Chapter 46
Hybrid Plasmonic Nanostructures:
Environmental Impact and Applications

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ABSTRACT

Plasmonic hybrid nanostructure including Semiconductor-metallic nanoparticles, and graphene-plasmonic nanocomposites have great potential to be used as photocatalyst for hydrogen production and for photodegradation of organic waste. Also, they are potential candidate as active materials in photovoltaic devices. Plasmonic-magnetic nanocomposites could be used in photothermal therapy and biomedical imaging. This chapter will focus on the environmental impact of these materials and their in-vitro and in-vivo toxicity. In addition, the applications of these hybrid nanostructures in energy and environment will be discussed in details.

1. INTRODUCTION

Recently, population growth and fast urbanization and industrialization have been increased dramatically. Therefore, several serious environmental issues such as; climate changes, global warming and pollution of water resources were still a main challenge for the whole world. These issues may become even worse if no efficient/sustainable solutions has been developed to reduce their reasons.(Li et al. (2015)) Due to these tremendous advances, the search for the suitable platforms, and materials to be used in wide-variety of environmental applications became the main target for several research groups.

Plasmonic materials and their hybrid nanostructures have unique and intriguing physico-chemical and biological properties compared to their bulk counterparts. This is attributed to their high *surface-to-volume* ratio, shape and size dependent optical properties and their localized surface Plasmon.(Li et al. (2001), Sharma et al. (2008), Iglesias-Silva et al. (2007), Huang and Yang (2008) and El-Nour et al.

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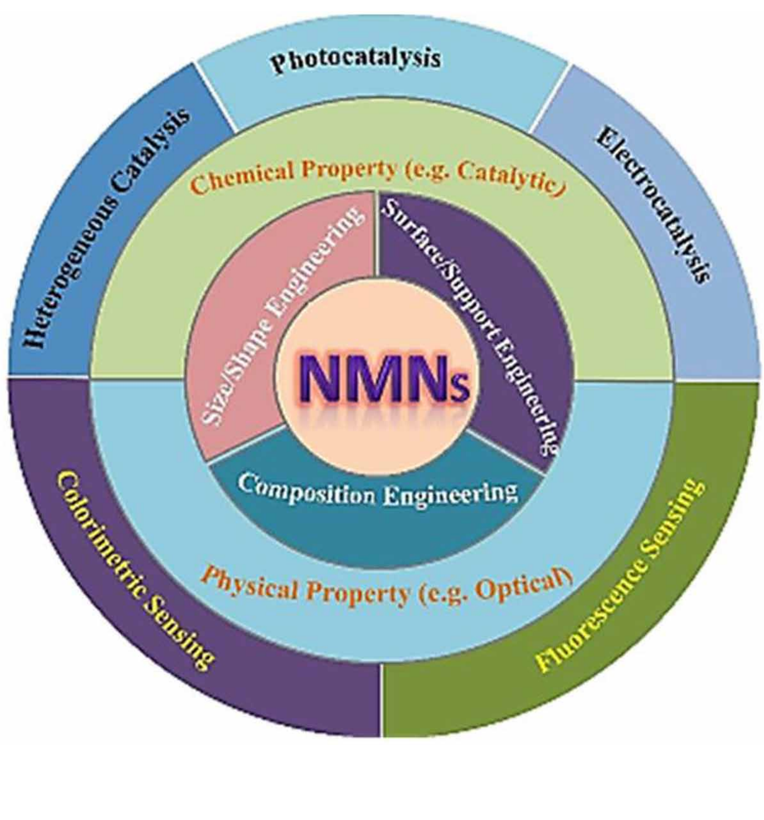
(2010)) Additionally, the ease of surface modification functionalization to be utilized in different applications.(Qu et al. (2013), Cuenya (2010), and Zhang et al. (2010)) Therefore, plasmonic nanomaterials and their hybrid nanocomposites represent new class of materials which could be good candidates to provide promising solutions for the most environmental issues.(Guo and Wang (2011), Cao et al. (2013), and Corma and Serna (2006)) These possible applications can varies either from their catalytic and photocatalytic applications, light harvesting, sensing, and antimicrobial applications (Figure 1). (Li et al. (2015))

2. ENVIROMENTAL APPLICATIONS OF PLASMONIC NANOPARTICLES

a. Silver Nanoparticles

Silver nanoparticles exhibit unique optical, catalytic, sensing and antimicrobial characteristics which made them have huge industrial demands, pegged at 16,000 to 24,000 tons per year. As an antimicrobial agent, silver nanoparticles are expected to have annual demand of 2800 tons/year in the fields of 'food, hygiene and water purification, in addition to 3125 tons/year for medicine. Only 36% of the silver consumed in these industrial processes is being recycled and the rest is let out to the environment. The widespread

Figure 1. Schematic illustration of the possible applications od plasmonic nanoparticles in the environmental field. Reproduced from[Li, J., Zhao, T., Chen, T., Liu, Y., Ong, C.N. and Xie, J., 2015. Engineering noble metal nanomaterials for environmental applications. Nanoscale, 7(17), pp.7502-7519] Published by The Royal Society of Chemistry



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