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THE ANTIMICROBIAL PROPERTIES OF MARINE-DERIVED NANOPARTICLES

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Abstract
Bioactive compounds have been discovered in a wide variety of marine organisms, including fish, algae, plankton, fungi, bacteria, marine mammals, and invertebrates. These active chemicals derived from marine sources have been employed extensively because of their various biological properties. Whole extracts or pure chemicals are employed to create nanoparticles because marine-derived materials are easily accessible, inexpensive to generate, nontoxic, and have low cytotoxicity against eukaryotic cells. Both infectious diseases caused by bacteria, fungi, and viruses as well as non-infectious conditions like cancer, diabetes, inflammatory response, and tumors have been treated with these marine-derived nanomaterials. They have also been applied to encourage the healing of wounds. Additionally, several marine polymers, such alginate and chitosan, are employed as drug delivery nanocarriers. Additionally, after being encapsulated onto polymeric nanocarriers, a range of pure bioactive chemicals have been used to treat infectious and non-infectious disorders. This paper aims to give a comprehensive overview of the creation of nanoparticles and their biological applications using their pure components or complete extracts that have been extracted from marine resources.
Keywords: marine, nanoparticles, infectious disease, antimicrobial, anticancer

1. INTRODUCTION

Infectious diseases have the capacity to raise the death rate on a worldwide scale. Infectious diseases can be caused by viruses, fungus, or bacteria. These microbes cause a variety of diseases, including as COVID-19, cholera, and candidiasis. COVID-19 is the most recent to trigger a pandemic [1]. Multiple drug resistance in viruses, fungi, and bacteria has escalated to alarming proportions and has to be addressed right away. Several worldwide health groups have called for the quick eradication of drug-resistant harmful microorganisms. Additionally, the drugs now utilized to treat infectious infections in patients with non-infectious diseases such diabetes, cancer, inflammation, and obesity may be detrimental to human health. Investigating novel compounds that can act as antimicrobials against harmful microorganisms is necessary to meet this requirement[2]. The marine ecology has not yet been studied by the terrestrial ecosystem. Marine chemicals have been used for a variety of purposes. Numerous applications exist for marine microorganisms' secondary metabolites[11].

Biological activity of marine organisms is a result of communication and defence mechanisms in their native habitat. Numerous potential antimicrobialsuse from marine sources have been studied.
Because of their diverse biological activity, natural chemicals originating from marine sources have significantly improved illness therapy when used in place of traditional medicines. Nanotechnology is a new technology with many applications in many different fields [3]. Recent research has shown that nanoparticles offer a wide range of therapeutic applications. Biosynthesis is an easy and affordable technique. Moreover, the process of forming nanoparticles from a range of natural materials is widely employed as an environmentally advantageous procedure since it generates no hazardous consequences. Numerous methods have been devised to produce various kinds of inorganic nanoparticles, including those composed of gold, zinc, titanium, magnesium, and silver[4]. Drug delivery, antibacterial, anticancer, and sensing applications all use nanoparticle biogenesis[12]. In particular, compared to conventional drugs, pure compound-based nanoparticles have more biological activity [16]. The potential therapeutic application of compound nanoparticles derived from marine sources for a range of biological systems is discussed in this review paper.

2. REVIEW OF LITERATURE

Nanotechnology is a new field of study that combines the chemical, biological, and physical sciences to create nanoparticles for a range of applications. Research has been done on the range of sizes of nanoparticles. Because of their high surface area to volume ratio, which increases their reactivity, nanoparticles have a substantially higher fraction of surface. Due to their small size, nanoparticles can have a wide range of forms and sizes. Because of their versatility, nanoparticles are used in a variety of industries, including reagents, biological sensors, drug development, medicine, and diagnostics. The different medicinal uses of nanoparticles, together with the epidemic of many infectious diseases, motivate this effort. The three most popular techniques for creating nanoparticles are physical, chemical, and bioassisted. Scientists are now more concerned with biological organisms than chemical approaches. It has been found that marine-derived fungi, bacteria, plants, and algae can produce nanoparticles. Green generated nanoparticles are more ecologically friendly than conventional agents since they are easily broken down by the enzymes they contain [5]. The metabolic mechanisms by which various marine organism types reduce metal ions must be understood because they inhabit the uncharted seabed.
Pharmaceuticals, environmental patterns, nanomedicine, and food are just a few of the industries that are experiencing exponential growth thanks to current marine science research and development. Water covers between 70 and 71 percent of the earth's surface. Oceans have been investigated in the past, with an estimated 2.2 million species. Unimaginable amounts of marine-derived compounds, including antibacterial chemicals, with numerous human-benefiting uses, can be found in the oceans. In the marine environment, there are more than 25,000 physiologically active substances with a range of uses. The maritime environment currently sets the standard for a variety of antiviral, antifungal, and antibacterial substances. Potential sources for treating infectious disorders include bacteria, fungi, and seaweeds [13]. According to earlier studies, the market value of sea-derived chemicals has already surpassed $10 billion USD[6]. Numerous marine microorganisms are perfect biological factories for the manufacture of green nanoparticles because they can withstand a wide range of temperatures, salinities, and pH levels. Metal ions mix with extracellular or intracellular inorganic elements produced by fungi and bacteria to generate nanoparticles. Additionally, the biocompatibility of nanoparticles derived from marine animal sources is exceptional. Specifically, the high value-added properties of discarded seafood during purification can be utilized to produce a range of biological products. provides a range of pure substances that have been extracted from marine life and act as reducing agents when nanoparticles are being formed.

