabetics have been found. Researchers have found that physical activity, weight management, and a healthy diet can reduce the risk of Alzheimer's disease (AD), a condition that can develop as a result of diabetes[26].

Homocysteine

In the development of Alzheimer's disease (AD) pathology, the sulfur-containing amino acid homocysteine contributes to the buildup of beta amyloid (Aβ) plaque[27]. Because it amplifies brain oxidative stress, homocysteine may also has a function in the sped-up onset of Alzheimer's disease symptoms[28].

Inflammatory Biomarkers

There is substantial evidence linking inflammatory biomarkers such as C-reactive proteins, interleulin-6, fibrinogen, alpha-1-antichymotrypsin, and other lipoprotein-associated phospholipase A2 to an increased risk of dementia. Notwithstanding, more assessments are required to get more results[29].

Obesity

Being overweight in middle age is associated with an increased risk of Alzheimer's disease, according to certain research. Despite the dearth of studies examining the disease's origins, this remains the case. Neuroimaging, obesity, and cognitive decline research do, with a few exceptions, indicate that obesity is associated with the progression of Alzheimer's disease (AD)[30].

Physical Activity

A substantial body of research implies that the rate of advancement of Alzheimer's disease is connected with the amount of physical activity that a person engages in. The rate of cognitive decline in senior people may be slowed down by engaging in regular physical activity that is both healthful and beneficial. According to the findings of earlier studies, activities such as yoga and meditation are known to make the brain more active. Furthermore,

ISSN: 2583-4053

Volume-3 Issue-3 || June 2024 || PP. 149-157

https://doi.org/10.55544/jrasb.3.3.24

there is strong evidence linking physical activity to gut bacteria, which are known to have a role in both the onset and prevention of Alzheimer's disease. Another study provided more evidence that exercise can help slow the advancement of Alzheimer's disease. Exercise not only has anti-inflammatory effects, but it also delivers other various benefits through multiple pathways. More research is required to confirm the negative correlation between inactivity and cognitive loss[31].

IV. ADVANTAGES OF NANOTECHNOLOGY IN ALZHEIMER'S DISEASE

Due to the fact that the medication is unable to pass across the blood-brain barrier, the only treatment option available for Alzheimer's disease at the present is symptom alleviation. This was noted earlier. As a result, there are a great deal of advantages to therapy that is based on nanotechnology, and it might be able to circumvent this limitation[32].

Nanotech Immunotherapy

Immunotherapy is now emerging as a potentially effective method for treating cancer. In both its conception and its implementation, immunotherapy is a pretty straightforward process. It begins with the collection of T cells from cancer patients for the purpose of in vitro reconstitution, which enables these cells to be guided towards specific cancer receptors. Following this, the patient is reintroduced to these changed T cells, which are responsible for the death of cancer cells in the bloodstream without causing any potential adverse consequences. Immunotherapy, on the other hand, can impede the immune system's ability to remove tumours if the malignancy of the tumour continues to advance and the patient's immune system is repressed. Additionally, it is probable that the T cells that have been generated and changed are not completely safe for use in human beings. It has been suggested that nanotechnology or nanoparticles, which are both examples of nanotechnology, could make immunotherapy both safe and effective, so overcoming these limitations and increasing the likelihood that it would be successful[33].

Safe Sterilization

There have been numerous applications of silver nanoparticles in the medical industry, particularly in the fields of drug formulations and medical devices[34]. It is possible to directly sterilise the citrate-stabilized silver nanoparticles by employing γ-radiation and an autoclave. The size of these nanoparticles ranges from 20 to 80 nanometers. The addition of silver nanoparticles to a chemical that generates hydroxy radicals was done in order to replicate the size and shape changes that were brought about by sterilisation, which proposed that a free radical mechanism of action was responsible for the effects[35]. Platelet accumulation, which is an in vitro sign of thrombogenicity, was also discovered to be more likely to occur with the sterilised silver nanoparticles in comparison to the unsterilized silver nanoparticles that were employed as controls[36].

