Chapter 11
Hybrid Nanostructures:
Synthesis and Physicochemical Characterizations of Plasmonic Nanocomposites

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ABSTRACT

The recent extensive interest of nanostructure materials associated with their unique properties is motivated to develop new hybrid nanocomposites that couple two nano-components together in the form of Core/Shell, nanoalloys, and doped nanostructures. Hybrid nanostructure provides another opportunity for tuning the physical and chemical properties at the nanoscale. This opens the door for the discovery of new properties and potential for more applications. This chapter is devoted to present, and discuss the recent advances and progress relevance for Plasmonic hybrid nanocomposites. In addition, literature reviewed on different attempts to obtain high quality plasmonic nanocomposites via chemical routes, and their physico-chemical aspects for this class of novel nanomaterials. The authors presented their recent published work regarding Plasmonic hybrid nanostructure regarding plasmonic-semiconductor, plasmonic magnetic and plasmonic graphene nanocomposites.

1. INTRODUCTION

Hybrid nanostructures are composed of two or more nanoscale materials to form nano-composites. In such materials, their individual components combined their functionalities, and advantages to be integrated into one nano-object (Kickelbick 2007, and Merhari 2009). Hybrid nanocomposite offer the possibility and flexibility to obtain new properties and functions, which different from that of their isolated components through varying the composition of the materials and related parameters such as morphology and interface for wide-range of applications.(Bogue 2011, Kickelbick 2007, Berthelot 1999, and Pandya

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2015) Importantly, their morphologies are versatile, such as zero dimensional (0D) nanoparticles (i.e. sphere), 1D dimension (i.e. rods, or wires).(Huang et al. 2014)

Most of the nanocomposites that have been developed and demonstrated technological importance can be classified according to the type of filler, as following (Figure 1): (Huang et al. 2014)

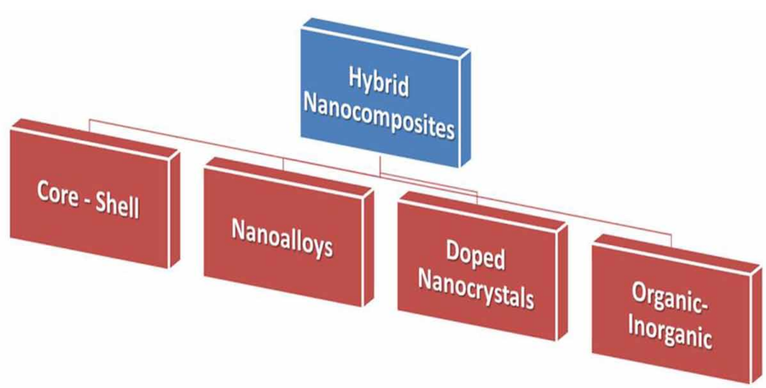
1. Plasmonic based nanocomposites.
2. Magnetic based nanocomposites.
3. Polymer based nanocomposites.
4. Semiconductor based nanocomposites.
5. Carbon based nanocomposites.

This chapter is devoted to explore the synthesis and characterizations of plasmonic hybrid nanocomposites including core-shell, nanoalloys, doped plasmonic nanomaterials and plasmonic-organic hybrid nanocomposite, and their applications as photo-catalysts in photo-degradation of organic wastes and waste water treatment.

2. PHYSICS OF PLASMONIC NANOSTRUCTURES

The optical properties of metal nanoparticles are dominated by what is called Plasmon (i.e. the collective oscillation of conduction electrons resulting from their interaction with electromagnetic radiation as shown in Figure (2). (Mody et al. (2010), Faraday (1857), Murray& Barnes (2007), Bruda et al. (2005) and Kreibig & Vollmer (1995)) Plasmon are resonant modes that involve the interaction between free charges (i.e. –ve electrons) and light.(Bruda et al. (2005)) When the size of metallic particles reduced within nanoscale, in which the particle size is smaller than the electron mean free path, the electrons motion will consequently confined within nanoscale (1-100 nm). In this case, unusual phenomena called plasmonic effects (i.e. surface plasmon band) are observed.(Creighton (1991), and Kreibig & Vollmer (1995)) The electric field of the incoming radiation induces the formation of a dipole in the nanoparticle. A restoring force in the nanoparticle tries to recover for this, resulting in a unique resonance wavelength,

Figure 1. The classification of Hybrid Nanocomposites



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