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Abstract

Combining multiple components into a single nanoparticle is an attractive way to engineer systems having diverse physical and chemical properties. To date many such kind of hybrid structures have been created and many of them are under process to be created. Out of the various hybrid composites structures magnetic-plasmonic nanoparticles have attracted much attention with demonstrating themselves as a successful candidate for various application ranging from their usage in the biological application to the optoelectronics. Although lots of promising work is going in this field, the magnetic-plasmonic nanoparticles systems are still in the prenatal stage of their development and for their usage in the commercial and scientific applications.

There are lots of issues in order to synthesize the magnetic-plasmonic nanoparticles owing to their immiscibility among each other, vast differences in the reduction potential, and the different behavior at chemical and physical level. These challenges were readily accepted by the scientific community and lots of work across the world is going on solving the challenges and exploring the new avenues in the field of magnetic-plasmonic nanoparticles. In this doctoral thesis, we have focused on development of novel multimetallic magnetic-plasmonic NPs, along with the fundamental investigation of their structural and functional properties. We have chemically synthesized AuFePt ternary alloy NPs, where individual metals played an important role for obtaining the structural and functional hybrid systems. It was found that Pt plays a crucial role to act as a bridging element which facilitates the diffusion of Au and Fe into the homogenously alloyed ternary structure without phase segregation, otherwise without Pt, the mixing of Au and Fe has been limited due to the immiscibility among each other which has been already reported and also observed during our research. A series of ternary alloy NPs were synthesized with various compositions and systemic studies were performed to investigate the resultant properties of the NPs in terms of size, morphology, composition, magnetism and plasmonics. It was found that magnetic and plasmonic properties are dependent on the final atomic composition of the alloy NPs. At optimized alloy composition, that is $Au_{52}Fe_{30}Pt_{18}$ these NPs have shown good plasmonic and magnetic properties simultaneously which demonstrates their promising ability to be used as a model for fundamental studies and for the biomedical applications. The current research is helpful for gaining the insights about the crucial roles played by physical and chemical properties of nanoparticles and correlation to nanoparticles usage in various applications.

Following the observations from as above mentioned studies, we extended the same synthetic technique and optimized reaction parameters to study another magnetic-plasmonic system where we chose Ag as the plasmonic component keeping the other two variables that is Fe and Pt to be same, in order to synthesize ternary AgFePt NPs. The current fundamental study is very attractive which can be used for manipulating the materials properties and at the same time presents a complex challenge. Understanding the basic fundamentals regarding the synthesis of the materials at the same gaining the in-depth knowledge of the fundamental properties of nanoparticles could be very useful for careful designing of the materials with the distinct desirable characteristics. Through my research during the PhD, I tried to design the new synthetic schemes hence, novel hybrid NPs systems and to make clear the controllability of the physical parameters which governs the resultant magnetic and plasmonic properties. In order to have the full picture, we clarify the interaction among three metals in two different systems (Au, Fe and Pt) and (Ag, Fe and Pt). This fundamental research will offer research society with useful means of designing and controlling the properties of multimetallic nanomaterials. Besides, these hybrid systems are equally promising for other scientific fields as they are well known candidates for the catalytic and bio-medical applications.

keywords: multimetallics, hybrid structures, plasmonics, magnetic nanoaparticles, dielectrics.