3. MATERIALS AND METHOD

highlights a thorough analysis of sea-based nanoparticles that have been applied to the treatment of a wide range of infectious illnesses. When applied to the treatment of harmful germs, nanoparticles exhibit exceptional bactericidal properties, which makes them interesting. The mechanism of marine-inspired nanoparticles as antibacterial agents has been the subject of numerous investigations. For instance, it has been discovered that the marine bacterium Pseudomonas rhizosphere produces highly antibacterial secondary metabolites of the benzene type [7]. However, polyphenols, terpenes, acerogenin, and aromatic compounds are secondary metabolites of marine algae that effect. The marine cyanobacterium used to make the silver nanoparticles shown antibacterial efficacy against Streptococcus pyogenes and Escherichia coli, two pathogenic bacteria that have been identified as novel antibacterials for upper respiratory tract infections. The control of dangerous microbes was enhanced by the synthesis of silver nanoparticles from cyanobacterium sources. Silver nanoparticles derived from a culture-free extract of marine Streptomyces sp. showed strong antibacterial activity. Al against strains of the microorganisms Enterococcus faecalis and Staphylococcus aureus that infect wounds. Through the release of intracellular components and the deformation of the cellular structure, these nanoparticles demonstrated antibacterial activity. S contains secondary metabolites. Fungal infections continue to be a leading cause of death. Fungal infections are becoming more common; about 150 million cases are estimated to occur each year, and 1.5 million people die as a result of fungal infections. Mammals, algae, and marine microbes all produce secondary compounds having antifungal and antibacterial properties. Different marine species have produced a variety of antifungal chemicals, including lactones, lipopeptides, and bacterial chitinases[17]. eco-friendly manufacturing of silver nanoparticles from U[14]. These silver nanoparticles generated an insoluble chemical that damaged and degraded the sulfhydryl group in the fungal cell wall, resulting in an antifungal effect. Specifically, by damaging the cytoplasm, cell wall, and cell membrane, biosynthetic silver nanoparticles showed antifungal action[8]. A viral particle is smaller than a living cell.

It has been discovered that certain viral disorders are caused by a virus. Numerous viral diseases are brought on by viruses, which raises the death rate. HIV, hepatitis C, smallpox, and polio are examples of viral illnesses. Marine polysaccharides prevent the virus from adhering, penetrating, decorating, biosynthesising, assembling, and releasing. Viral attachment, penetration, and reproduction were found to be hampered by one of the metabolites that were separated from marine organisms. platensis-mediated gold nanoparticles shown antiviral efficacy against herpesvirus. Glycoprotein aggregation and surface changes brought on by these nanoparticles may inhibit viral binding and penetration. Poliovirus was inhibited in RD cells by silver nanoparticles that were separated from extracellular preparations of Streptomyces sp. and marine actinomycetes. Silver nanoparticles and viral proteins interacted to inhibit the poliovirus. The Newcastle disease virus was significantly inhibited by silver nanoparticles that were separated [9]. By adhering to the viral glycoprotein envelope, these silver nanoparticles prevented the virus from entering.

4. RESULT AND DISCUSSION

In order to develop anticancer medications that are hazardous to cancer cells but not to humans, several investigations are being carried out. The utilization of nanoparticles carrying various physiologically active chemicals is one of the most successful drug delivery methods for the treatment of cancer[10]. Because they can influence numerous pathways, including immunity, tumor growth, and cancer cell death, natural compounds derived from marine sources are particularly promising as agents for the development of anticancer medications. Caulerpa taxifolia silver nanoparticles had anticancer efficacy against lung cancer cells. Silver nanoparticles from marine algae were shown to mediate the necrosis and cell condensation; as a result, nanomaterials are crucial for research on cancer cells[15].

