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Review article

Fluorine-containing bio-inert polymers: Roles of intermediate water

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ABSTRACT

Fluorine-containing polymers are used not only in industrial processes but also in medical applications, because they exhibit excellent heat, weather, and chemical resistance. As these polymers are not easily degraded in our body, it is difficult to use them in applications that require antithrombotic properties, such as artificial blood vessels. The material used for medical applications should not only be stable *in vivo*, but it should also be inert to biomolecules such as proteins or cells. In this review, this property is defined as "bio-inert," and previous studies in this field are summarized. Bio-inert materials are less recognized as foreign substances by proteins or cells in the living body, and they must be covered at interfaces designed with the concept of intermediate water (IW). On the basis of this concept, we present here the current understanding of bio-inertness and unusual blood compatibility found in fluoropolymers used in biomedical applications. IW is the water that interacts with materials with moderate strength and has been quantified by a variety of analytical methods and simulations. For example, by using differential scanning calorimetry (DSC) measurements, IW was defined as water frozen at around -40°C. To consider the role of the IW, quantification methods of the hydration state of polymers are also summarized. These investigations have been conducted independently because of the conflict between hydrophobic fluorine and bio-inert properties that require hydrophilicity. In recent years, not many materials have been developed that incorporate the good points of both aspects, and their properties have seldom been linked to the hydration state. This has been critically performed now. Furthermore, fluorine-containing polymers in medical use are reviewed. Finally, this review also describes the molecular design of the recently reported fluorine-containing bio-inert polymers for controlling their hydration state.

Statement of significance

A material covered with a hydration layer known as intermediate water that interacts moderately with other objects is difficult to be recognized as a foreign substance and exhibits bio-inert properties. Fluoropolymers show high durability, but conflict with bio-inert characteristics requiring hydrophilicity as these research studies have been conducted independently. On the other hand, materials that combine the advantages of both hydrophobic and hydrophilic features have been developed recently. Here, we summarize the molecular architecture and analysis methods that control intermediate water and provide a guideline for designing novel fluorine-containing bio-inert materials.

Contents

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