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NANOMATERIALS ARE USEFUL IN PAINTS

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ABSTRACT

This research paper aims at highlighting the concept of nanomaterials and their use in paints. It is covered in mainly 3 sections, description, the development of High-Performance Paint Film Biocides for Architectural Coatings, and conclusion. The introductory part includes the description of nanomaterials and how they are made. It also consists of microorganisms and paint, traditional paint biocides, nanomaterial biocides in paints, nanosilver, nano titanium oxide, and copper nano. The next part consists of the development of the paint for architectural coatings. The research design is created as the limitations for each variable are selected. However, one selection matrix method is described in this paper. The limitations are the microbial range, water-solubility, globally harmonised system, and multi-region study. This paper aims at describing the widespread use of paints everywhere and why nanomaterials are so popular these days. It is important for consumer awareness and therefore, the research paper talks about its description and its limitation.

DESCRIPTION OF NANOMATERIALS

Substances with at minimum one external size of 1 to 100 nanometers are referred to as nanomaterials (Wang, et al., 2022). The proportion of particles in the quantitative size distribution must have a particle size of 100nm or smaller, as per the European Committee's requirements. Nanomaterials can form naturally as by-products of combustion products or can be produced expressly for a specific application. These substances may have different physical and chemical properties than their bulk-form counterparts. Nanomaterials, in general, require unique production procedures due to their lightweight and the accuracy required to make them properly. Nanomaterials are made in two ways. The first is what is known as top-down production. This technique begins with a huge piece of material. Chemical and physical procedures degrade it until the required nanomaterial is created. This procedure can be simple or complex, depending on the materials (Wang, et al., 2022).

With the proper tools, metallic nanoparticles may be crushed down from microscopic particles. Bottom-up production is the second category of production methods. These techniques start with individual atoms or molecules. They bind them together using physical and chemical techniques to form functional nanomaterials. Bottom-up tactics produce the most distinctive and potent nanomaterials, but they are more difficult to implement than top-down methods. Antimicrobial, antifungal, and antibacterial biocides are predicted to become more widely used as building and industry expand. Biocides in paints stop the formation of fungi, algae, and germs, which can be severely damaging to the topcoat. While appropriate biocides are now commercially available, experts believe that the incorporation of nanomaterial biocides into paints in the long term will provide better antibacterial qualities at a lower cost (Upadhyay and Chakma, 2022).

MICROORGANISMS AND PAINT: Microorganisms deteriorate both outdoor and indoor paints. Such microorganisms are mostly fungal species that thrive in damp environments. Such as high-temperature and high-humidity exterior situations, as well as indoor places. Such as in the kitchen or bathroom, in which the environment is conducive to microbial activity. Whenever microorganisms damage paint, a web of cells forms on the exterior. It might discolour the paint due to spore proliferation or enhanced dirt retention. The coloured surfaces would discolour and distort as a result (Behera, 2022).

TRADITIONAL PAINT BIOCIDES: Many of the first biocides, including phenylmercuric acetate (PMA) and tributyltin, comprised highly poisonous heavy metal components (TBT). The capacity of these metals to inflict significant environmental damage, along with their poor efficiency as antibacterial additions, resulted in their eventual removal from the market (Kumar, et al., 2021).

The biocides are presently included in paints and coatings have excellent sensitivity for the targeted organism, but they are generally highly expensive and don't work as well as classic metallic biocides.

NANOMATERIAL BIOCIDES IN PAINT: Nanoparticles' exceptional qualities have improved the way a range of sectors throughout the world work. Nanoparticles, according to researchers, can significantly improve the hardness, UV-light absorption, and bactericidal qualities of paints and coatings. The most common nanoparticles used throughout paints are titanium dioxide (TiO2) and silicon dioxide; nevertheless, more research into the possibilities of silver, zinc oxide, aluminium oxide, cerium dioxide, copper oxide, and magnesium oxide is required (Chen, et al., 2022).

