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Fluorescent Organic Nanoparticles

New Generation Materials with Diverse Analytical and Biomedical Applications

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Preface

Fluorescent organic nanoparticles (FONs) are a very interesting class of materials with diverse analytical and biomedical applications. Several FONs have been reported as attractive agents for cell imaging applications. Over the last few decades, several bioprobes, e.g. organic dyes, fluorescent proteins and fluorescent inorganic/organic nanoparticles, have been reported for biomedical applications. FONs are thought as more promising agents for biomedical applications owing to their possibility of diverse designs and biodegradability properties. Drug delivery systems have brought about a great revolution in the pharmaceutical field. The use of drug delivery systems can help in avoiding some of the inherent drawbacks of the commonly used drugs, such as low solubility in physiological systems, leaching, lower activity, unwanted interactions with different biological macromolecules other than the target ones, toxicity, and decomposition. Photoresponsive nanoparticles have been the preferred choice for drug delivery applications owing to their ability to control the release of pharmacologically important drugs via externally regulated stimulation of light. In the light of these facts, FONs have also been extensively studied as sensors in drug delivery systems and for other applications like photodynamic therapy and apoptosis inducers of cancer cells.

Nowadays, design and development of highly sensitive and selective fluorescent probes for sensing biologically important analytes in aqueous or cellular environments is an active area of research. Several types of fluorescent materials, such as small organic dyes conjugated with polymers, organic nanoparticles, inorganic quantum dots, metallic nanoclusters and upconversion nanoparticles, have been used for sensing different types of analytes including cationic and anionic ones.

The recent research carried out on the design and development of aggregation-induced emission (AIE) nanoparticles is a promising stimulation towards the development of highly fluorescent nanoparticles as the natural aggregation is kept busy in increasing the fluorescence of the nanoparticles. AIE is therefore truly a novel finding of this subject. The encapsulation of an emitter into different matrices affects their aggregation, molecular packing and distribution in the nanoparticles. Thus, care is needed while selecting the polymeric matrix and the emitter-to-matrix ratio, which may help in the tuning of nanoparticle size, brightness and stability. Several reports have been published with polymer-encapsulated emitters having sizes ranging from few to several hundred nanometres. Such nanoparticles have versatile surface functional groups that have been tailored to provide space for different imaging needs, for example imaging of cellular organelles, targeted *in vitro* and *in vivo* imaging of tumours, tracing of cancer cells, and imaging of blood vessels and specific chemical and biomolecular species.

The recent exploration of the cell imaging, chemosensing and drug delivery applications of FONs has brought about a great revolution. This is very important and interesting from the materials point of view. Nevertheless, there has been a good deal of work in the development of highly fluorescent nanoparticles for cell imaging, sensing and drug delivery applications; several existing FONs are not very emissive in the aggregated states. Thus, FONs with strong near-infrared (NIR) absorption and active non-radiative emission are the materials of choice at the moment. The non-radiative pathway is generally associated with heat production, and thus, such FONs might have great potential for use in photothermal therapy, wherein highly specific, non-toxic and non-invasive treatments of cancers may be carried out. It is of great interest that several FONs have also been tried as agents for photodynamic therapy of cancers; however, this field of research is at an early stage as the principles of design of such FONs and their action mechanisms are not fully established. However, such nanoparticulate systems have successfully confirmed their promise for the deep in vivo tumour imaging and photodynamic therapeutic uses with minimum or no side effects on normal cells and tissues. The future research on FONs needs to be focused on the design and development of smart stimuli-responsive sensing, imaging and drug delivery systems. Besides, the future work must focus on developing FONs and AIE fluorogens with far red/near-infrared (FR/NIR) emitters displaying narrow band emission for specific analytical and biomedical applications.

In this book, attempts have been made to address the advances made in the development of FONs as materials of choice for the design and fabrication of sensors, bioimaging agents and drug delivery systems. Basically, four important methods, namely self-assembly, polymerization, emulsification and nanoprecipitation/reprecipitation, have been used for the preparation of FONs with diverse applications in analytical and biomedical sciences. Out of these techniques, nanoprecipitation is the simplest and the most widely used technique. This technique enables the transformation of soluble organic molecules into nanoparticles in the aqueous media and later ensures their fast screening for various analytical and biomedical applications. We have also tried our best to throw light on the outlooks of the research and development in FONs as smart materials with various possible applications. In the context of fluorescence-based sensing, drug delivery and cell imaging, the properties of FONs that are of major importance include their stability, brightness, toxicity and biodegradability. Overall, FONs represent a very interesting field of research with promise for varied applications in analytical and biomedical sciences.

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