ABSTRACT

Nowadays, people are affected by different types of diseases or injuries such as tissues damage, bone cancer, dental, hip and knee etc. The effective treatment of these diseases or injuries requires synthetic biomaterials which have the ability to contact and bond with the living tissue, as well as replacement of hard and soft tissues. Artificial biomaterials are used in clinical applications in the form of implants for ear, hip, knee, elbow joint damage and as biomedical products like blood bags, syringes and needles, etc. Interaction between the implant and natural tissues is a significant subject for investigation in biomaterials science.

Bone is a composite of organic and inorganic components. The major inorganic portion of bone is hydroxyapatite (HAp). Depending on the size of the wound, HAp is used as implants in different forms like powder, paste, solid and ceramic coated metals. Stoichiometric HAp has poor bioactivity due to poor resorbability. Owing to this reason, researchers are developing new types of resorbable and non-resorbable materials such as mixed phase of calcium phosphates, polymer scaffolds and its composites.

HAp coated on metal bonds directly with the bone and has better mechanical properties. However, HAp coated metals have their disadvantages such as less adhesion strength, lattice mismatching between metal and HAp thin film, low bioactivity, bacterial infections and no clear chemical composition. Therefore, the bioactivity of the calcium phosphate coated metal

implants is improved through different processes like surface modification and preparation techniques.

Surface treatment by irradiation has been identified as a good method to modify the surface properties of implant materials to significantly improve its osseointegration, sterilization and bulk properties. Apart from this, swift heavy ion (SHI) irradiation induces free lattice mismatch of HAp film and improves the bioactivity. Local drug delivery has recently attracted attention to cure the bone infection (osteomyelitis). Recently, drug delivery efficiency of nanosized biomaterials is increased by modification of surface properties and preparation methods.

The main aim of the present investigation was to improve the bioactivity of nanosized organic-inorganic composites and HAp thin films, and to investigate its antibiotic drug loading/release behavior. The HAp thin films were prepared by different methods and their surface were modified by swift heavy ion beam irradiation. In addition, the physico-chemical characteristics, biological performance and drug release of the above materials were also investigated.

Nanosized HAp/agarose composite was synthesized by sol-gel technique followed by microwave treatment. During the reaction, pH of sol-gel was maintained using a pH stat. As synthesized and calcined powders were characterized using XRD, FTIR, SEM-EDX, BET, in vitro bioactivity, dissolution and haemolysis. The length of HAp rods were found to decrease on microwave treatment. Controlled manner of drug release (Amoxicillin

(AMX) and 5-fluorouracil (5-Fcil)) was obtained in microwave treated samples. Antibacterial activity of S. aureus and S. epidermidis were less susceptible than E. coli in AMX loaded samples.

Nanosized carbonate HAp/agarose (CHAp/agarose) composite was synthesized by a solvothermal technique under different temperatures. The as-synthesized samples were subjected to calcination process. The phases of CHAp/agarose composite were confirmed by XRD, FTIR and Raman studies. Nanosized rods of CHAp/agarose composite were synthesized and its length was found to increase with increase in temperature. Agglomerated rods and spherulites of HAp were observed after the calcination. The surface area was decreased with increase in temperature. All samples showed better in vitro bioactivity and haemocompatibility. The sample synthesized at 120 °C showed controlled release of antibiotic (AMX) and anticancer (5-Fcil) drugs for a prolonged period.

Nanosized biphasic calcium phosphate thin films (500 nm) consisting of resorbable β-TCP and non-resorbable HAp was deposited on (001) silicon substrate by electron beam evaporation. The crystalline phase of the films on annealing at 700 °C was confirmed by XRD analysis. Uniform deposition of calcium phosphate on silicon substrate was verified from elemental mapping using EDX analyzer (SEM-EDX). Annealing of the samples lead to decrease in surface roughness, contact angle and dissolution of the coating layer. AMX loaded thin films exhibited significant bacterial resistance. In addition, BCP thin films did not exhibit any cytotoxicity.

Coating of HAp on titanium, 316L stainless steel and silicon substrates were investigated using RF magnetron sputtering technique by varying the parameters of temperature and annealing process. Titanium coated with HAp was subjected to SHI irradiation with Si^{9+} ions of 125 MeV with various ion fluences. GIXRD analysis confirmed the HAp phase of the irradiated film. There was a considerable decrease in crystallinity and particle size after irradiation. In addition, DRS-UV reflectance spectra revealed a decrease in optical band gap from 5.2 eV to 4.6 eV. HAp thin films irradiated with a fluence of 1×10^{11} ions/cm^2 showed significant increase in wettability. Surface roughness, pores and average particle size were varied after irradiation. The SHI irradiated samples exhibited enhanced bioactivity, and there was no significant variation in cell viability.

The effect of swift heavy 100 MeV Ag^{7+} ions irradiation was studied on HAp thin film prepared by PLD technique. The crystallinity of the films was found to decrease with an increase in ion fluence. Decrease in optical band gap for irradiated samples was noted. The surface roughness of irradiated sample increased at lower fluence. Wettability, AMX loading capacity and bactericidal effect increased after irradiation. The irradiated samples showed fast rate of AMX release.

The results of the investigations have been published in International journals and presented in several National/International conferences.