NANOSILVER: The capacity of silver ions and nanosilver to attach to bacterium cell proteins and cause cell death is responsible for their antibacterial qualities. Numerous studies have reported that nanosilver paint solutions are preferable to existing biocides in terms of antimicrobial, deodorizing, and defence of paint surfaces from mildew and other bacterial variants. Nanosilver was also found to be considerably less hazardous to the environment than other conventional paint biocides (West, et al., 2021).

COPPER NANO: Copper, in its form of nanoparticles, triggers cell injury by generating reactive oxygen species (ROS), that are disruptive to most biological components, particularly DNA, protein, and lipids. Copper toxicity is determined by the proportion of organic and inorganic copper in solutions; nevertheless, nano copper is far less poisonous than bulk copper. Nano copper has antibacterial properties at relatively low concentrations as 40-60 mg/mol3. Because the use of nanostructured materials to substitute biocides in coatings is still in its beginning phases, more research is needed to determine how these nanoparticles' outstanding antibacterial characteristics may benefit these sectors. Experts are also looking into how these and many other nanomaterials can enhance paint's moisture resistance, resistance to abrasion, and strength characteristics (Ermini and Voliani, 2021).

NANO TITANIUM DIOXIDE: TiO2 nanoparticles are well-known nanomaterials for their photocatalytic activity, which generates hydroxyl radicals in water, which then destroy organic molecules like cellular proteins in microbial species. This unusual process allowed TiO2 nanoparticles to have self-cleaning qualities that have already been seen used in interior paints. Nevertheless, more research on these nanoparticles is needed to accomplish the complete oxidation of organic molecules (Yuan, et al., 2021).

THE DEVELOPMENT OF HIGH-PERFORMANCE PAINT FILM BIOCIDES FOR ARCHITECTURAL COATINGS

According to Deng, et al., (2021), Bacterial infection on painted surfaces has a matter of great concern for the production of paints. Bacterial activity on coated surfaces can cause both cosmetic and physical damage. Mould, mildew, and algae growth have noticeable visual consequences, but physical damage caused by its enzymes can result in physical decay. Development in the transparency of the surface treatment or a lack of adherence to the base are examples of this deterioration. The bottom timber can become infected with fungus as a result of moisture infiltration. Microbial degradation is not confined to the top coatings or dry paint layers; it can also happen during the paint's manufacturing and preservation. When it comes to choosing dry film biocides, coatings makers confront a variety of obstacles. Another of the formulator's primary objectives is to choose dry film biocides that provide broad-spectrum and long-term safety for the coating film. One of the difficulties is that there are few biocide active participants accessible, and those who are accessible should satisfy numerous requirements at the same time (Deng, et al., 2021).

In the words of Istirokhatun, et al., (2021), outdoor exposure testing is almost always required when evaluating fungicides and algaecides as part of a paint formulation biocide program. This form of testing entails a complicated set of variables. This is especially true when the results are expected to apply to multiple geographic regions. There are procedural aspects that should be addressed in addition to the characteristics, microbiological spectrum, and regulatory status of the biocide active participants. All aspects to be considered include the type of surface to be covered, the coating preparation technique, panel orientation and orientation, the number of responses, and the existence of suitable controls. Due to the enormous set of possibilities, judgments about how to restrict the range of the panel study experimental method should be taken (Istirokhatun, et al., 2021). The research design is created as the limitations for each variable are selected. However, one selection matrix method is described in this paper.

THE MICROBIAL RANGE: In the wisdom of Huang, et al., (2021), the microbiological spectrum of commonly used paint film biocides can be characterized. In other words, they can be divided into two groups based on whether they are fungicidal, algaecidal, or both. Paint formulation biocide programs are normally focused on preventing fungal defacement; however, algal growth can also be a serious issue. Most paint film fungicides are ineffective against algae, but zinc pyrithione has both anti-algal and anti-fungal properties. Anti-fungal and anti-algal treatments are not required on every painted surface. The kind and amount of biocide active agents required to battle the local combination of disfigurement creatures will be heavily influenced by the local climate. Local biocide rules and environmental public awareness concerns, on the other hand, frequently bound the number of accessible lively agents or the quantity of these actives that can be existing in a covering (Huang, et al., 2021). Algal growth necessitates a high level of humidity as well as enough sunlight to allow photosynthetic processes to take place.

