# 1. Introduction

Nanosized noble metal particles have gained recently a considerable interest due to their unique optical and electrical properties[1, 2] which are strongly dependent on their size and shape as well as on their arrangement and mutual interactions in the particle assemblies[3-5]. The unique optical responses of plasmonic metal nanoparticles (NPs) arise from an electrodynamic phenomenon known as surface plasmons. These originate from collective oscillations of free electrons in response to an electromagnetic radiation of characteristic frequency. The coupling of electrons in metal NPs with light is accompanied by a local electromagnetic field enhancement which gives rise to surface-enhanced optical processes. The growing field of scientific research and applications focused on such light-metal interactions is known as „plasmonics“[5]. Plasmonic NPs have potential applications in surface-enhanced (Raman) spectroscopy[6], catalysis[7], displays, microelectronics, and also they are exploited as biological probes for diagnostic purposes[8]. Nanoparticle size, generally, provides an important control over many of the physical and chemical properties of hybrid nanoscale materials such as luminescence, conductivity, and catalytic activity. Laser ablation[9] and nanoparticle fragmentation[10, 11] appear to be promising tools for obtaining NPs of desired size distribution, which provide the largest surface plasmon resonance in their functional assemblies, e.g. in their dimers.

The extensive range of unique size-dependent properties inherent to noble metal NPs makes them very attractive candidates for integration into composites with $\pi$-conjugated polymers[12, 13]. In such nanocomposites (NCs), interactions between delocalized $\pi$-electron states of polymer chain and localized surface plasmon states are expected. It can be assumed that $\pi$–$\pi^*$ absorption band of the polymer will be, at least to some extent, affected by an interaction with plasmonic metal NPs and, in the same time, the optical properties of the metal NPs will be affected by the presence of the conjugated polymer. It can be expected that the key role will be played by the actual morphological characteristics of the metal NPs in NCs. Understanding and tuning such effects which are currently a subject of focused interest could lead to hybrid optical devices based on these NCs with improved optical properties. Embedding metal NPs into host polymers provides means for introducing a variety of new properties to composite materials, including increase in conductivity[14, 15], in catalytic activity as well as enhancement[16] or quenching of fluorescence[17] of the polymer. Future applications of the NCs of $\pi$-conjugated polymers and metal NPs in optoelectronic devices such as solar cells, light emitting diodes, sensors, electronic memories can be envisaged.





NCs of the conjugated materials and metal NPs have been recently prepared by several ways from a range of different metals and many different types of conjugated polymers, oligomers and conjugated linkers[12, 13, 18]. The effect of the conjugated systems on the optical properties of metal NPs and electronic behavior of both the NPs and conjugated materials have been reported in several papers[19-22]. To illustrate this effect, the study reported by Wessels et al.[19] can be mentioned. They investigated optical and electrical properties of films of Au NPs interlinked by short $\pi$-conjugated molecules. In the case of bis-dithiocarbamate, the disappearance of surface plasmon extinction (SPE) band, which is characteristic for isolated NPs, and formation of metallic absorption were observed. This effect was attributed to an overlap of the molecular orbitals of the linker and nanosized metal wave functions leading to the formation of a resonant state that affects the absorption of the film. Moreover, the conductivity of the film was one order of magnitude higher than that for a similar film formed by non-conjugated linker of the same type as conjugated linker. They suggested that the electron transport is a partially nonresonant tunneling process along the non-conjugated parts of the molecule and partially resonant tunneling process through the conjugated parts of the molecule. Some photophysical processes such as Raman scattering enhancement[23, 24] or fluorescence enhancement/quenching[16, 25, 26] were investigated in some studies for these NCs and the results obtained from these studies were compared with those observed for the systems of monomer non-conjugated adsorbates and metal NPs. Some of the early possible applications have been also reported[12].