CHAPTER – I

INTRODUCTION

CHAPTER – I

Introduction

Inorganic materials in nanometer scale can exhibit different physiochemical and size related properties. It's giving rise to new applications in the areas of biomedicines, drug-delivery agent, pharmaceutical fields and hygienic product. According to the green chemistry principles a general concern remains that these new nanomaterials ought to be evaluated for their safety to the environment [1-2]. In the last decade, the design of new materials growing interested towards combining inorganic clay nanocomposites with metal/metal oxides nanoparticles. Natural bentonite clay is montmorillonite clay; it's commonly used in natural medicine for thousands of years.

Bentonite (bent) is a 2:1 clay consists of one octahedral (O_h) sandwich between two tetrahedral (T_d) sheets. Bentonite materials are excellent low-cost fillers/substrates for metal/metal oxides (M/M-O) nanocomposites. The interlayer between the units that contains positive cations [e.g. sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), and Hydrogen (H^+)] and large number of water molecules. Na-bentonite has more superior physicochemical characteristics, i.e., better thermostability, dispersibility and higher ion exchange capability. The recent advances in biomedical applications of cationic bentonite clay minerals based on their specific physiochemical properties such as an ability of high swelling, surface area, cationic exchange capacity and multifarious bio-related applications [3]. Moreover, bentonite can be appropriate natural silicate which can be utilized for encapsulating metal/metal oxides materials in intercalation processes [4]. Interest in these composite materials originates from the combination of a biological active noble metal and semiconductor metal oxides materials. Noble

metal loaded with metal oxides nanoparticles like silver (Ag) on titanium oxide (TiO_2), copper oxide (CuO), zinc oxide (ZnO), and manganese oxide (Mn_3O_4) have received much attention for decades. They have been found to have wide ranging applications in the bio-medicinal fields [5].

Nowadays, the synthesis of nanocomposites considers the room temperature aliphatic ionic liquids (RTILs) are commonly used; because of their unique physiochemical properties such as low vapour pressure, high thermal stability, ionic conductivity, low volatility, high fluidity, air, and water stability [6-7]. Ionic liquids have been used for the synthesis of nanocomposite, because it has significant influence on the size, shape, and structure of the nanocomposites based on the following mechanisms, such as dipole-dipole interaction, electrostatic force of attraction, strong hydrogen bond network, self-assembled, columbic attraction and so on. These goodness aliphatic ammonium-based ionic liquids have been used as a capping agent, template, solvent, and stabilization agent for the synthesis of inorganic metal/metal oxides nanoparticles supported on bentonite clay nanocomposites [8]. Thus, nanocomposites can be synthesized by various characterizations based on conventional techniques such as hydrothermal, chemical reduction, ion exchange processes, sol-gel, co-precipitation, and solvothermal methods. Furthermore, these methods frequently lack good control of morphology and large amounts of corresponding materials and energy are used. Hence, any new synthesis method that helps to control particle size and uniform dispersion of nanoparticles into the bentonite surface would be extremely beneficial. In recent times, thermal decomposition method has been applied in the synthesis of metal/metal oxides/bentonite clay nanocomposites.

For the past couple of years, bacterial infections are cause major problem in global. The design of new nanocomposites with antibacterial properties has enhanced enormous awareness,

since infection by pathogenic and nonpathogenic microorganisms is of great concern in many bio-related fields, especially in food industries, pharmaceutical fields, cosmetic, drug release, tissue engineering, bio-sensor, and cell adhesion [9-10].

Here, we report and develop a new approach for the synthesis of metal/metal oxides nanoparticles using bentonite clay as a support, resulting in a high swelling, specific surface area, and cation exchange capacity. The antibacterial activity of the composites was investigated using *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) bacteria. Finally, the cytocompatiability of composites was evaluated through 3-[4,5-dimethylthiazol-2-yl]2,5-diphenyltetrazolium bromide (MTT) colorimetric assay. To our knowledge, that is the first report related to the metal/metal oxides/bentonite nanocomposite with and without ionic liquid for drug delivery applications.

References

[1] Haohong Duan, Dingsheng Wang and Yadong Li, Green chemistry for nanoparticle synthesis, Chem. Soc. Rev. 44 (2015) 5778-5792.

[2] Sangeetha Gunalan, Rajeswaro Sivaraj, Venckatesh Rajendran, Green synthesized ZnO nanoparticles against bacterial and fungal pathogens, Progress in Natural Science: Materials International, 22 (2012) 695-702.

[3] Engelbert Redel, Eric Arsenault, Paul G. O Brien, Nazir P. Kherani, Geoffrey A. Ozin, Green growth of metal nanocrystals on nanostructured metal oxides - dramatic effect of antimony doping, Chem. Mater. 32 (2011) 1353-1355.

[4] Juggnu Bhatt, Rajesh S. Somani, Haresh M. Mody, Hari C. Bajaj, Rheological study of organoclays prepared from indian bentonite: effect of dispersing methods, Appl. Clay Sci. 83-84 (2013) 106-114.

[5] Chengli Huo, Huaming Yang, Synthesis and characterization of ZnO/palygorskite, Appl. Clay Sci. 50 (2010) 362-366.

[6] Changhui Xu, Aleksander Durumeric, Hemant K. Kashyap, Jorge Kohanoff, and Claudio J. Margulis, Dynamics of excess electronic charge in aliphatic ionic liquids containing the bis(trifluoromethylsulfonyl)amide anion, J. Am. Chem. Soc. 135 (2013) 17528-17536.

[7] Chisato Takahashi, Takashi Shirai, Masayoshi Fuji, Study on intercalation of ionic liquid into montmorillonite and its property evaluation, Mater. Chem. Phys. 135 (2012) 681-686.

[8] Xiaochuan Duan, Jianmin Ma, Jiabiao Lianc and Wenjun Zheng, The art of using ionic liquids in the synthesis of inorganic nanomaterials, Cryst. Eng. Comm. 16 (2014) 2550-2559.

[9] F. M. Vitucci, F. Trequattrini, O. Palumbo, J.-B. Brubach, P. Roy, M. A. Navarra, S. Panero, and A. Paolone, Stabilization of different conformers of bis(trifluoromethanesulfonyl)imide anion in ammonium-based ionic liquids at low temperatures, J. Phys. Chem. A. 118 (2014) 8758-8764.

[10] Khalid Mahmood Zia, Mohammad Zubera, Mehdi Barikani, Rizwan Hussain, Tahir Jamild, Sohail Anjum, Cytotoxicity and mechanical behavior of chitin-bentonite clay based polyurethane bio-nanocomposites, Int. J. Biol. Macromolec. 49 (2011) 1131-1136.