Water Solubility: As per Veloso and Oliveira, (2021), the coatings formulator should also examine the water solubility of the biocides chosen for paint film protection, in addition to their microbiological range. Water solubility is an incredibly significant feature for exterior coatings since the lifespan of the biocide in the film is directly proportional to its water solubility. When the water solubility of regularly used fungicides and algaecides is examined, three groups emerge. There are three types of active agents: those with very low water solubility (Group A), those with an intermediate water solubility (Group B), and those with a reasonably high water solubility (Group C). In the traditional model of a paint film, the paint film contains a reservoir of fungicidal or algaecidal active agents, as well as a biocide on the surface. Rain washes away the biocide on the paint film's surface, but new biocide pulled from the reservoir replenishes it. The coating provides long-term protection against microbial attack if it happens to deplete biocide from the surface at the same time as it migrates from the film's interior. The coating will fail if there is a lack of equilibrium. By way of illustration, consider the following scenario (Veloso and Oliveira, 2021).

With regards to Riley and Narayan, (2021), considering the case in which the selected biocide has abnormally high-water solubility. For a duration of 12 to 18 months, the coating will provide adequate safety, however, the biocide reservoir in the surface would soon decrease, and the coating would break down after that time. For a long time, the covering would not be maintained. Consider the case where the chosen biocide has a water solubility that is too low. When a coated surface is first exposed to the elements outside, it has a high susceptibility to fungal infection for a short period. Some of the small-molecule paint components are leaching from the coating film during this time, which is one of the causes for the increased vulnerability. The fungi may be able to get nutrients from these small-molecule components. The nutrients are washed away over time in the outdoors, making the covering less susceptible to fungal attack. Fungi can twitch to create themselves during the original phase of increased sensitivity if the biocide used to defend a covering has low water solubility (Riley and Narayan, 2021). Although biocide is present on the film's surface, not enough of it migrates from the film's biocide reservoir to stop the fungi from establishing themselves.

If they establish themselves during the early phase of increased susceptibility, the fungus will remain to assault the coating film long after nutrition levels have dropped (Singla, et al., 2021). The coating will not be protected for a very long time. Given the circumstances, combining a Group A biocide with a co-biocide is a standard technique for ensuring long-term coating layer protection (relatively high-water solubility). The highly water-soluble fungicide will swiftly travel across the film, preventing fungus from establishing themselves during the peak microbial susceptibility period of the coating. Even as the coated film is released to the environment, the less water-soluble biocide would progressively move from the biocide storage to the surface layer. Since the coating's microbial sensitivity has diminished after the first-time frame, the amount of less-soluble antimicrobial applied to the coating's exterior is capable of preventing microbial defacement. The coating can be protected for a long time if this method is followed. Considering the preceding considerations, they chose to begin with a reduced fungal and subsequently introduce a more water-soluble co-fungicide. As a consequence, the first stage in the decision matrix was to choose between carbendazim, chlorothalonil, and zinc pyrithione (Singla, et al., 2021).

Globally Harmonized System: As previously indicated, regional biocide laws and environmentally awareness campaigns considerations typically restrict the types of active participants that could be used in a covering, as well as the volume of these active ingredients that can be used. The adoption of GHS in 2015 is an example of a significant factor in the US marketplace. The UN's Global Requirements Plan of Hazard Communication is a model for a worldwide harmonised system of risk management. Both carbendazim and chlorothalonil are anticipated to necessitate serious health risk labelling in the scope of GHS at some levels. For instance, for carbendazim, the level that is anticipated to activate the GHS use for the serious health risk pictogram (e.g., STOT, reproductivity, and/or carcinogenicity) is anticipated to be significantly smaller than for chlorothalonil. Several of these bioactive components have already been studied for agrochemical applications (Subhan and Subhan, 2021).

