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Nanosilver

Environmentalist organizations have perceived nanotechnology to be a new technology that is opportunistic to campaign against. Nanosilver has been selected as a key target for nano-fear campaigning. When viewed through the prism of their priorities, it is a material with growing presence in consumer products ("visible") and is supported by a small and fragmented niche industry ("weak opposition") – ideal preconditions for a public campaign. Nanosilver may use the term „nano" due to the size of the particles, but it is not a new material and in fact has a decades -long history of safe and regulated use. Development of bacterial resistance to silver has often been presented as a concern for *silver use in general.* The decision to focus on nanosilver for an issue presented as general for silver illustrates a bias that is not justified.

Nanosilver has been made and used by man for decades.
The earliest rational synthesis of nanosilver to our knowledge was by Carey Lea in1889 [1]. Throughout the early 1900's nanoscale silver was one of the earliest materials that formed the basis of colloid science - the discipline focused on the synthesis and characterization of extremely small particles [2]. In the first half of last century, nanoscale silver was referred to as "millimicron silver" or "colloidal silver". Colloidal nanosilver was widely and successfully used as a topical disinfectant throughout the first decades of the 20th century until antibiotics took over as the technology of choice [3]. Colloidal nanosilver continued to be applied to new applications throughout the 20th century and found widespread use as an algaecide for swimming pools and in drinking water purification systems. In the last two decades, nanosilver has been used for numerous medical applications and in engineered articles such as textiles, coatings and plastics. Not only is nanoscale silver demonstrably NOT a new material, it must surely be one of the oldest manufactured materials used by humans – nanosilver has been in continual use throughout a period of at least 12 decades.

Nanoscale silver products have been safely regulated since the 1950s.
The false assumption that nanosilver is new leads to an equally false assumption that antimicrobial nanosilver products have not been regulated. Reality shows that there is a long history of safe commercial use of nanoscale silver registered under enacted biocide regulations. The very first silver product registered under the FIFRA regulations was a colloidal nanosilver algaecide product that has been safely used for over 50 years. Every EPA silver registration between 1970 and the 1990 was in fact a colloidal nanosilver or nanosilver-composite product. Significantly, the very first NON-nanosilver product registered by EPA was not registered until 1994. An overall analysis reveals that today over 50% of all EPA registered silver products are based on nanoscale silver [4]. Throughout a period of 5 decades the EPA has not recorded any incidents of significance on the EPA's formal incident reporting database (EPA OPP IDS) indicating that thorough monitoring of real-life use supports the safety of nanosilver products.

Nanosilver has been safely used in direct aquatic applications for decades.
Colloidal nanosilver algaecides and composite materials have been in wide consumer use since the 1950s. These products have been safely used for swimming pools and municipal and domestic drinking water purification continually since the 1970s. Both swimming pools and drinking water are applications with

direct exposure to high volumes of water that ultimately pass to sewerage treatment facilities and natural aquatic systems. The reason for this long history of low impact is that there is a demonstrated tendency of silver particles to be strongly passivated by ubiquitous natural environmental complexing agents such as sulphur, chlorides, phosphate and dust [5, 6]. Furthermore, this tendency of silver nanoparticles to speciate in a similar manner to the well recognized environmental passivation of silver ions is further supported by recent scientific research [7, 8, 9]. The ecological fate and toxicity of environmentally passivated silver, typically forming silver sulphide, is a thoroughly investigated topic, particularly from the long history and high volume of photographic use of silver [10, 11].

Nanosilver is safely used in dermal wound care since decades.
Studies have shown that nanosilver does not penetrate unbroken skin. Moreover, medicinal research on nanosilver clearly demonstrates that there are no ill effects even when it is used directly on wounds and broken skin. FDA approved nanosilver dermal wound care ointments and bandages are used in thousands of hospitals every day to promote skin repair by reducing inflammation and such products often save lives by preventing infections [12].