Early disease diagnosis

A significant amount of research has been conducted due to the fact that nanotechnology has the potential to be utilised in medical imaging for the purpose of illness diagnosis and therapy[37]. The utilisation of superparamagnetic iron oxide nanoparticles (NPs) can result in an increase in contrast for spectroscopy imaging[38][39]. In addition, nanoparticles (NPs) can be coupled to specific biomarkers, which enables the evaluation of these indicators as well as the ultrasound detection of distinct cancer shapes. In addition to its application in advanced medical imaging-based detection, nanotechnology is recognised for its stability and reliability in performance attributes. It is also utilised as a disease detector with high sensitivity for the purpose of early diagnosis[40].

Biosensors

Utilising a physical transducer in conjunction with a sensitive biological recognition mechanism, such as an enzyme, an antibody, or nucleic acid, a biosensor is a device that is capable of detecting chemicals. This is accomplished through the utilisation of certain components[38]. The data allow for the formation of conclusions that are both qualitative and quantitative in nature. Biosensors that are able to satisfy the requirements of low cost, rapid detection, high sensitivity and selectivity, and graphene are becoming more and more popularity[39]. In addition to graphene and gold nanoparticles, photonic crystals and carbon nanotubes are also included in this category of materials. In addition, the inclusion of nanotechnology into biosensors has led to a great number of innovative breakthroughs in the field of signal transduction. The development of instruments and processes for photographing and quantifying items at the nanoscale has led to an increase in the popularity of biosensors that interact with minute molecules for the purpose of evaluation[41].

Sustainability

Nanotechnology, which is one of the most important factors in facilitating sustainable growth, has the potential to improve the efficiency of a wide variety of manufacturing processes, in addition to its many other potential benefits. As a field of application, nanotechnology is still in its infancy due to the fact that there are problems that have not been solved and unforeseen consequences. People ceased caring as much about the project when the initial excitement subsided, despite the fact that each year offered new and exciting discoveries as a result of the tremendous research and development that went into the project. A precipitous surge in the number of patents relevant to engineered nanomaterials has occurred, and a great deal more patents are currently in the process of being developed. These materials belong to a revolutionary category that possesses amazing possibilities; there are already some fascinating applications for them in the business sector.

ISSN: 2583-4053

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Current and future uses of nontechnology in science include cell sorting, DNA diagnostics, kidney dialysis, probe tips for scanning probe microscopes, targeted drug delivery devices, pharmaceutical purification, lab-on-a-chip, proteomics, single-cell analysis, BioMEMS, CytoSensing, enzymes, cancer treatment, biophotonics, and countless more examples. These applications are primarily in medicine, pharmaceuticals, and biology[42].

V. NANOTECHNOLOGY IN ALZHEIMER'S DISEASE

Nanotechnology focuses on the creation, manufacturing, and application of materials that have a size that is between 1 and 100 nanometers on at least one dimension. This is the primary objective of nanotechnology. It is common for materials of this scale to exhibit bulk-independent properties, such as surface plasmon resonance or superparamagnetism, which are of interest to the field of medicine. Because their size range is comparable to that of nanomaterials, particularly nanoparticles, proteins and nucleic acids are perfect for interacting with cells and other biomolecules. This is because of the unique properties that they possess. In a similar vein, nanometric size, which is distinguished by a high surface-volume ratio, offers benefits in the context of sensing and other applications involving biological identification.

These compounds have been subjected to extensive research in order to determine the possible medicinal applications of these molecules[43]. Recent years have also seen research into the applications of nanomaterials being conducted in the field of precision medicine. As a result of the drug's failure to circumvent the blood-brain barrier, the only treatment for Alzheimer's disease that is now available is symptomatic alleviation. According to Ling et al. (2021), therapy that is based on nanotechnology has a number of benefits and may be able to avoid this constraint. The FDA has given its approval for the use of a wide range of nanocarriers, which can be found in medications that are available for commercial sale. These nanocarriers range in size from extremely small to extremely large. The utilisation of these nanocarriers has the potential to reduce the symptoms of chronic neurological disorders such as Alzheimer's disease and brain cancer[44].

A vast range of nanocarriers, each of which contains a different medication, are included in the category of nanomedicines. The potential for employing nanomaterials to regulate the symptoms of Alzheimer's disease has been the subject of a significant amount of research. Later on, we will discuss delivery systems that are based on nanostructures because they are now being used to treat Alzheimer's disease. Nanoparticles that are based on lipids, nanostructures that are organic, and metallic nanoparticles are the three categories that the majority of them belong to.

