EVOLUTION OF STUDIES ON BIOMIMETIC MATERIALS WITH APPLICATIONS IN REDUCING INFILTRATION BY ELETRODRAINAGE ON INFRASTRUCTURE WORKS

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Abstract. *This paper analyzes and compares various methods and materials for drainage and waterproofing of heritage building foundations at different deterioration stages due to water action. The study emphasizes the selection of drainage solutions based on comprehensive analysis of factors such as topography, slope, stratification, structural system, architecture, regional climate, and water flow characteristics. Recognizing the impact of these variables, the research highlights how identical drainage types can yield different results in distinct contexts. The durability of heritage structures, particularly those made of earth and brick, is heavily influenced by water-related deterioration, especially in high-rainfall regions. Recent intensification in research on surface water management, driven by climatic and morphological changes, underscores the importance of effective drainage and waterproof solutions. The study acknowledges the complexity of choosing optimal materials and systems from the diverse construction market and the significant resource consumption involved in such works. Hence, it advocates for the use of sustainable materials and resource-efficient methods. The proposed study focuses on innovative solutions for efficient drainage and waterproofing of heritage buildings, utilizing sustainable materials derived from waste or recycled sources. It emphasizes the adoption of electro drainage techniques alongside the application of silica nanoparticles to create superhydrophobic surfaces inspired by the lotus effect. These biomimetic surfaces, achieved through the modification of silica nanoparticles, offer superior water repellency and durability. Additionally, the study highlights the role of dimethicone as a key component in enhancing these properties. Electro drainage techniques are explored for their effectiveness in managing water infiltration and promoting efficient drainage in heritage structures. This method uses electrical fields to facilitate the movement of water away from building foundations, providing an eco-friendly and efficient alternative to traditional drainage methods. Silica nanoparticles are integral to the study, primarily for their role in creating superhydrophobic surfaces. These nanoparticles, when modified, mimic the micro- and nano-structural characteristics of lotus leaves, providing exceptional water repellency. The lotus effect, named after the self-cleaning properties of lotus leaves, is characterized by water droplets forming spherical shapes and rolling off surfaces, thereby carrying away dirt and contaminants. This effect is achieved by coating surfaces with silica nanoparticles, which create a rough nanostructure that traps small-scale air pockets, drastically reducing water adhesion. Dimethicone, a silicone-based polymer, is incorporated into the silica nanoparticle coatings to enhance their*

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hydrophobic properties. This combination not only improves water resistance but also increases the overall durability and flexibility of the treated surfaces, making them more resilient to environmental factors. The study also compares the technical specifications and performance of calcium oxalate, a proposed material, with traditional materials used in drainage and waterproofing works. Calcium oxalate, known for its durability and environmental sustainability, demonstrates superior performance in maintaining the integrity of heritage buildings while minimizing the ecological impact.

Keywords: Nanomaterials, Biomimetic Materials, Hydrophobicity, Silica Nanoparticles, Dimeticone, Lotus Effect, Electro Drainage, Heritage Building Preservation

1. Introduction

Nanomaterials are extremely small-scale structures, with dimensions on the order of nanometers (a nanometer is one billionth of a meter) [1]. They have caught the attention of researchers because of their unique properties, which differ significantly from those of macroscopic materials. The history of nanomaterials is relatively recent, but their development has had a profound impact in fields ranging from medicine to engineering and information technology.

The first steps in exploring the world of nanotechnology were taken in the 1950s and 1960s, when advanced microscopy techniques such as transmission electron microscopy (TEM) and scanning electron microscopy (SEM) allowed scientists to observe and manipulate structures at the atomic and molecular level [2]. However, the term "nanotechnology" was introduced by physicist Richard Feynman in his famous 1959 speech, "There's Plenty of Room at the Bottom", in which he discussed the possibility of manipulating materials atom by atom [3].

A milestone in the field of nanomaterials was the discovery of buckyballs, a form of nanostructured carbon, by researchers Harold Kroto, Robert Curl, and Richard Smalley in 1985 [4]. This discovery, which was awarded the Nobel Prize for Chemistry in 1996, paved the way for research into other forms of nanostructured carbon, such as the carbon nanotubes discovered in 1991 by Sumio Iijima [5].

The applications of nanomaterials are vast and diverse. In medicine, nanoparticles are used for targeted drug delivery, improved medical imaging, and the development of new therapies for diseases such as cancer [6]. For example, gold nanoparticles are used to improve the effectiveness of thermotherapy treatments, where the heat generated by nanoparticles helps destroy tumour cells with increased precision [7].

In the field of energy, nanomaterials contribute to the development of high-energy-density batteries and to increasing the efficiency of solar cells [8]. Carbon nanotubes, for example, are being used to improve the conductivity and strength of composite materials used in batteries [9].