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Nanotechnology in Aquaculture

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Introduction

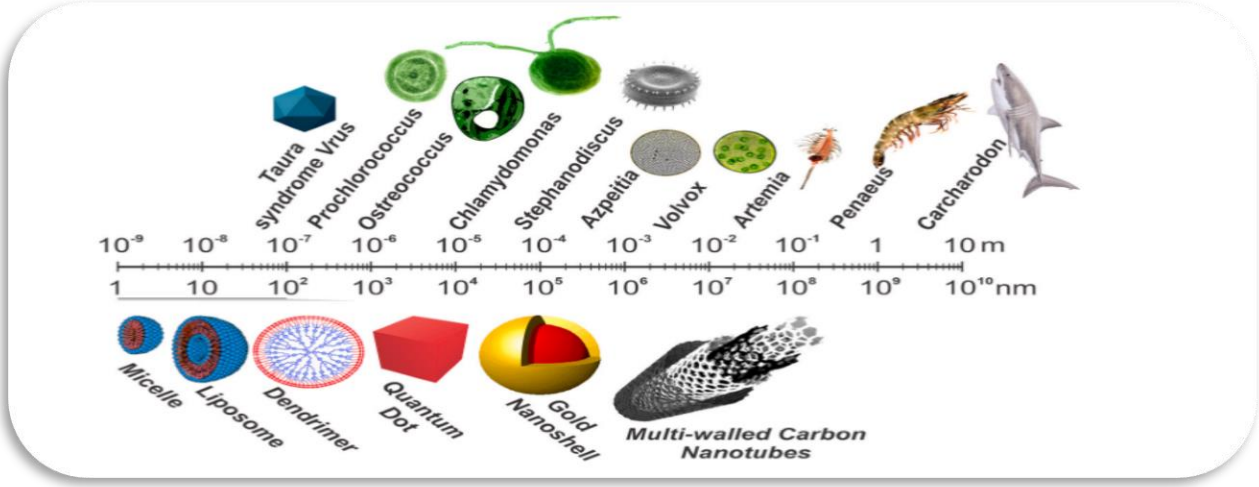
Nano a *"prefix"* derived From Greek word Nano meaning *"Dwarf"*. Which means Extremely small

What is Technology?

Technology is a branch of Knowledge that deals with creation in the fields of:

- Engineering
- Applied Science
- Pure Science
- Industrial Arts...etc.

Father of Nanotechnology – *Richard Feynman*



Relative size of Nanoparticles compared to different aquatic organisms

The United States National Nanotechnology Initiative (NNI) defined nanotechnology as the "understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications"

- Nanotechnology has enormous potential to provide innovative improvements to aquaculture systems in farm management, increase efficiency and to reduce our impact on the environment, as a necessity impacting our ability to feed the 7 billion plus inhabitants of the planet. Nowadays, nanotechnology is a multi-billion and rapidly expanding industry, exemplified by the more than a thousand products containing nanomaterials currently in the market. Since the past decade, over 300 nanofood products have become available in international markets several dimensions of structural elements, crystallites, molecules and clusters are manifest in nanomaterials, which includes
- **zero dimension** (nanoparticles, nanoclusters, and quantum dots)
- **one dimension** (carbon nanotubes and multiwalled nanotubes)
- **two dimensions** (graphene layers and ultrathin films)
- **three dimensions** (nanostructured materials)

Role of Nanotechnology in Aquaculture

- On the other hand, the utilization of nanoparticles to advance aquaculture and the seafood industry is gaining enormous momentum.
- Aquaculture is the food industry showing the fastest growth and produces more than 50% of seafood used for food.
- However, environmental degradation, chemical contamination, suboptimal nutrition and disease prevalence, are among the factors that negatively impact this sector for the achievement of global food security.

Applications

- Drug delivery for health management.
- Nano sensors for pathogen detection.
- Microbial disinfection.
- Treatment of pollutants in water.
- Delivery of dietary supplements and nutraceuticals.

Drug delivery for health management

- Disease outbreak is one of the main obstacles for the sustainability and development of aquaculture.

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- In this context, nanotechnology has an enormous role to play, linked to provide novel perspectives related to disease diagnosis and health management.
- In last few years, controlled release delivery systems and diagnostic sensor based on nanoparticles have been developed to change their properties and structure according to environmental stimulus such temperature, ionic strength, pH, or enzymatic activity.

Nano- sensors for pathogen detection

- Nano-biosensor systems are currently being developed to allow the detection of very low concentrations not only of parasites, bacteria and viruses, but also of polluting elements in the water (Chen et al., 2016).
- This is particularly important in outbreaks at commercial aquaculture systems, since it can take too much time before the etiological agent causes an impact so that its presence is identified, delaying the treatment to control the pathogen, creating an important economic impact.

Microbial disinfection

- Many of metal NPs have been used for disease prevention and treatment, such as silver, titanium, copper, among others.
- Metal NPs have different modes of action against bacteria, of which, one of the strongest effects is against the cell membrane and cell wall by attaching to them by electrostatic interaction and being able to disrupt them.
- Metal NPs are also known to trigger a higher oxidative stress state increasing the amount of reactive oxygen species (ROS) which can damage proteins, lipids, and DNA.

Treatment of pollutants in the water

- Nanotechnology has also been used to treat water pollution, which is one of the main problems in aquaculture.
- Nevertheless, graphene nano-sheets and graphene oxide, linked to removal of several types of pollutants from water, have attracted tremendous attention in last few years.
- Graphene oxide-titanium oxide nanocomposite have been used for adsorption, removal of heavy metal and organic compounds from residual water.

Delivery of dietary supplements and nutraceuticals

- One of the main underlying concepts behind the idea that nanoparticles can improve the fish development is based on their ability to increase the quantity of nutrients absorbed across the digestive tract.

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- Micronutrients, in the form of nanoparticles, incorporated in aquaculture feeds, can penetrate in cells more efficiently, and therefore, rise absorption rate.
- This has been demonstrated in sturgeon and young carp, which showed faster growth rates when fed with iron nanoparticles.

Use of microelements in the form of nanoparticles to be included in aquaculture feeds

Currently, the potential toxicity of nanoparticles in biological system is becoming a public concern. Nanomaterials may constitute a new source of pollutants to the environment, and research is being focused on the potential negative impact that they could produce. A sustainable approach of the use of nanotechnology into the fisheries and aquaculture industries will require more studies of those issues, including the understanding of how nanomaterials can accumulate and if they could become toxic to aquatic organism or humans.

Nanotechnology risk assessment and governance

Many nanoparticles are not bio-degradable and tend to accumulate in various organs in host.

Some nanoparticles are extremely combustible and spontaneously burst into flames. Some Nanoparticles such as Nickle, Cobalt and Silicon dioxide are carcinogenic.

Conclusion

Nowadays, there are many potential applications for nanomaterials in the fisheries and aquaculture industry. Some of the most promising areas in this field are applications related to fish health management, nanoscale ingredient incorporation. Use of nanotechnology in aquaculture feeds and food packaging, as well as applications linked to value-added products, stress reduction and health management. Currently, most of these applications are in an early stage, and high cost is considered the main limiting factor for their wide implementation.

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