Nanomedicine

In the treatment of neurodegenerative illnesses, theranostics is an emerging method of treatment strategy. It is the diagnostic and therapeutic applications of nanomedicine that are at the core of the field of theranostics. The field of medication targeting has seen significant advancements in recent years thanks to the application of nanomedicine. Through the introduction of magnetism-enhanced nanoparticles (NPs) that carry carmustine into the brain tumour, it is feasible to decrease the volume of the tumour. Through the utilisation of theranostic nanoparticles in conjunction with antiretroviral medications, a drug targeting mechanism can be put into effect. As a result, efforts are currently being made to generate nanoformulated particles and ligand targeting in order to measure reductions in therapeutic doses. In addition, another type of nanomedicine that is currently undergoing modification is haemoglobin that has been encased in liposomes. It is possible for these molecules to enter ischemic regions in the event that there is a sudden interruption in the flow of blood circulation. It is therefore possible to use haemoglobin molecules that are wrapped in liposomes in order to monitor stroke models that have inadequate blood flow. The utilisation of cerium oxide nanoparticles (NPs) as a source of reactive oxygen species (ROS) is another application of nanoneuromedicine. CeO2 nanoparticles have further applications, one of which is neuroprotection, which is the prevention of nerve damage[45].

Nanoparticles in Stem Cell Regeneration

It is possible to accommodate functional biological components that are known as nanomaterials within the range of a nanometer, which is sufficiently large. As a consequence of this, the components will have a better opportunity of interacting with the living creature. Nanoparticles (NPs) have the potential to enhance tissue regeneration without necessitating an immune response or providing protection against infections, which is the fundamental concept underpinning nanoneuromedicine. One of the most well-known applications of nanoparticles (NPs) in stem cell research is the utilisation of magnetic nanoparticles for the purpose of stem cell isolation and sorting[46]. Molecular imaging and stem cell tracing are two further applications that fall within the category of quantum dots. Furthermore, nanoparticles have the potential to exert an influence on the proliferation and differentiation properties of stem cells.
It is possible that organ failure is one of the most serious medical issues that could present itself. Within the field of tissue engineering, scaffolds are an essential component. In order to recellularize using induced pluripotent stem cells, which have the ability to restore organ function, natural scaffolds are obtained through the process of decellularization. This process ensures that the extracellular matrix retains its original composition. During the process of selective differentiation, stem cells have the potential to evolve into specialised cells that

ISSN: 2583-4053

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https://doi.org/10.55544/jrasb.3.3.24

contribute to the maintenance and construction of the tissues of the body. For this reason, nanoparticles (NPs) might be utilised in conjunction with stem cells in order to boost the proliferation and differentiation of cells[47].

Furthermore, nanomaterials have the potential to enhance the regulation of the conditions within the microenvironment of transplant cells. It is possible to cultivate organoids in three dimensions using the stem cells that have been collected. Because postmortem materials are used, research that involves the brain is inevitably limited by these particular resources. This attempt is worthy of investigation since it has the potential to pave the way for more in-depth research on the functioning processes of the brain.

The process of stem cell regeneration needs to be continuously monitored and evaluated in order to ensure that it is both structurally and functionally right. The use of nanoparticles in confocal imaging could be considered for the purpose of further evaluating the bioengineered tissue. Nanotoxicology is a relatively young discipline that has evolved as a result of significant improvements that have been made in this area. The reason for this is that clinical trials cannot begin until after it has been demonstrated that nanoparticles are harmful.

Liposomes

Liposomes, which include a phospholipid bilayer, are the most likely vehicle for medications to pass through the blood-brain barrier (BBB). Any deviation from the BBB, on the other hand, is severely forbidden. In order to improve their ability to pass through the blood-brain barrier, lipid carriers have undergone substantial surface modification[48]. There is a possibility that the surface of the BBB is home to a multitude of ligand receptors, which may include proteins, peptides, and antibodies. Transcytosis can be improved by using these compounds, which contain surface-active ligands that can be applied accordingly[49]. There is simultaneous occurrence of both transcytosis and the absorption of cationic liposomes into the blood-brain barrier. Liposomes are typically coated with nutrients like glucose in order to streamline the process of transporting these substances throughout the body. It is possible that a process known as passive diffusion will start just after liposomes arrive in the brain. This process is started and initiated by the brain's passive efflux[50]. The medicine can be carried to the central nervous system more effectively across the cells of the blood-brain barrier that possess important receptors when curcumin is included in liposomes. When administered to Alzheimer's disease-affected brain tissue, a liposome carrier system surface-modified with a mannose ligand and cell-penetrating peptides (CPPs) can deliver apolipoprotein E (ApoE2)[51]. Functionalized liposomes effectively and safely carry high concentrations of genes to target tissues, according to the results, which has implications for the treatment of Alzheimer's disease. Osthole, often known as Ost, is a molecule that inhibits Alzheimer's disease (AD) by protecting neurons in the hippocampus and exhibiting anti-Aβ characteristics. A carrier system for osteoliposomes has been created in order to overcome the problems of bioavailability and exposure to target regions in the brains of Alzheimer's disease mice[52].