On either side, the existence of zinc pyrithione in paints is doubtful to activate the GHS need for a serious health risk pictogram. As a consequence, the committee's low-water-solubility base fungicide was zinc pyrithione. Zinc pyrithione, commonly known as zinc 2-pyridinethiol-n-oxide, is a component of Lonza's antibacterial Zinc OmadineTM. Zinc pyrithione has been used in anti-dandruff shampoos and other personal care products for a long time. Zinc pyrithione has greater heat and alkaline pH stability when compared to other regularly used fungicides. Zinc pyrithione, unlike chlorothalonil, is not related to disappearing or chalking, hence it can be utilised for both whites and colours (Riaz, et al., 2021). While pyrithiones can operate as chelating agents, they can also be used to decrease this behaviour. Zinc Omadine ZOE antimicrobial, a colour-stabilised zinc pyrithione formulation, was released to the US market and it showed strong compatibility with an extensive variety of latex binders and other popular paint additives.

Multi-Region Study: Choosing between co-fungicides with better absorption constituted the best solution in their choice grid. To investigate increased absorption co-fungicides as elements of a possible three-active mix, a large multi-region dried films biocide panels investigation was launched. For every area, the coverings were sprayed on the most common base. The paint was applied to the substrate using a local painting technique. Biocide active compounds that had received local regulatory approval were employed. Within every area's study, a biocide-free negatives reference sample and a positive sample solution maintained with a common dry screen biocide were employed. As earlier mentioned, the climate condition would have an important influence on the mixture of defacement species which the paints film biocides should combat. An elevated setting is ideal for demonstrating that a certain biocide mixture offers anti-algal and anti-fungal resistance (Nizam, et al., 2021).

As a consequence, southern Florida was selected as the testing facility for the U.S. half of the experiment, and each of the fungal mixes in the research would include an extra algaecide. Based on price and legal accessibility, Diuron was selected as the extra algaecide for the trial's U.S. portion. A preliminary investigation was carried out utilizing both wood and cementitious panels. On both types of panels, the three active blends were ranked similarly in this initial study. Only wood panels were used in a second follow-up investigation. All of these surfaces received one layer of primer and two applications of test paint (Hodson, et al., 2019). The testing was performed out with a normal acrylic smooth exterior design prepared in a lab. It was established during the study that all three main mixtures functioned brilliantly.

In the words of Kumar, et al., (2020), the 3 major mixes that contained OIT as a co-fungicide exceeded the mixtures that also included both IPBC and BBIT in terms of total effectiveness. Combinations with IPBC or BBIT, but on the other side, looked impressive. Lonza is offering two new dry film biocide formulations based on the results of our panel study. The first product, DensilTM ZODTM antibacterial, has been approved by the Environmental Protection Agency. It is currently available in the United States and will soon be offered in several other countries. Densil FAZ antibacterial, the second product, is being offered exclusively for the Asian market. Long-term, broad-spectrum microbiological protection is provided by Densil ZOD and Densil FAZ for paint films. Lonza's Zinc Omadine antibacterial with patented colour stabilization technology is used in both products (Kumar, et al., 2020).

Conclusion

Nanosilver, photocatalytic active nano titanium dioxide, or nanosilica dioxide as additions for protective coating against microbiological, mechanical, and biochemical deterioration are being considered by the paints and lacquer sectors as a substitute for traditional organic-based additives. Because there are no long-term studies available, it is still unclear whether nanomaterials in coatings will reach the required benefits. Another thing to consider would be that the possible hazards of nanoparticles to human and environmental health are currently being debated. Finally, thorough biocide active agent identification, comprising the study of their properties, microbiological spread, and regulatory status, can enable long-term, wide microbiological management on paintwork. The lung is the most vulnerable entry point for nanomaterials. Nanoparticles, on the other hand, may have an impact on various biological organs and systems. As a result, the study's goal was to analyse possible risk consequences.

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