coatings

Editorial

Recent Advances in Surface Functionalisation

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Surfaces and interfaces have become a highly relevant topic in recent years, mainly due to their technological importance in the design and development of high-performance components. Through advanced surface modification procedures, mechanical, physico-chemical and aesthetics characteristics can be modified in a wide range of materials. The development of specific surface modification procedures to modify the initial characteristics and properties of materials are highly related with the improve of the functional performance, or surface functionalization.

Surface functionalisation refers to the process of modifying the properties of a surface in order to give it physical, chemical or biological characteristics different from the ones originally possessed by it. Properties such as wettability, haptics, optical appearance, reflectivity and sliding properties, among others, are just some examples of possible modifications that can be carried out by surface functionalisation.

This process of improving the characteristics of a surface has a wide range of applications, including in the fields of medicine, electronics, transport and materials science, among others. It can be used to improve the performance of materials in a variety of applications, such as in sensors, catalysts, drug delivery systems, tribo-systems, etc. Additionally, functionalisation can be used to impart specific characteristics to a material, such as increased biocompatibility or improved corrosion resistance. Overall, functionalisation is a powerful tool for modifying the properties of materials and has the potential to revolutionise a wide range of fields and industries.

There are multiple approaches for achieving surface modification depending on the source material, the functional intent, and the required duration of the surface change. Nevertheless, chemical, physical and biological approaches can be highlighted among the most used processes. A short description, together with a deeper discussion of the advances are given below.

Functionalization procedures of surfaces by physical techniques involve the use of specific methodologies, such as heat or pressure, to modify the surface properties of a material. This can be performed through techniques such as annealing or sintering, which involve the application of heat to a material in order to alter its surface properties. Physical functionalization can be used to alter the surface finish, in terms of roughness, porosity, or mechanical properties of a material, among other properties.

Based on these considerations, physical functionalization of surfaces refers to the process of modifying the surface properties of a material through physical means, rather than through chemical reactions. This can be achieved through a variety of processes, such as mechanical grinding, plasma treatment, laser texturing, and physical vapor deposition (PVD). The goal of physical functionalization is to alter the surface properties of a material in order to improve its performance in a particular application.

One example of physical functionalization is the use of mechanical grinding to create a rough surface on a material. This rough surface can increase the material's surface area, which can improve its performance as a catalyst or adsorbent. Mechanical grinding can also be used to create patterns or textured surfaces on a material, which can alter its wettability or improve its friction properties [1,2].

Plasma treatment is another technique used for physical functionalization. In this process, a material is exposed to a plasma, which is a high-energy state of matter that can alter the surface properties of the material. Plasma treatment can be used to create a variety of surface modifications, including roughening, cleaning, and functionalizing the surface with a particular chemical group [3,4]. In addition, atmospheric pressure plasma treatments have shown an important growth of interest, because of their technological and economics advantages. Atmospheric pressure plasma technique has been effectively used for the treatment of polymers, and composites being used among others applications, in surface activation processes, and to obtain specific liquid retention characteristics [5,6].

The use of irradiation processes to modify the micro-geometrical characteristics is commonly known as laser surface texturing (LST). On the one hand, by varying the irradiation parameters such as energy density or scanning speed of the beam, a wide range of textures can be obtained with different shapes or sizes of the tracks. In addition, the variation of the pulse duration to ultrashort regimes allows us to reduce the thermal effects of these treatments [7,8]. On the other hand, laser-based processes can also be used for polishing or hardening of the surfaces [9].

Physical vapor deposition (PVD) is a process that involves the deposition of a thin film of material onto a substrate. PVD can be used to create coatings with improved resistance to wear, corrosion, or thermal phenomena. It can also be used to create coatings that have specific electrical or optical properties [10,11]. Physical functionalization of surfaces by PVD techniques has a wide range of applications, including improving the performance of catalysts and sensors, increasing the wear resistance of machine parts, and enhancing the performance of solar cells and other electronic devices.

Another common methodology for the surface functionalization is chemical modification, which involves the use of chemical agents to alter the surface properties of a material. These processes are widely carried out through the use of chemical reactions, such as oxidation or reduction, or through the use of chemical coatings or films. Chemical functionalization can be used to alter the surface energy, wettability, or biocompatibility of a material, among other properties. Most chemical surfaces are based on a limited variety of techniques, such as chemical vapor deposition (CVD), atomic layer deposition (ALD), and chemical modification of the surface through the application of various chemical agents. The goal of chemical functionalization is to alter the surface properties of a material in order to improve its performance in a particular application [12].

One example of chemical functionalization is the use of chemical vapor deposition (CVD) to create thin film coatings on a material. In this process, a chemical precursor is vaporized and then deposited onto a substrate, where it reacts with the surface to form a thin film coating. CVD can be used to create a variety of coatings, including those that are resistant to wear, corrosion, or heat [13].

Atomic layer deposition (ALD) is another technique used for chemical functionalization. In this process, alternating layers of chemical precursors are deposited onto a substrate in a highly controlled manner. The precursors react with the surface to form a thin film coating that can have a range of desired properties [14].

Chemical modification of surfaces can also be achieved through the application of various chemical agents to the surface of a material. These agents can react with the surface to form a chemical bond, which can alter the surface properties of the material. For example, the application of a hydrophobic chemical agent to a surface can make the surface more resistant to water, while the application of a hydrophilic agent can make the surface more receptive to water [15]. This type of surface modification technique has a wide range of applications, including improving the performance of catalysts and sensors, increasing the wear resistance of machine parts, and enhancing the performance of solar cells and other electronic devices.

The biological functionalization of surfaces involves the use of biological agents, such as enzymes or cells, to modify the surface properties of a material. This can be performed through techniques such as cell culture, which involves the growth of cells on a surface, or through the use of enzymes to catalyse chemical reactions on a surface. These processes can be used to alter the surface biocompatibility, biodegradability, or bioactivity of a material, among other properties.

The goal of biological functionalization is to create materials that are more compatible with living systems, which can be used in a variety of applications including drug delivery, tissue engineering, and biosensors. It is a rapidly growing field that has the potential to revolutionize the way we interact with biological systems.

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