Nanogels

According to the available evidence, nanogels are a more efficient method of medication administration than administering free drugs on their own. One way to demonstrate this was by examining the efficiency with which free medication was provided. Several factors contribute to this, including improved cellular absorption of medicine, decreased drug toxicity, improved drug loading, and targeted controlled release of the loaded drug[53]. The ability of nanogels to bind active chemicals, macromolecules, and pharmaceuticals has led to their application as drug delivery vehicles addressing a number of issues associated with diseases including Alzheimer's. Deferoxamine administered as nanogels using the chitosan and tripolyphosphate method is among the most effective therapies for Alzheimer's disease, according to a recent study. Artificial chaperones, made of polysaccharide pullulan backbones modified with cholesterol moieties, can reduce the pathogenesis of Alzheimer's disease (AD) by halting the formation of Aβ amyloids[54]. A preclinical investigation conducted on mice revealed that the utilisation of nanogels as a carrier resulted in an improvement in the distribution of insulin from the nose to the brain. Insulin is a potential treatment for Alzheimer disorder. When combined with polysaccharides, the nanoparticles not only displayed outstanding stability, hydrophilicity, and biodegradability, but they were also non-toxic when employed on their own[55].

Antibody based nanoparticles

After getting immunotherapy dosages for the treatment of Alzheimer's disease, patients may experience several adverse effects, including meningoencephalitis and other complications. Nanoparticles (NPs) coated with antibodies directed against specific target proteins are the most efficient alternative to immunotherapy. Because of this, protein aggregates in brain cells may be located and broken up[56]. Using antibodies that have been coated with metal oxide nanoparticles allows one to detect AD-related proteins in the brain. Cells harbouring amyloid compounds, linked to Alzheimer's disease, can be targeted selectively using nanovehicles encased in chitosan and Aβ fragments. The absorption of NP-Aβ across the blood-brain barrier can be enhanced by contrast chemicals like Alexa Fluor and fluorescein isothiocyanate (FITC)[57]. Positive progress has been made in the treatment of Alzheimer's disease by the utilisation of the class A receptor activator XD4 (W20/XD4-SPIONs) and the A oligomer-specific scFv-AbW20 coupled to SPIONs[58-60]. The combination of an A-oligomer-specific antibody and a category A scavenger receptor activator improved the early diagnostic potential for Alzheimer's disease[61]. The creation of nanoparticles of

ISSN: 2583-4053

Volume-3 Issue-3 || June 2024 || PP. 149-157

https://doi.org/10.55544/jrasb.3.3.24

superparamagnetic iron oxide was the outcome of this combination[62].

VI. CONCLUSION

Improving the transport of antiamyloid, therapeutic proteins, and medications across the blood-brain barrier is one way nanotechnology is being used to treat Alzheimer's disease. Another method that nanotechnology is being used to treat Alzheimer's disease is by delivering antioxidants to mitochondria to stop the production of reactive oxygen species (ROS). Another technique is by delivering genetic material to cells. Nanotechnology has the potential to revolutionise bioimaging and proteomics, which bodes well for the battle against Alzheimer's disease. Additional research on the possibility for long-term damage is necessary before using nanotechnology in clinical trials, but it has shown promise in the treatment of Alzheimer's disease. There are a lot of financial hurdles associated with using nanotechnology to cure Alzheimer's disease. There is concern about the high expense of a nanotechnology-based treatment for Alzheimer's disease, which is presently under investigation as a possible mainstream therapeutic option.

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