DATASHEET

Application of Copper Nanoparticles and Microparticles in Fishing and Aquaculture Nets

1. TECHNOLOGY OVERVIEW

This technical document compiles and synthesizes the scientific and engineering data on the use of copper-based additives (both copper oxide nanoparticles, CuO-NPs, and micrometric copper powder) integrated into fishing and aquaculture nets. The main objective of this technology is to provide a permanent biocidal property that inhibits biofouling (marine incrustations) and reduces the load of pathogens critical to farmed fish, drastically lowering the operational cleaning costs and the use of chemical treatments or antibiotics in modern aquaculture.

2. TECHNICAL SPECIFICATIONS OF THE ADDITIVES

Technical Parameter	Copper Nanoparticles (CuO-NPs)	Micrometric Copper Powder (Micro-Cu)
Chemical Formula / Type	Metallic Copper (Cu0)	Pure Metallic Copper (Cu0) / Alloys (Brass)
Particle Size Range	10 nm – 100 nm (Typical: 14 nm - 50 nm)	1 µm – 50 µm (Typical: 10 µm - 45 µm)
Base Metal Purity	≥ 99.0% - 99.9%	≥ 99.5% (Electrolytic Grade)
Specific Surface Area	Very high (50 - 120 m^2/g)	Low to moderate (0.5 - 5 m^2/g)
Mechanism of Action	Ultra-fast release of Cu^{2+} ions / Direct cellular contact damage	Controlled and sustained long-term release of Cu^{2+} ions

3. BIOCIDAL AND ANTIMICROBIAL PROPERTIES

Copper acts through a process called "contact killing". When microorganisms come into contact with the additivated net, copper ions (Cu^{2+}) are released that cause severe damage to the outer cell membrane of the pathogens, generate oxidative stress through reactive oxygen species (ROS), and destroy cellular DNA/RNA, preventing replication and the emergence of bacterial resistance.

Proven effectiveness against specific aquaculture pathogens:

- **Piscirickettsia salmonis: Causes Salmonid Rickettsial Syndrome (SRS). Copper-additivated nets drastically reduce the adhesion and survival of this bacterium on the mesh.**
- **Tenacibaculum dicentrarchi / maritimum: Responsible for tenacibaculosis. The presence of metallic copper or CuO-NPs inhibits bacterial biofilm growth by more than 95%.**
- **Aeromonas hydrophila / Vibrio parahaemolyticus: Common opportunistic pathogens in fresh and salt water. A logarithmic reduction of up to 6-log has been demonstrated in Gram-negative bacteria on surfaces treated with CuO-NPs.**

4. APPLICATION AND INTEGRATION METHODS IN NETS

There are two main methods to incorporate copper into fishing and aquaculture nets:

A. Polymer Masterbatch Extrusion (Permanent Integration)
This method consists of mixing the copper additive (CuO nanoparticles or metallic copper microparticles) directly into the polymeric matrix of high-density polyethylene (HDPE), polyamide (Nylon) or polyester during the monofilament extrusion process. It is the most durable method (used by leaders such as Garware and Plasticopper).

- **Additive concentration: Generally between 0.02% and 2.0% by weight of active masterbatch.**
- **Durability: Practically equal to the service life of the net (up to 5-10 years), since the copper does not detach mechanically.**

B. Surface Coating
This consists of applying a polymeric resin, hydrogel or conductive polymer (such as polyaniline - PANI) loaded with CuO nanoparticles onto the surface of the already-woven net.

- **Additive concentration: Typically immersion solutions of 0.02% - 0.05% CuO-NPs.**
- **Durability: Moderate (1 to 3 years). Requires periodic reapplication due to marine abrasion.**

5. PERFORMANCE AND DURABILITY PARAMETERS

Mechanical / Physical Property	Standard Net (Without Copper)	Copper-Additivated Net (HDPE / Polyamide)
Tensile and Knot Strength	Standard breaking limit according to fiber denier	Maintains ≥ 95% of the original strength. An excessive addition (>5%) of micro-Cu can embrittle the polymer, so it is optimized to <1%.

Biofouling Accumulation Rate	100% colonization within 30-45 days of exposure	Reduction of up to 50% - 80% in wet biomass accumulation after 6 months.
Washing / Cleaning Frequency	Every 15 to 30 days in summer	Extended to every 90 - 120 days, cutting operating costs in half.
Operational Service Life of the Net	2 to 4 years (degradation by abrasion and UV)	5 to 8 years. Copper acts as a secondary UV stabilizer in the polymer and prevents biological degradation.

6. BIOSECURITY AND ENVIRONMENTAL ASPECTS

The use of copper in aquaculture is strictly regulated to prevent toxicity in non-target organisms and the accumulation of heavy metals in marine sediments.

- **Leaching Rate: Copper leaching from extruded nets is extremely low and controlled, remaining within a safe range of 0.009 mg/L to 0.06 mg/L (within international marine water quality standards).**
- **Bioaccumulation in Fish: Comprehensive 7-month scientific studies (such as those by ICAR-CMFRI) demonstrate that fish raised in cages with nets treated with CuO-NPs do not accumulate copper in their muscle tissues above human consumption limits (residual copper in muscle remains well below the 10 mg/kg limit).**
- **Aquatic Toxicity (Zebrafish Embryo Test): Toxicity tests on zebrafish embryos show that the environmental safety of the net depends directly on the control of polymer crystallinity during extrusion, which underscores the importance of acquiring nets from certified manufacturers with validated R&D processes.**