Exposure is far less than to conventional silver products and synthetic chemical antimicrobials
The assessment of risk is a balance between potential for harm (toxicology) and exposure. An analysis of exposure patterns for nanosilver would reveal that most products employ miniscule amounts of nanosilver (tens of parts per million by weight of treated article) and most often this is employed in forms that are bound and secured in plastic matrices and/or coatings. Furthermore, an exposure analysis in comparison to conventional silver products and synthetic chemical antimicrobials shows significantly lower quantities of active substance are required for nanosilver to achieve an equivalent effect. Such analysis shows a compelling potential for less chemicals to be used to treat consumer products and less pollution of the environment.

Nanosilver Benefits Consumers
Antimicrobial products bring benefit to millions of consumers every year. Products such as plastics, textiles, and cosmetics last longer and provide better value for money and increased utility to consumers. This is a market that has been served by many different synthetic and inorganic materials over multiple decades, only a small portion of which is served by silver additives, of which nanosilver is just one form. Antimicrobial treatments can bring a number of functionalities to consumer articles, including longer shelf life (e.g. cosmetics) giving more safety, less waste and ultimately lower prices for consumers; plastics that are protected against the degrading action of bacteria (e.g. discoloration); and textiles that are protected against colonization of bacteria that can lead to odors (e.g. sports clothing), ultimately giving greater comfort and prolonged use. Additional benefits such as reduced washing frequency at lower temperatures can give significant water and energy savings. Antimicrobial treatments, of which nanosilver represents less than 0.1% of the numerous materials available for this purpose, therefore serve a broader purpose giving benefits to numerous consumer goods every day.

Bacterial resistance?
The concern regarding potential for bacterial resistance development from widespread use of silver as a justification for recommending against the use of nanosilver in consumer goods is unfounded. This concern is based on a selective review and interpretation of the literature that disregards multiple publications that state the risk of microorganism resistance to silver in reality is low. A notable example is provided by Percival et al. who state that "*it is important to note that bacteria have been exposed to subinhibitory levels of* Ag^+ [silver ions] *for over four billion years and no widespread resistance has been evident to date"* [13]. Humankind in all types of societies have processed and used silver for thousands of years without ill effects. It is important to recognize that silver is a natural element that is prevalent throughout the world at low concentrations with no evidence to support a concern for widespread bacterial resistance.
All silver antimicrobials act against bacteria through a silver ion (Ag+) mode of action. To single out nanosilver in order to address a concern over silver resistance in general is not right. To highlight nanosilver when other silver materials are used and will continue to be used in often higher volumes, makes no sense.

Unusual behavior of nanosilver?
The justification for acting against nanosilver boils down to the conviction that due to the small particle size nanosilver must be new and accordingly must behave differently to conventional silver. Macro forms of silver ("macro" particles or conventional silver materials) are rarely employed in the market – silver ion and silver salt materials dominate the antimicrobial treatment market. Regardless of form, all silver substances have antimicrobial properties. In this way, nanosilver is fundamentally no different from any other antimicrobial silver materials available in the marketplace e.g. silver-glass, silver-zeolites, silver salts etc. This is particularly true for applications where the silver is embedded in a substrate as is typically the case for plastics, coatings and textiles. The mode of action is therefore not unusual in comparison to other silver forms employed in the marketplace or used throughout history. Singling out nanosilver in this manner is not scientifically justified and is based on a flawed understanding of silver materials and nanosilver in particular.

Moving Beyond Fear
It would be a mistake to ignore the accumulated knowledge of our scientific and regulatory heritage in a mistaken bid to declare nanosilver materials as new chemicals, with unknown properties and automatically harmful simply on the basis of a change in nomenclature [14].

What is needed now is no more of this fear mongering campaigning against very important emerging nanotechnologies. In recent months, the SNWG has interacted with the EPA in challenged exchanges on how best to regulate nanopesticides leading to a clear, reasonable, and responsible path for registration.

It is hoped that the EPA and other agencies will ultimately no longer impose unwarranted barriers to these emerging nanotechnology industries, but instead nourish the benefits these can provide while screening finished products claiming pesticidal properties on a case by case basis for any environmental risk. We need a sensible path forward for registering nanopesticides that is not burdensome for either the government or industry.

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