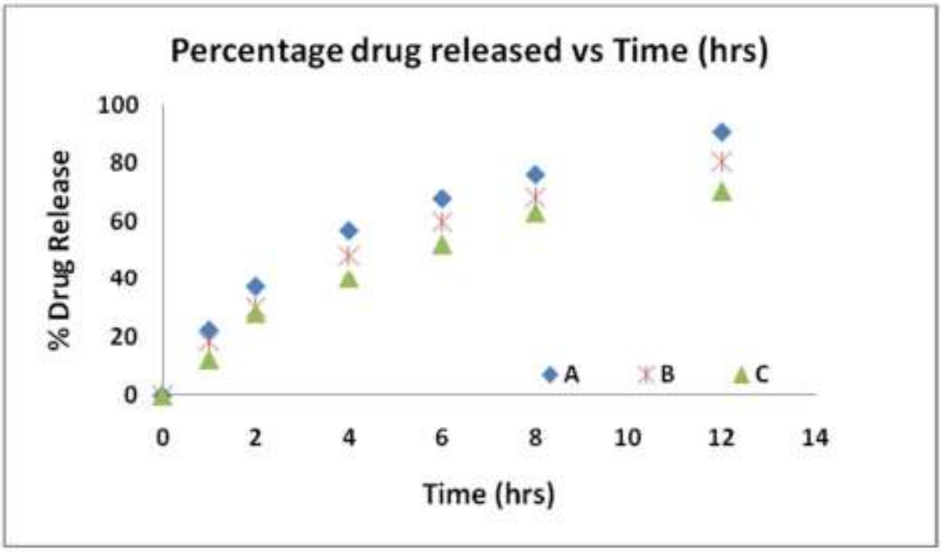

Figure 1: Cumulative Percent drug release

Cells generate potentially toxic ROS due to oxygen metabolism through enzymatic and non-enzymatic reactions. Excessive ROS levels brought on by oxidative stress cause a number of illnesses, including diabetes, high blood pressure, and Alzheimer's. However, antioxidants help slow down, control, and stop the oxidative process that causes the disease to start and progress. Research is currently conducted to examine natural products that are able to regulate oxidative stress, thus paving the way for the study of nanoparticles with antioxidant effects.

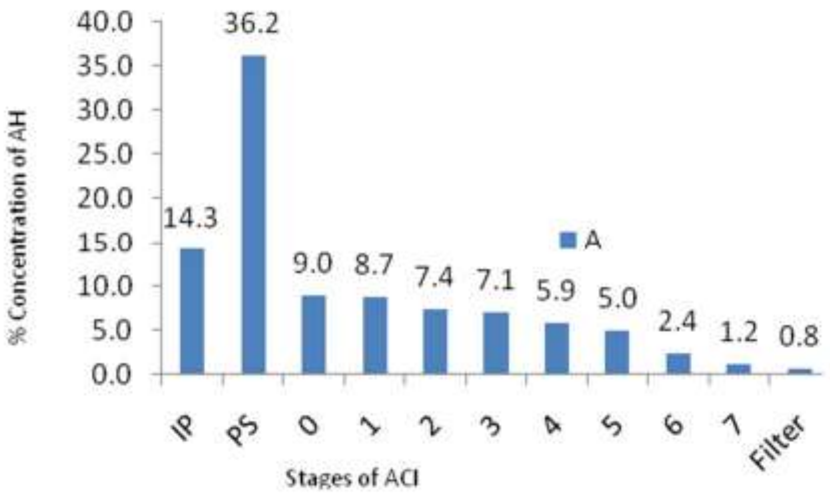

Figure 2: ACI for % deposition profiles

Because of their potential biological activity, certain species of marine organisms, in particular, have been isolated and have drawn attention from researchers. The marine fungus A produced gold nanoparticles with antioxidant properties. Furthermore, by concentration-dependent DPPH scavenging action, gold nanoparticles mediated by the cell-free supernatant of marine bacteria demonstrated strong reducing power. Selenium nanoparticles derived from Spirulina phycocyanin protected INS-1E rat insulinoma cells from the cell death caused by palmitic acid. Cells were shielded from oxidative damage and downstream signalling by phycocyanin and selenium. These findings demonstrate the potential of sea-derived nanoparticles as effective natural antioxidants.

5. CONCLUSION

In conclusion, due to their potential biological activity, items produced from marine sources have found extensive usage in the pharmaceutical sector. Since their biological actions have been better known, many compounds that come from marine sources have been employed to create nanoparticles. Additionally, a polymeric component is used to effectively transport the medication for treating both infectious and non-infectious illnesses. Additionally, it has been discovered that nanoparticles have antibacterial properties against viral, bacterial, and fungal infections. Cell membranes are destroyed, and DNA and cell walls are harmed, as part of antimicrobial action. These sea-derived nanoparticles may also be used to treat non-infectious conditions such leishmanial infections, diabetes, cancer, wounds, and inflammatory reactions. Despite considerable advancements in the production of nanoparticles using extracts from marine sources, relatively little is known about the production of nanoparticles from pure active compounds. This is due to the fact that various environmental elements actually generate a great deal of variation in the preparation of the extracts. As a result, future efforts should focus on using pure active compounds to manufacture nanoparticles. The majority of antibacterial studies employing these nanoparticles have been phenotypic in nature; nonetheless, gene-level studies are essential to comprehending the molecular mechanism.

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